

Faunal Analysis from Amud Cave: Preliminary Results and Interpretations

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ABSTRACT The Late Mousterian Neanderthal site of Amud Cave (dated ca. 70–55 kyr) is situated on the margins of the Dead Sea Rift, about 5 km northwest of the Sea of Galilee. Recent excavations at the site yielded rich lithic, faunal and human skeletal assemblages. This paper presents some characteristics of the faunal assemblages from Amud Cave, combined with pertinent results of taphonomic and micromorphological studies, and places them in the context of other Late Mousterian archaeofaunas in the southern Levant. Copyright © 2004 John Wiley & Sons, Ltd.

Key words: Levant; Amud Cave; Neanderthal; fauna; Mousterian

Introduction

The Levant, a small geographical area, is rich in Middle Palaeolithic sites. Because the region was populated during the Middle Paleolithic by two human groups—Neanderthals and *Homo sapiens*—undiagnostic human skeletal remains cannot be attributed *a priori* to Neanderthals, as is the case for most of the Middle Palaeolithic period in Europe. Only in a handful of localities are human skeletal remains preserved sufficiently to be identified taxonomically. As a result of this situation, those sites that do contain identifiable human remains are important sources of information about the specific groups that inhabited them, as well as the local palaeoecology and site structure of the two hominid groups.

Amud Cave, where Neanderthal remains were found in two series of excavations (Suzuki & Takai, 1970; Rak *et al.*, 1994; Hovers *et al.*,

1995), is one such site. Broadly contemporaneous with the Neanderthal cave sites of Kebara and Dederiyeh (in Israel and Syria, respectively), Amud Cave contributes to the growing database on Neanderthal existence in the Levant, which documents considerable variability in behavioural aspects within this group. In addition to the documented variability in lithic reduction processes, one can now recognise and address variations in modes of faunal exploitation.

In this paper we present a preliminary analysis of the medium to large mammalian fauna from the new excavations at Amud Cave. We underline patterns that are similar to those observed in other Neanderthal occupations in the Levant, and single out some aspects of the faunal assemblage that are characteristic of Amud Cave but not necessarily shared by other Levantine Late Mousterian occupations.

The site

Amud Cave is situated on the margins of the Dead Sea Rift, about 5 km northwest of the Sea of

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Galilee (Hovers *et al.*, 1991, 1995). The site is found in the Mediterranean biogeographical zone, characterised by long, hot, dry summers (temperatures range between 18°C to 38°C in the hottest month, August), and short, cool and rainy winters (temperatures from 5°C to 10°C in January). Annual precipitation fluctuates a great deal. Mean annual precipitation is 450 mm, but the annual rainfall may reach 1000 mm or more in rainy years. The cave is located in an east-facing cliff in the Amud drainage, at an elevation of 110 m below mean sea level and some 30–35 m above the present channel bed. At present the cave consists of a small chamber (some 7 × 5 m), a large open 'middle' terrace (25 × 12 m; Figure 1), and a lower terrace that is actually a steep slope towards the channel bed. Excavations at the site took place in 1961 and 1964, and again between 1991 and 1994 (Suzuki & Takai, 1970; Hovers *et al.*, 1991, 1995, 1996), and have established the existence and nature of the Middle Palaeolithic occupations. The current physical configuration of the cave is relatively recent and dates to the late Upper Pleistocene (Hovers, 1994; Inbar & Hovers, 1999; Valladas *et al.*, 1999).

A cumulative 4.5 m thick column of sediments consists of Middle Palaeolithic deposits (unit B), unconformably overlain by unit A, dated to the Holocene. Unit B was originally divided by the Japanese researchers into four stratigraphic subunits (B1–B4 top to bottom), with the lowest one deposited directly on bedrock (Chinzei, 1970). This framework was confirmed in the course of the more recent excavations, with some further subdivisions of the stratigraphic subunits into layers in the various excavation areas (Hovers *et al.*, 1995; e.g., B1/6, B2/8 in Area A and B2/4 in Area B). The remains of 15 Middle Palaeolithic hominids were recovered from subunits B1 and B2 in Area A (Hovers *et al.*, 1995; Figure 1). Of these, two were identified as Neanderthals on the basis of their morphological characteristics (Rak, 1993; Rak *et al.*, 1994; Hovers *et al.*, 1995).

Subunits B1, B2 and B4 are rich in stone artefacts (Hovers, *in press*; Alpersen, 2001), and faunal remains. Sediments of these layers are composed of a powdery dry matrix of grey to white colour. This matrix consists of ash derived from anthropogenic activity and reworked to some extent by biological activity

and possible human scattering and trampling. The ashes were originally associated with hearths, many of which have been modified by bioturbation. Intact material, little influenced by such processes, is still found in the relatively stone-rich deposits along the north wall of the cave and in Area B (Figure 1). These appear as alternating cemented, often laminated, ashy grey and black horizons, each several cm thick, and in cemented calcareous ash units in all of the excavated areas. The latter deposits are presumably hearths or burned zones that were cemented shortly after their accumulation and thus escaped bioturbation (Madella *et al.*, 2002). Within subunit B4, the outlines of small intact hearths were discerned. Wood and herbaceous plants were possibly used as fuel for the hearths, but phytolith studies suggest that in all the units, reliance on grassy plants for a number of purposes might have been relatively substantial (Madella *et al.*, 2002).

Subunit B3, which consists of coarse-grained stony debris with little matrix, is archaeologically sterile and represents a hiatus in the human occupation of the cave, one that is clearly reflected in the radiometric age estimates. The occupations of subunits B1–B2 are estimated to have taken place within a relatively short time span ca. 55 kyr ago, whereas subunit B4 dates back to ca. 70 kyr ago (Valladas *et al.*, 1999; Rink *et al.*, 2001). This chronological framework places the occupation of subunit B4 in a colder and drier climatic phase (marine isotopic stage 4), whereas the settlements of subunits B1–B2 probably took place at the beginning of marine isotopic stage 3. In the Mediterranean zone, climatic conditions at that time were similar to those of the present day, namely Mediterranean semi-arid type climate with C3 type vegetation, although rainfall distribution and its effectiveness might have been slightly different in the Rift Valley (Bar-Matthews *et al.*, 2000; Bar-Matthews & Ayalon, 2001; Vaks *et al.*, 2003).

The faunal assemblages

Animal remains were retrieved from all of the archaeological units at Amud Cave and from all areas of excavation (with the exception of subunit



Figure 1. Schematic map of Amud Cave. Various shades indicate different years of excavation.

B3, which is not an occupation horizon). All sediments were excavated by 1×1 m grids and in 5 cm-thick spits following the inclination of the sediments. All the sediments were dry- and wet-sieved (through a 2 mm mesh) in the field, and then dry-sieved through a fine (0.1 mm) mesh during sorting in the laboratory.

The studied assemblages include bones that were collected in the field as well as those found in the sorting process. The sample discussed here includes material from the three major stratigraphic divisions of unit B (B1, B2 and B4) from the various excavated areas (Figure 1). We have opted *not* to lump material from the various stratigraphic units (in spite of small sample sizes), because the chronological placement of subunit B4 as opposed to B2–B1 clearly separates them as different occupations. At the same time, we emphasise that the preliminary results presented here do not touch upon the question of spatial differences within any stratigraphic unit, a topic that deserves separate treatment.

The animal remains derive from a number of depositional microenvironments. In layers B1 and B2, near the north wall of the cave (area A; see Figure 1), the bones were found either in breccia-like sediments, in cemented calcareous ash units ('concretions'), or in the loose ashy sediments. In area C, bones of subunit B4 originated mostly from powdery grey sediment, which is the ash of the preserved hearths. As a rule, bones from all stratigraphic units were found incomplete due to breakage in antiquity, with most elements less than half preserved. When observed macroscopically, many of the bones appeared to be coated with calcareous encrustations. Microscopic examination of the 'concretions' and breccia-like sediment lumps has shown that the bones embedded in them occurred in various states of preservation. In any single lump there are splintered, weathered and exfoliated bones, as well as burned ones. Still, the bones of young mammalian individuals as well as of small-bodied non-mammalian species (e.g., birds, reptiles, fish), both of which are prone to relatively fast diagenesis, were found preserved in these sediments (Figure 2). Such observations point to the complex nature of the formation processes and of the depositional microenvironments of the ash sediments.

As a result of these different depositional microenvironments, preparation of the bones for archaeozoological analysis required varied procedures. The majority of bones necessitated intensive cleaning to remove the calcareous encrustations, which was carried out with dilute (5%) acetic acid. This procedure was not always successful, so that bones (especially those from the breccia-like sediments or the 'concretions') remained lumped together. Unfortunately, some bones (ca. 5%) broke, and exfoliation of the outer surfaces of the bones was sometimes enhanced by this cleaning procedure. However, once cleaned, mammalian bones revealed a variety of taphonomic features, including clear and unambiguous cut marks, which had been totally unrecognisable before treatment.

Bone identification was conducted in the Department of Evolution, Systematics and Ecology at The Hebrew University of Jerusalem, using their comparative osteological collections. Long bone shafts and other fragmented bones were identified only to body size category. The body size categories are based on an animal's weight, following common archaeozoological procedures (Lyman, 1994) and adjusted to Levantine species (see Table 1). Unless otherwise specified, analyses were conducted only on the B1 and B2 samples, due to sample size constraints (Table 1).

Species distributions

The medium-large mammalian fauna is dominated by gazelle (*Gazella gazella*), followed by fallow deer (*Dama mesopotamica*), wild goat (*Capra aegagrus*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), aurochs (*Bos primigenius*), wild boar (*Sus scrofa*) and rhinoceros (*Dicerorhinus bemitoechus*). Small carnivores (e.g., red fox, *Vulpes vulpes*) occur in low frequencies, whereas the remains of large carnivores are rare (e.g., bear, *Ursus* sp.). In addition, micromammals, birds and fish were retrieved (Table 1, Figure 3).

The two samples shown in Figure 3 exhibit minor differences in species distribution. The fauna from subunit B1 includes more fallow deer and gazelle than B2, but fewer foxes. In subunit B2 there are more bones of large animals (body size group A, consisting of animals weighing over

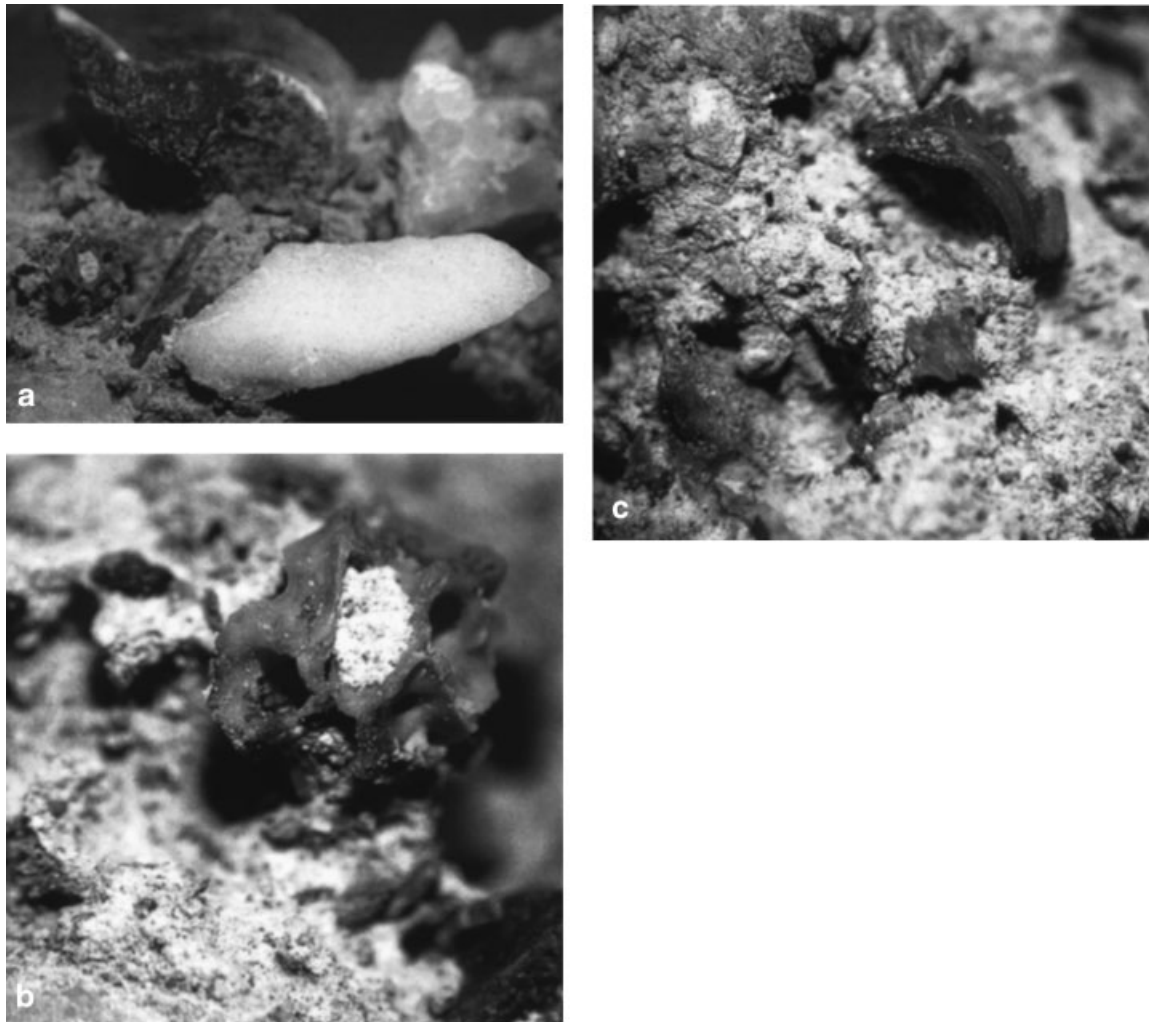


Figure 2. Burned bones in 'concretion'.

1000 kg), as well as body size C (wild goat size). This sample also includes more unidentified mammalian bone fragments.

To test whether the species distribution is the same in subunits B1 and B2, we used a χ^2 test for independence. First, we have examined the mammalian remains that were defined to species (Table 1). Since the χ^2 test involves some rather small expected frequencies, the χ^2 distribution cannot be used reliably. To correct for this, the P value (i.e., the probability of rejecting the null hypothesis that the distribution is the same in both samples) was estimated by computer simulations. A thousand simulated samples were drawn under the assumption of a similar distribution.

The proportion of samples that had a χ^2 statistic larger than the observed one was taken as an estimate of the real P value (Motro *et al.*, 2001). The estimated P (0.187) and the observed χ^2 value of 11.64 ($df=9$) suggest that species distributions in the two samples do not differ from one another. Statistically significant differences were found between the two subunits in the distributions of elements identified to the level of body size groups only ($\chi^2=36.95$, $P<0.001$, $df=3$; see discussion below).

Only six bird bones, all derived from a random sample from subunit B1, have been identified to date and represent six different species. The hooded crow (*Corvus corone*) and jackdaw (*Corvus*

Table 1. Species distribution (NISP) for Amud Cave, with body sizes

	B1	B2
<i>Bos primigenius</i>	1	
<i>Rhinoceros</i> sp.		1
<i>Cervus elaphus</i>	3	2
<i>Dama mesopotamica</i>	37	23
<i>Capreolus capreolus</i>		1
<i>Capra aegagrus</i>	10	8
<i>Gazella gazella</i>	166	125
<i>Sus scrofa</i>	9	8
<i>Ursus</i> sp.		1
<i>Vulpes vulpes</i>	16	27
Body size A	6	13
Body size B	112	74
Body size C		23
Body size D	775	559
Und. mammal	27	97
Total	1162	962

Key to body sizes (after Rabinovich, 1998a,b):

A (> 1000 kg), aurochs, rhinoceros;

B (250–80 kg), red deer, fallow deer, wild goat;

C (80–40 kg), wild goat;

D (40–15 kg), gazelle, roe deer.

monedula) are generalists, while the rock partridge (*Alectoris chukar*) is an open field dweller. The mallard (*Anas platyrhynchos*), the lapwing (*Vanellus vanellus*) and the woodcock (*Scolopax rusticola*) are found in open fields near water bodies and banks (T. Simmons, pers. comm., 2003). While the jackdaw nests in caves and crevices, the hooded crow and rock partridge are occasional visitors. However, mallard, lapwing and woodcock are not likely to be found in cave settings. Although the current small sample cannot be treated as representative of the avifaunal assemblage of Amud Cave, it does suggest the possibility of human agency in the accumulation of avifaunal remains on site. In addition, we note that none of these species preys on fish. If this pattern holds when the sample is enlarged, birds would be an unlikely source for the fish bones found at the site.

The micromammalian assemblage analysed to date is dominated by *Microtus guentheri*. It also

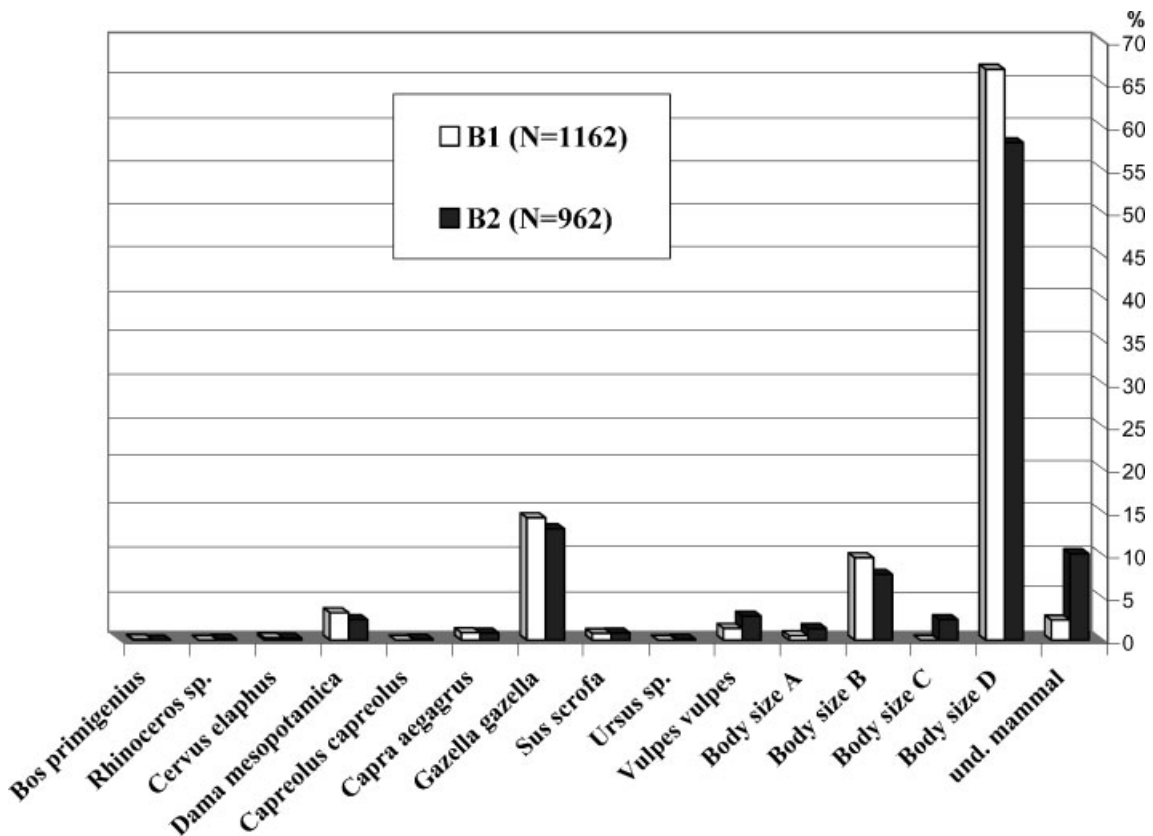


Figure 3. Species distributions in the Amud Cave faunal samples.

includes *Apodemus* spp., *Meriones tristrami*, *Spalax ebrenerbergi*, *Mus macedonicus*, *Cricetulus migratorius* and *Myomys roachi* (E. Tchernov, pers. comm., 2002). *Apodemus* spp. is an arboreal species, while the rest of the species are savannah and steppe rodents. With the exception of *Mus* and *Apodemus*, commensal micromammals are rare in Amud Cave. This species distribution is similar to that observed in the broadly contemporaneous Mousterian units of Kebara Cave (Tchernov, 1998). The few reptilian remains comprise some unidentified limb bones and tortoise carapace fragments.

Age distributions

Ageing of the mammalian assemblages was conducted for the three main stratigraphic subunits (B1, B2 and B4). Unfortunately, only the gazelle sample is sufficiently large for discussion of age structure in any detail. Given the highly fragmented nature of the assemblages, fusion state of the epiphyses could not be used as a reliable age estimator, even though unfused ends of long bones were observed. Instead, efforts to age the animals focused on dentition. The ageing scheme is based on eruption and wear states observed on both upper and lower premolars and molars on a large sample of aged recent gazelles from Israel (see details in Rabinovich, 1998a). The 13 stages used in this analysis (*ibid*, Figure 6) correlate with age groupings used by other scholars (e.g., Stiner, 1994) in the following manner:

- **Young** (Stages 1–6), from birth to the replacement of deciduous teeth.
- **Adult** (Stages 7–10), from the occurrence of permanent dentition to ca. the age of 4–4.5 years old.
- **Senile** (Stages 11–13), all dentine exposed.

In the case of Amud, only lower jaws were sufficiently available. The sided aged mandibles comprise a small sample, where young and adult animals dominate the sample and senile specimens are rare (Table 2).

The small numbers of aged teeth from other species do not warrant a detailed discussion. We do note that the aged teeth of fallow deer (B1, N = 5; B2, N = 1) and wild goat (B1, N = 5; B2, N = 3; B4, N = 3) (aged according to Payne,

Table 2. Frequencies of aged gazelle teeth based on use wear stages (see text for description of the method)

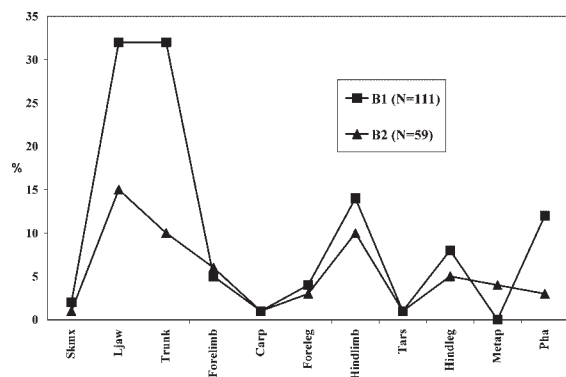
Subunit	Young W1–W6	Adult W7–W10	Senile W11–W13
R-mandible			
B1	1	3	
B2	3	3	
B4	3	3	1
L-mandible			
B1	2	5	
B2	1	5	
B4	2	3	2

1987; Brown & Chapman, 1990, 1991a,b,c) derive from adults. The aged teeth of wild boar (after Grant, 1982) are mainly from young animals (B2, N = 2; B4, N = 2).

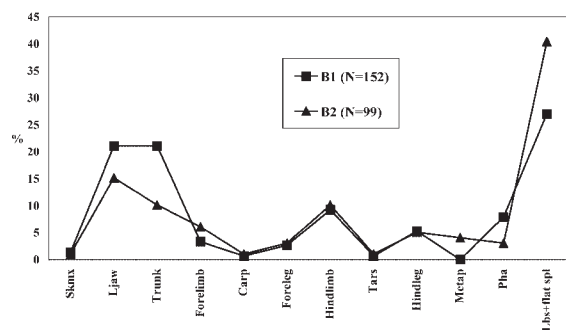
Body part distribution

Body part analysis was conducted on the assemblages of subunits B1 and B2. The largest body size category (A) encompasses elements of rhinoceros (represented by a molar) and aurochs. Mainly long bone shafts, followed by a few fragmented limb bones, represent this body size category. While much smaller, wild goat and boar, are also represented mainly by tooth fragments and by some limb bones. Red deer is represented by tooth and antler fragments, with the exception of an almost complete maxilla that was found in association with the Amud 7 burial (Rak *et al.*, 1994; Hovers *et al.*, 2000).

Fallow deer and its corresponding body size category B is represented mainly by post-cranial elements and by mandibles, while skull and upper teeth are rare. The relative frequencies of lower jaw and trunk elements are lower in subunit B2 (Figure 4a–b). Differences between the two stratigraphic subunits are not significant ($\chi^2 = 14.4$, $P = 0.150$, using the χ^2 test described above; long bone shafts excluded). Long bone shafts comprise between 27–40% of the NISP in this size category in each sample (Figure 4b). When they are incorporated into the samples, the differences between the two units are statistically significant ($\chi^2 = 18.65$, $P = 0.053$). Fisher's exact test indicates that the frequencies of long bones



a

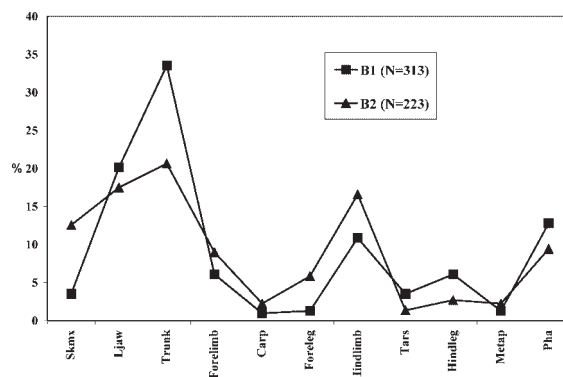


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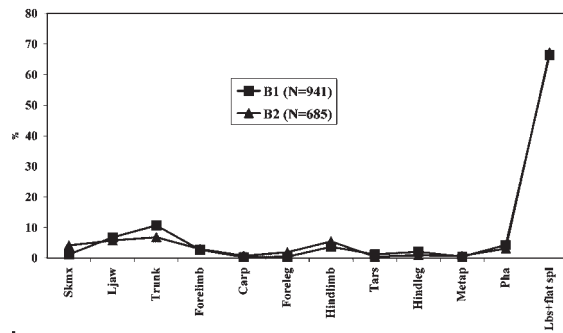
Figure 4. The distributions of anatomical elements (NISP) of fallow deer at Amud Cave: (a) excluding long bone shafts; (b) including long bone shafts. **Skmx** skull fragments, maxilla, maxillary teeth; **Ljaw**: mandible, lower jaw teeth; **Trunk**: trunk elements, vertebra, pelvis, ribs; **Forelimb**: scapula, humerus, radius, ulna; **Carp**: carpals; **Foreleg**: metacarpals; **Hindlimb**: femur, tibia, fibula; **Tars**: tarsals; **Hindleg**: astragalus, calcaneum, metatarsal; **Metap**: metapodials; **Pha**: phalanges; **Lbs+flat spl**: long bone shafts and flat splinters.

(fore- and hindlegs and limbs, metapodials and long bone shafts) versus all other identified bones is significantly different between the two samples ($P = 1.12 \times 10^{-3}$), with a higher proportion in subunit B2.

All body parts of gazelle and its corresponding body size category D are encountered in the Amud Cave samples (Figure 5a). When long bone shafts and flat splinters are included, they comprise more than 60% of the NISP in each sample (Figure 5b). The two samples differ in the representation of skull parts, which are relatively more abundant in subunit B2, whereas trunk parts are more numerous in subunit B1 (Figure 5a). In this case, the differences between the samples are statistically significant when long bone shafts are excluded ($\chi^2 = 45.05$, $P < 0.001$) and when they



a



b

are included ($\chi^2 = 44.99$, $P < 0.001$). Most of the small carnivore remains, probably foxes, consist of tooth fragments and trunk elements. Large carnivores are represented by a single lower P3 of a bear (Table 1).

MNI counts were calculated by taking into consideration the most prolific sided part per species (White, 1953). Very few bones could be sided. As can be observed in Table 3, the values of MNI dentition or post-cranial elements based on the most prolific species (gazelle and fallow deer) are low. Although not surprising, a much higher estimation of minimum number of individuals (MNI) counts of gazelle and fallow deer occurred based on dentition (Table 3). Most of the assemblage (98%) comprises bones that are less than half preserved. Thus MNI counts provide an additional illustration of the high degree of fragmentation at the site.

In addition we used %MAU (minimum number of animal units necessary to account for the

Table 3. NISP and MNI counts of gazelle and fallow deer, taking into consideration the most prolific sided part per species (after White, 1953)

Subunit	Teeth		Post Cranials	
	NISP	MNI	NISP	MNI
<i>Gazella</i>				
B1	63	6	878	3
B2	32	6	653	3
<i>Dama</i>				
B1	16	3	95	2
B2	5	1	54	2

specimens observed; Lyman, 1994) to examine the nature of the body part distribution. First we examined the body part distribution of the most prolific species by correlation with the average bone mineral densities. Since gazelle bone density values are not available in the literature, we used the published values for deer (Lyman, 1994, Table 7.6) despite the problem of assessing values from other species. There are no correlations between %MAU and average bone density of gazelle in both studied subunits (B1, $r = -0.042$, $P = 0.792$; B2, $r = 0.161$, $P = 0.403$).

Utility indices provide the theoretical basis for models evaluating past transport behaviour. For example, the scatterplot of the %MAU against the %MGUI (modified general utility indices) is a way to examine the strategies of utilising and/or transporting animal carcass parts (after Binford, 1978, in Lyman, 1994). MGUI values are not yet available for gazelle. Gazelle bone parts were therefore correlated against sheep and caribou MGUI values (Binford, 1978, in Lyman, 1994, Table 7.1): %MAU in both examined subunits show no significant correlation (Figure 6) to their respective %MGUI. Based on these we cannot explain the body part distribution at Amud Cave as resulting from any specific transportation or utility mode. Taking into account the fragmentary nature of the bones and the low estimates based on such data, this picture is not surprising.

The reasons for the breakage intensity at Amud Cave are not yet fully understood. One possible explanation is that the bones had been broken for extraction of marrow before being tossed and possibly trampled (see discussion below).

Bone modifications

All identifiable bones and all bone fragments (see below) were examined under a light microscope (10–40x), and modifications such as striations, cut marks, scratches, tooth marks, gnawing, burned elements and pathology were coded. Scratches, tooth marks and large carnivore gnawing are absent from the sample. Cut marks occur in low frequencies (Figure 7; B1:N=12; B2:N=31), mostly on the shafts of long bones. Their locations indicate disarticulation (for example, on the malar bone as shown in Figure 8a) and filleting (over the shaft on long bones, Figure 8b). Clear impact signs of hammer stone percussion are rare (N=5), and only a few flakes of long bones (N=11) resulting from splitting of the shafts during marrow extraction were identified. Still, the high frequencies of long bone shafts in the assemblages suggest that marrow extraction was an important activity that was carried out on site in addition to meat consumption (e.g., Binford, 1981; Enloe, 1993). A significant difference occurred between cut mark frequencies in the studied subunits (Fisher Exact test two-tailed, $P = 0.00055$).

About 6% of the identified bones exhibit exfoliated surfaces, which in most cases have not totally destroyed the outer surface of the bone. While the occurrence of exfoliation might have caused some obliteration of the marks, we believe that it has not significantly influenced the final picture of damage patterns. Importantly, it cannot account fully for the absence of carnivore damage, given that cut marks do occur on exfoliated bone surfaces (Figure 9).

A large proportion of the identified specimens in each stratigraphic unit (55% and 22% for subunits B1 and B2, respectively; Figure 7) show signs of burning, based on their general appearance and coloration. Most of the bones identified as being burned are reddish-black, attesting to indirect exposure to fire. Grey-white, calcinated bones, indicating direct exposure to live coals (Nicholson, 1993; Stiner *et al.*, 1995), occur rarely. In subunit B1 the high proportion of burned bones is consistent with the origin of most bones from ashy 'concretions' and breccia-like features.

The distribution of burned bones across anatomical parts is not uniform in the two

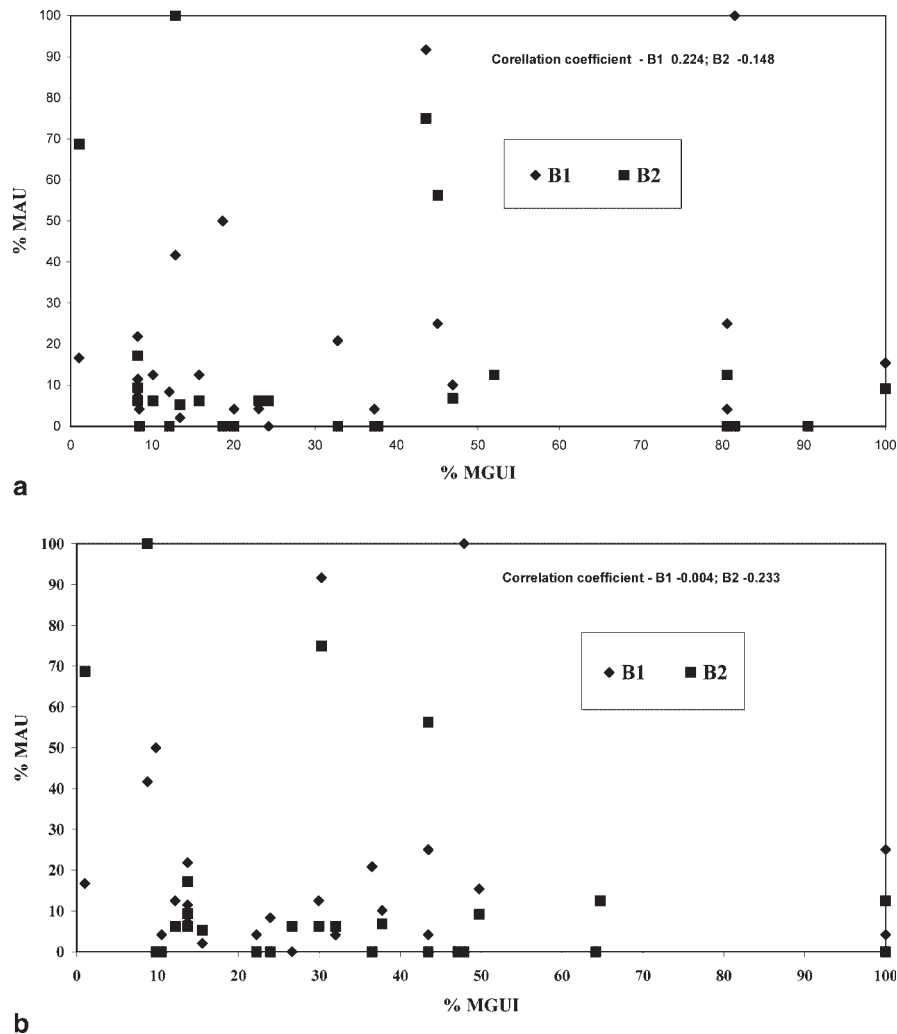


Figure 6. Scatterplots of %MGUI against %MAU: (a) Sheep %MGUI against %MAU gazelle; (b) caribou %MGUI against %MAU gazelle.

stratigraphic units. In B1 78% ($N=506$) and in B2 77% ($N=164$) of the burned bones are long bone shaft of gazelle and gazelle size group. This distribution echoes the dominance of long bone shafts in the assemblages (Figure 6), as would be expected if bones were burned accidentally after being exploited and tossed aside (see Speth & Tchernov, 2001: 62).

Unidentifiable bones

Although not normally a major focus of research, analysis of bone splinters is necessary for an

understanding of taphonomic and butchery patterns (Rabinovich, 1990). At Amud Cave, unidentifiable (either to species or body size group) bones comprise a large portion of the studied assemblages. For the purpose of this study, we have examined in detail a sample of such fragments from each stratigraphic unit, documenting their length and width, as well as surface modifications and breakage patterns.

The ranges and averages of the length and width of bone fragments are shown in Figure 10. Average length ranges between 35 mm to 20 mm in the three stratigraphic units, with the highest value in subunit B4. Subunit B1 exhibits the

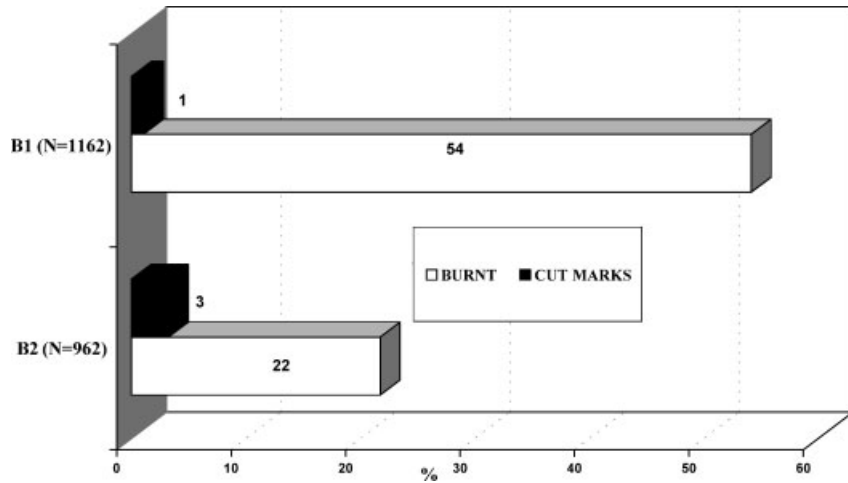


Figure 7. Frequencies of cut marks and of burning of bones in subunits B1 and B2, Amud Cave.

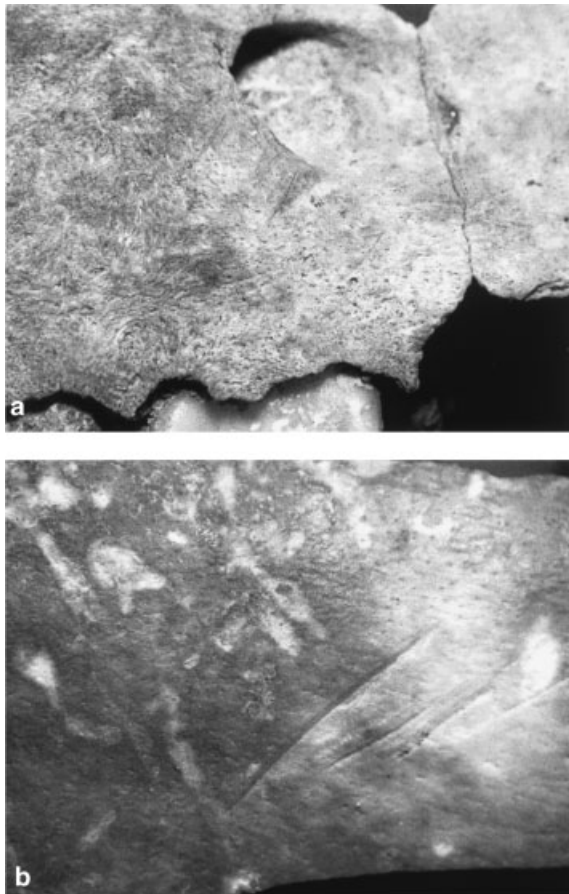


Figure 8. Cut marks: (a) on a malar bone of gazelle; (b) on a long bone shaft.



Figure 9. An example of an exfoliated bone surface bearing cut marks on a long bone shaft of gazelle body size group.

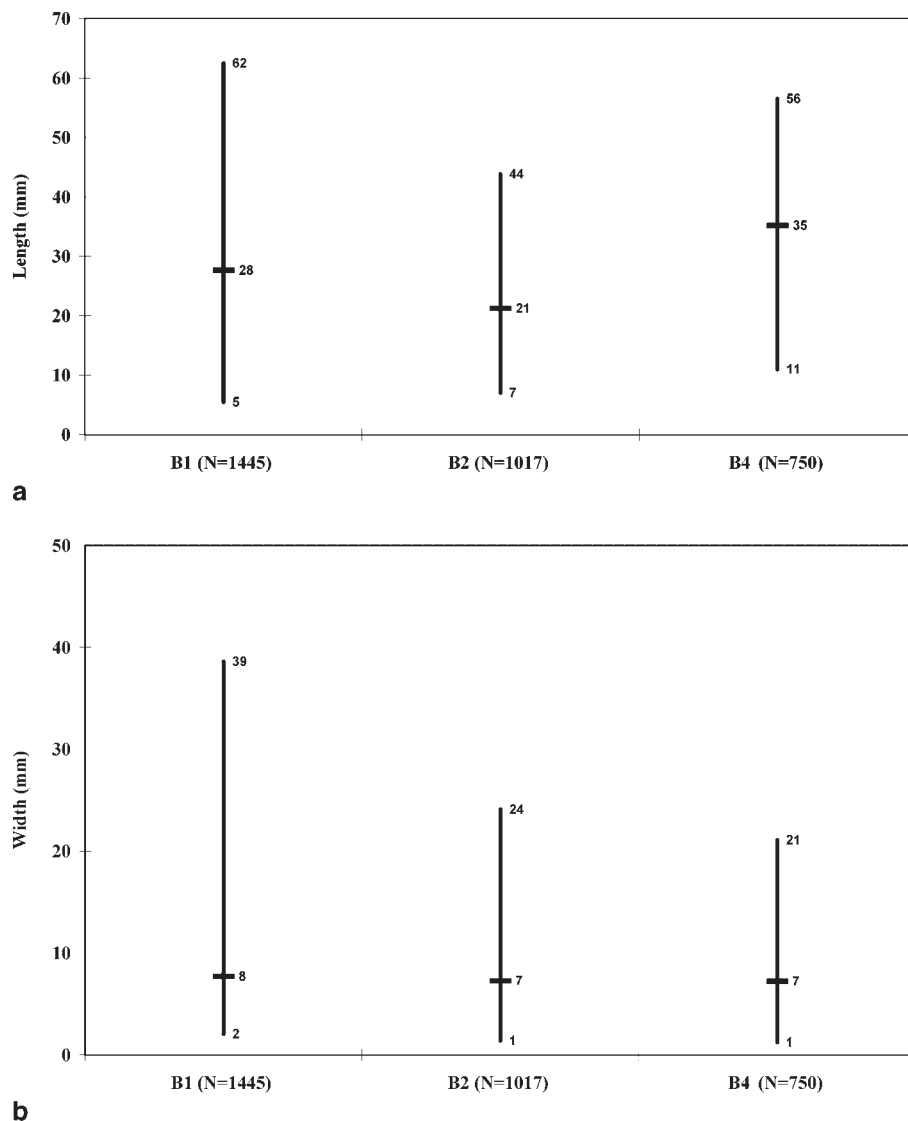


Figure 10. Descriptive statistics of dimensions of unidentifiable bone fragments from Amud Cave: (a) length; (b) width.

broadest range of both length and width values (Figure 10). The average width of ca. 7 mm is similar in all the stratigraphic units. The data shown in Figure 10a and 10b indicate that the majority of splinters fall within the lower part of the respective distributions.

Two types of bone surface damage—exfoliation and burning—were encountered on the unidentifiable splinters (Figure 11). The highest frequency of exfoliation was encountered in subunit B4 (15%), while subunits B2 and B1 exhibit much lower values (9% and 6%, respectively). Burned

elements comprise 19% of the subunit B1 sample, followed by 11% (subunit B2) and 6% (subunit B4; Figure 11). The frequencies of burned and of exfoliated specimens exhibit reversed trajectories with respect to one another along the stratigraphic sequence. One may argue that exfoliation biased the frequencies of burned specimens, in that it removed signs of burning. However, this would have obliterated only superficial signs of burning caused by either exposure to low temperatures or/and to indirect heating (Bennett, 1999, and references therein), which is not the

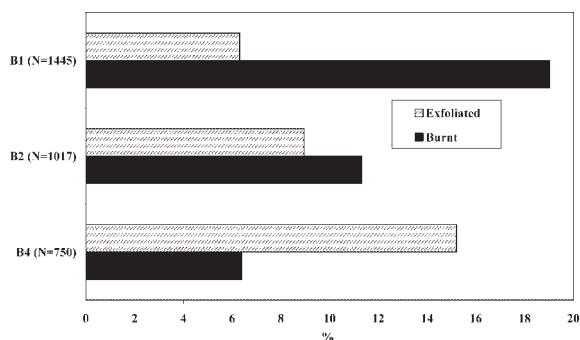


Figure 11. Frequencies of bone modifications on unidentifiable bone fragments. Note the reversed tendencies of both modification types (see discussion in text).

case here. Moreover, as discussed above, exfoliation does not affect the total bone surface and hence does not mask significantly its characteristics (see above).

Similarly to the identified bones, all the unidentifiable splinters from subunit B1 derive from 'concretions' and from breccia-like ashy sediments. Despite their shared depositional origins, frequencies of burned unidentifiable splinters in subunit B1 are lower than those observed among the identified specimens (Figure 7). The same is true of subunit B2.

Discussion

The study of the mammalian faunas from Amud Cave is in its preliminary stages. The analysis presented here is by no means conclusive, and patterns discussed here may change as the analysis progresses. None the less, we find it useful to elucidate the trends emerging from these preliminary results and to contemplate their implications for further research.

While species compositions do not show any statistically significant differences between subunits B1 and B2, this is not the case with other characteristics, specifically those pertaining to distributions of body size groups and modification marks. The body part distributions of gazelle and its corresponding body size group differ between subunits B1 and B2, with more trunk elements in the former and more skull elements in the latter. This difference persists when long bone shafts are included in the comparison. In

the absence of clear indications for density-mediated attrition, this suggests possible slight differences between the two subunits in transportation modes of gazelle carcasses. A somewhat different pattern is observed for body part distributions of fallow deer and its corresponding size group, which do not show a statistically significant difference between the two subunits. However, significant differences found between the distributions of fallow deer long bones suggest possible differences in modes of exploitation of this animal, given the lack of evidence for differential preservation conditions.

In both samples, cut marks appear mostly on long bone shafts, although their distributions in the two units differ significantly. While burned bones occur more frequently in subunit B1, their distributions across anatomical parts are highly similar in the two samples, in that they occur mostly on long bone shafts. That both types of modification are found mainly on long bone shafts is not necessarily meaningful, as this may be a reflection of the prevalence of the latter in the assemblages.

Some aspects of its faunal assemblage place Amud Cave squarely in the familiar southern Levantine Late Mousterian world. Most notably, the species composition of the medium-to-large mammals is similar to that known from contemporaneous Levantine cave sites in the Mediterranean zone. This is shown by the emphasis on gazelle as the main prey species, followed closely by fallow deer. As is the case in the majority of cave sites, large-bodied species (e.g., aurochs) are relatively rare and are represented by few anatomical elements. The age distributions, dominated by adult individuals, are also similar to those of other Late Mousterian sites. The age distribution of boar in the Amud assemblages also echoes a familiar pattern known from most Late Mousterian and Upper Palaeolithic sites in the southern Levant, in that it includes a relatively high frequency of younger individuals (Rabinovich, 2003).

A large number of archaeozoological analyses have demonstrated that Middle Paleolithic hominids in Eurasia relied heavily on hunting rather than scavenging as their mode of meat acquisition (Patou-Mathis, 2000; Speth & Tchernov, 2001). The patterns of age and body part

distribution of gazelles seen at Amud are similarly compatible with a hunting scenario.

Agents of accumulation and selective preservation

The patterns of choice, acquisition and consumption of animal food by humans are usually assumed to result from rational decision-making, aiming to obtain food in the most profitable manner, given resource availability. Element abundance data with their relevant utility indices are commonly used to investigate prey selection, butchery practices, bone transport decisions, nutritional needs, activity specialisation, and so on (Lyman, 1994). However, it is necessary first to address potential biases in agents of accumulation and/or of selective preservation.

Bones were encountered in all the excavated areas and stratigraphic units of the Mousterian sediments of Amud Cave. We have not observed areas devoid of bones, which might suggest the existence of dissolution fronts (e.g., Weiner & Bar-Yosef, 1990; Weiner *et al.*, 1993, 1995; Karkanas *et al.*, 2000; Stiner *et al.*, 2001). Bone has been encountered in thin sections of the ash-related sediments, indicating its presence also on a microscopic level. Additionally, in mineralogical analyses of several sediment samples, calcite has been shown to be present. The presence of calcite (and/or dahlite, its immediate diagenetic derivative) indicates that chemical conditions are conducive to good bone preservation (Weiner *et al.*, 1993). The combined evidence thus suggests that bone preservation at Amud Cave may not have been severely affected by chemical diagenesis.

Another common agent of selective bone preservation is carnivore activity (see Lyman, 1994, for review). The imprint of large carnivores is seen in the majority of southern Levantine Middle Palaeolithic cave sites in the presence of the bones of the carnivores themselves, and/or in the way they damaged the bones of other animals in the site. Intercalation of human and carnivore presence in caves is recognised until as late as the beginning of the Epi-Palaeolithic, when this pattern tends to disappear (Rabinovich, 2002). For example, carnivores, especially hyenas, were

present at Kebara Cave in all the Mousterian occupation units. The magnitude of carnivore impact is higher in the more ephemeral occupations, but even in this case, there is no doubt that humans were the major agent of fauna accumulation at the site (Speth & Tchernov, 2001). Against this background, the rarity of carnivores at Amud Cave, coupled with the paucity of indications for carnivore damage on either human skeletal remains (Hovers *et al.*, 2000) or on animal remains, stands out. A similar situation was reported for the Mousterian layers of Dederiyeh Cave in Syria (Griggo, 2002).

One possible explanation for this situation at Amud Cave is that specific palaeo-topographic conditions restricted carnivore access to this particular cave. Specifically, the cliff morphology at the time of occupation created a steep slope, which could have rendered carnivore ascent to the cave difficult (Inbar & Hovers, 1999). It is also possible that high intensity of human activity (Hovers, 2001) inhibited carnivore presence at the site. It thus seems likely that carnivores played a negligible role in the accumulation of faunal remains in the various occupation units at Amud Cave. The high degree of splintering (98% of the identified specimens are less than half preserved) and the high frequencies of burned bones should be interpreted as purposeful and/or accidental outcomes of human activities, coupled with post-depositional effects.

Selective human activities and differential non-human mechanisms

Where body part element frequencies are concerned, the Amud Cave assemblages present a methodological challenge. The identified skeletal elements are predominantly shaft parts. It is thus difficult to apply to this material some of the methods currently used to assess the effects of density-mediated attrition and other mechanisms of selective preservation (e.g., Lyman, 1994). The absence of any significant correlation between bone mineral density and %MAU suggests that attrition was not a major factor in shaping the bone assemblages. The splintered condition of the bones also renders impractical some methods for evaluating the role of human selection as

regards body part transport (e.g., refitting; Marean & Assefa, 1999). No significant relationships were found between element frequencies and modified utility indices.

That said, the faunal assemblages allow a tentative interpretation of the medium-to-large mammal body part distributions at the site. Gazelle is not only the most abundant prey species at Amud Cave; it is also the one represented by most body parts. This suggests that gazelles were most likely transported complete into the site. The more limited sample of fallow deer implies a similar pattern, although skull parts are uncommon. Not surprisingly, the rare occurrences and the less variable element representation (long bone shafts, a few fragmented limbs and a few teeth) of large animals (body size category > 1000 kg) imply drastically different transport behaviour on the part of humans, where only selected body parts were brought to the cave. Cordain *et al.* (2000: 689) pointed out that animal body fat increases with body mass. They suggested that even in lower latitudes, when technologically possible, hunter-gatherers prefer to hunt large prey species in order to obtain fat, thus circumventing the problem of excess dietary protein (Speth & Spielman, 1983; Speth, 1989; Cordain *et al.*, 2002). It is possible that in the Levant, too, large animals might have contributed to the diet more than is reflected by their proportional occurrence in the faunal assemblages. The paucity of bones of large-bodied animals in the assemblages suggests either selective transport of body parts or, alternatively, transport of meaty chunks after disarticulation and filleting, after marrow and fat from bones had been consumed at the butchery site.

Bones and hearths in Amud Cave

The high frequencies of burned bones in both subunits B1 and B2 raise questions as to the agents responsible for this situation. Among the possible reasons for the occurrence of burned bones are natural fires, accidental burning of food, the use of fire for refuse disposal, or the intentional use of bones as fuel. Natural fire is a less likely cause for the burned bones at Amud Cave, which was roofed during the Middle Paleolithic (Hovers,

1994; Hovers *et al.*, 1996; Inbar & Hovers, 1999) and probably would not have been vulnerable to grass fires. Other potential processes need to be considered. The use of bone as fuel has been recognised in several Middle and Upper Paleolithic Eurasian sites (e.g., Burke, 2000; Patou-Mathis, 2000; Griggo, 2002; Théry-Parisot, 2002, and references therein).

Based on experimental work, Théry-Parisot (2002) concluded that an appropriately proportioned mix of wood and bone extended the duration of combustion and improved heat transfer by convection and radiation. These in turn factored into many activities carried out in prehistoric sites (e.g., heating, drying and cooking). The regular use of bone as fuel could be carried out only as a specific, informed response to a need for a fire with particular properties, or else for low energy requirements only. Costamagno *et al.* (1999) focused on the properties of bones used as fuel, suggesting that complete long bones or the cancellous portion of bones make good fuel. Moreover, intentional fragmentation of cancellous portions of bones helps to release their grease and enhances their ignition and combustion properties, whereas bone shaft fragments burn badly because of their low grease content. Their observations complement Théry-Parisot's (2002) in indicating that it is impossible to ignite a fire using only bones as tinder. Bones can be added to the fire only after a critical temperature has been reached. From this point on, a fire may be sustained using bones only if the temperature is not allowed to drop below a critical threshold.

The high frequencies of burned bones in the Amud Cave assemblages are not sufficient in themselves to establish the circumstances of burning. Phytolith studies, micromorphological and mineralogical analyses indicate that woody and herbaceous plants were used as fuel in the hearths (Madella *et al.*, 2002). Indeed, the abundance of burning signs on long bone shafts may suggest that bone was not used regularly as a source of fuel. On the other hand, the relatively high frequencies of burned and fragmented trunk elements of gazelle (51% in subunit B1, 13% in subunit B2) may point to such intentional use of selected anatomical elements.

While we cannot completely rule out the possibility that some body parts were used

intentionally as combustibles, other unintentional mechanisms of bone burning should be considered. An intriguing aspect of the faunal assemblages is that specimens in various stages of burning and of splintering were observed in all the excavated areas of Amud Cave. Similarly, microscopic bone fragments, both burned and unburned, are encountered in thin sections from all the stratigraphic units and from all areas of the excavation. Concretions and brecciated ash sediments in the Amud deposits are 'sealed' archaeological contexts (see above). Therefore the presence of burned and unburned bone elements, splintered to various degrees, in any single feature reflects the complexity of the processes leading to the observed patterns. It seems that the observed patterns of bone burning and splintering are best understood as the end result of a combination of several depositional and post-depositional agents.

The degree to which bones change their colour and crystallinity as a result of heating varies according to the temperature and duration of fire (Nicholson, 1993), as well as with the amount of meat that they bear. It has been shown that bones can be affected also in the subsurface (i.e., post-depositionally and accidentally), in which case the depth of burial and the type of sediment also factor into their colour change. The experimental data presented by Stiner *et al.* (1995) and Bennett (1999, and references therein) show that calcined bones occur only in the coal bed or immediately underneath it, and will rarely survive macroscopically in the archaeological record. Among bones that had been subjected to less intensive heating, Stiner *et al.* (1995) identified a monotonic, non-linear decrease in fragment length across colour categories designating various degrees of heating.

The majority of burned bones in the Amud Cave assemblages exhibit colours typical of indirect exposure to fire, implying that they were deposited in the periphery of hearths or had been buried shallowly underneath active hearths. The few discerned incinerated bones were encountered in the same ashy 'concretions' and breccia-like features as the less burned bones, an observation that is repeated on the microscopic level. Significantly, unburned bones are also encountered in the very same ashy features.

Post-depositional processes are an obvious agent of sediment mixture that could explain the observed pattern. This explanation may be pertinent to some depositional contexts (e.g., uncemented ash sediments), but cannot be invoked in the case of the 'concretions' that represent *in situ*, non-disturbed ashy hearth materials (Madella *et al.*, 2002: 711), from which most of the current sample originated. Of significance here are field observations indicating that many of the 'concretions' were quite thick. Combined with the micromorphological observations, this suggests that 'concretions' represent hearths that were repeatedly lit in the same location (see Weiner *et al.*, 2002 for discussion of hearths at Hayonim Cave). The differences in bone colouration, as well as breakage frequencies and patterns, may therefore be related to a number of hearth-associated depositional events, not all of which were strictly contemporaneous.

Stiner *et al.* (1995) also concluded that burned bones tend to become more friable and are more prone to breakage due to trampling than are unburned bones. As noted above, the unidentifiable bones in the Amud assemblages are rather small. Despite the fact that among the identified bones there are some very small pieces (indeed within the size range of unidentifiable ones), specimens in this category are on average larger. On the basis of their colouration, however, identified bones exhibit higher frequencies of burning. Given the similar depositional context of identified and unidentifiable bones (i.e., ash-related features), this pattern raises the possibility that some of the bone fragmentation was not related directly to burning. One possible scenario explaining the diversity of bone preservation states in the concretions suggests that after their original deposition as food refuse (either by being tossed into the fire or by discard in a hearth's vicinity), bones may have laid on the surface for a short while. Such bones might be affected by such trampling as would be likely to occur in an intensely occupied site such as Amud Cave. By the time a fire was lit in the same or nearby spot, some of these bones would be buried in shallow sediments (up to 5 cm in depth from surface) or would happen to be in the peripheral areas of the fireplace, thus obtaining the typical colourations of indirect exposure to

heat. This would have led also to increased bone friability and often to additional fragmentation of heat-affected bones. At the same time, bones that happened to be exposed would have been incinerated in the new fire bed (and are probably not preserved in the archaeological record). In this scenario, concretions are taken to represent cycles of bone deposition and exposure in ash-associated sediments. This taphonomic model should be tested in the future through studies of breakage morphologies and anatomical distributions, combined with detailed spatial studies of the hearth exposures.

Conclusions

The spectra of species found in the various assemblages of Amud Cave include the regional composition of medium-sized mammals known from most Late Mousterian cave sites in the Mediterranean area, typically predominated by gazelle and fallow deer. The emphasis on adults of these two species has been shown to reflect selective methods of hunting, where hunters, targeting larger specimens, were more likely to focus on adults (Stiner & Tchernov, 1998; Speth & Tchernov, 2001; Stiner, 2002). In fact, the focus on adults of medium-to-large mammals is a common behaviour in the entire Eurasian Middle Palaeolithic (e.g., papers in Burke, 2000), although particular species distributions are to a large degree environment-related (Patou-Mathis, 2000). An additional common pattern is the occurrence of only a few individuals belonging to body size group A (e.g., aurochs and rhinoceros), represented by few, often fragmented, anatomical elements. It is possible that the role of large-bodied animals in Middle Paleolithic diet is underrepresented due to transport decisions. Specifically, filleted meat could have been transported to the occupation sites. Thus faunal assemblages in these sites may not reflect the true contribution of large mammals to hominid diet.

The most significant differences between Amud Cave and other Levantine Mousterian cave sites are in the taphonomic processes that influenced the faunal material. The site constitutes a rare case where the presence and activity of carnivores is negligible to the degree that it

allows the study of bone assemblages without the need to consider any significant influence of predators. In addition, there is no compelling indication for density-mediated bone attrition. Other aspects in which Amud Cave differs from other Late Mousterian cave sites are the high frequencies of fragmented bones and burned bones. In both these phenomena Amud bears some resemblance to one reported Neanderthal site—Dederiyeh Cave in Syria (Griggo, 2002). This analysis implies that overall variability in the faunal assemblages of Levantine Mousterian sites is not related solely to palaeoecological settings. Rather, much of it stems from site-specific patterns of animal exploitation and taphonomic histories. As is the case with lithic variability, the recognition and study of the postulated faunal variability is an essential tool for deciphering Middle Paleolithic human behaviour in Eurasia.

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