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Hearth-side socioeconomics, hunting and paleoecology during the late Lower Paleolithic at Qesem Cave, Israel

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ABSTRACT

The late Lower Paleolithic archaeofaunas of Qesem Cave in the southern Levant span 400–200 ka and associate with Acheulo-Yabrudian (mainly Amudian) industries. The large mammals are exclusively Eurasian in origin and formed under relatively cool, moist conditions. The zooarchaeological findings testify to large game hunting, hearth-centered carcass processing and meat sharing during the late Lower Paleolithic, not unlike the patterns known from Middle and Upper Paleolithic caves in the region. Well-defined hearth features are rarely preserved in Qesem Cave, but the heterogeneous distributions of burned bones indicate areas of frequent hearth rebuilding throughout the occupation sequence. The hominins delayed consumption of high quality body parts until they could be moved to the cave, where hearths were hubs of processing activities and social interaction. Paradoxically, the cut marks on the Qesem bones are both more abundant and more randomly oriented than those observed in Middle and Upper Paleolithic cases in the Levant. These results suggest that several individuals were directly involved in cutting meat from the bones and that the social mechanics of meat sharing during the late Lower Paleolithic at Qesem Cave differed from those typical of both the Middle and Upper Paleolithic in the region.

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Introduction

The final burst in hominin encephalization between ca. 500 and 250 ka (Rightmire, 2003) would seem to be fertile ground for exploring the evolution of social and economic behaviors. Yet hominin economic and social lives in this interval remain something of a mystery in the Levant and elsewhere. The technological record has received the most attention, thanks especially to its consistent preservation. Information on subsistence has been more elusive as a result of either poor preservation of features and faunal remains or heavily cemented sediments from which bones are difficult to extract (Garrod and Bate, 1937; Rust, 1950; Jelinek et al., 1973; Garrard, 1983; Weinstein-Evron et al., 2003). Recent discoveries of early Paleolithic horizons in open and shelter settings with well-preserved bones are beginning to change this picture and, along with revisiting of previously known sites, have stimulated a new generation of intensive study in the Near East (e.g., Marder et al., 1999; Goren-Inbar et al., 2000; Weinstein-Evron et al., 2003; Chazan and Kolska-Horwitz, 2007; Monchot and Kolska-

Horwitz, 2007; Rabinovich et al., 2008; see also Garrard, 1983 on the Adlun caves, and Le Tensorer and Hours, 1989; Le Tensorer et al., 2007 on the El-Kowm spring sites in Syria). What emerge from these data are similarities between the late Lower Paleolithic (LP) and early Middle Paleolithic (MP) in many of the basic aspects of hunting. Some subtle but fascinating differences may exist as well, particularly with respect to on-site activities and how sites were used within hunting territories.

This multi-scale zooarchaeological study investigates the character of the meat diet in ecological and economic contexts—from mammal community dynamics to hominin hunting to on-site carcass processing and food sharing—during the Acheulo-Yabrudian at Qesem Cave ca. 400–200 ka. Comparisons to other Lower Paleolithic faunas in the region, and to unequivocally hunted faunas of the early and late Middle Paleolithic at Hayonim and Kebara Caves, set the Qesem results in broader perspective. Following a brief review of regional trends in species composition, the faunal comparisons will focus on cave sites. Caves represent stopping points or endpoints in food transport trajectories. Thus we may expect to learn about the later stages of carcass processing, delayed consumption, and possibly food sharing from the archaeofaunas of caves. Some of the greatest differences between the late LP and

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early MP may relate to the simple mechanics of feeding and meat sharing.

This study also considers whether there is a basis for arguing for residential camps during the late LP in a broad sense, using evidence for hearth-centered patterns of carcass processing, delayed benefits and cooperation. One may take for granted in recent cultures the existence of residential camps or central places to which food from diverse individuals or foraging events may be brought, pooled and processed. All of this implies some degree of sharing at a central place, where all group members might have some access to the bounty of diverse foraging efforts. Even the MP record supplies many good examples of this basic phenomenon. Can we say the same or different for the late Lower Paleolithic?

Background

Levantine LP sites dating from roughly 1.4 Ma to 400 ka (Fig. 1a) are defined by the presence of Acheulean industries. Acheulean artifacts occur in the later cultural layers of the 'Ubeidiya formation (Goren, 1981; Bar-Yosef and Goren-Inbar, 1993) and subsequently at open sites such as Gesher Benot Ya'akov (Goren-Inbar and Saragusti, 1996; Goren-Inbar et al., 2000), Revadim (Marder et al., 1999), Holon (Chazan and Kolska-Horwitz, 2007), and Evron Quarry (Ronen, 1991). Acheulean industries have also been found in the lower layers of Tabun Cave (Jelinek et al., 1973; Ronen et al., 2000), in the Adlun Cave complex (Roe, 1983), Berkhat Ram (Goren-Inbar, 1985), Eyal 23 (Ronen and Winter, 1997), and possibly in Layer G of Hayonim Cave (Meignen, pers. comm.). The Acheulean sites of the LP provide important background to this research on the final phase of the LP known as the Acheulo-Yabrudian or "Mugharan" tradition (Rust, 1950; Jelinek, 1990). Acheulo-Yabrudian industries are stratigraphically younger than Acheulean deposits in Levantine caves (see Gopher et al., 2010) and have been recovered from Layer E of Tabun (Jelinek et al., 1973), Layer F of Hayonim (Meignen, 2000, 2007), the collapsed cave of Misliya (Zaidner et al., 2006), and in Qesem Cave (Barkai et al., 2003).

Lower Paleolithic faunas of the Near and Middle East are rich in large herbivores and surprisingly varied in content, ranging from camels (*Camelus* spp.) and equids (*Equus* spp.) in the arid inner basins of Syria (Reynaud Savioz and Morel, 2005) to predominantly fallow deer and aurochs and/or megafauna in the coastal Mediterranean Hills area of the Levant (Tchernov, 1992). Open air and cave faunas tend to differ in the importance of megafauna remains, which occur in large numbers in some open sites (Tchernov, 1992) and less commonly in cave deposits. Overall, ungulates ranging in size from wild cattle to deer formed the core of hominin meat diets in the Levantine LP sites that preserve faunal remains.

The late Lower Paleolithic site of Qesem Cave

Qesem Cave lies roughly 12 km east of the modern city of Tel Aviv (Fig. 1b) at the interface of the Samaria Hills and the Mediterranean coastal plain (Barkai et al., 2003; Frumkin et al., 2009). The cave was discovered by accident in 2000 during a highway enlargement project. The roof of the cave and portions of its deposits were damaged, enabling the discovery of a large and previously sealed chamber that contained Pleistocene sediments, lithic artifacts and well-preserved bones. Construction was brought to a temporary halt to permit a large salvage excavation in 2000 and 2001. The remaining parts of the site are now protected by a covered enclosure, and excavations continue within this area. The bulk of the faunal sample discussed here comes from excavations conducted between 2000 and 2005 and includes portions of the site that no longer exist. The excavation grid is aligned with the main axis of the collapsed cave chamber (Fig. 2), and the main entrance faced SW.

Speleothems dated by $^{230}\text{Th}/^{234}\text{U}$ indicate that hominin occupations of the cave began around 400 (420–320) ka and ended around 200 (220–194) ka (Barkai et al., 2003; Gopher et al., 2010). No younger or later Paleolithic cultural horizons have been found in the cave. The dates imply a long temporal span for the Acheulo-Yabrudian. The Qesem cultural deposits may be generally coeval

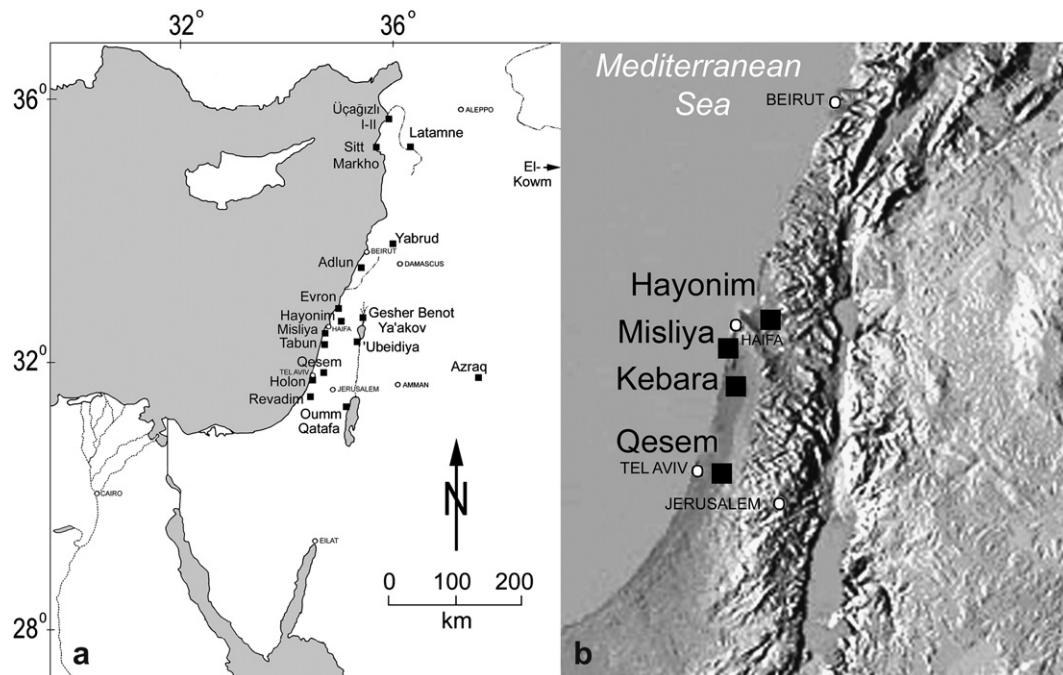


Figure 1. Map of Levantine Paleolithic sites discussed in text: (a) Lower Paleolithic cave and open sites, plus the Middle and Upper Paleolithic sites of Üçağızlı caves I and II at the northern edge of the Levant, which are the sources of comparison data on cut marks; (b) locations of Qesem Cave, Kebara Cave, Misliya Cave, and Hayonim Cave (Meged Rockshelter 1 km upslope from Hayonim) in the Mediterranean Hill zone.

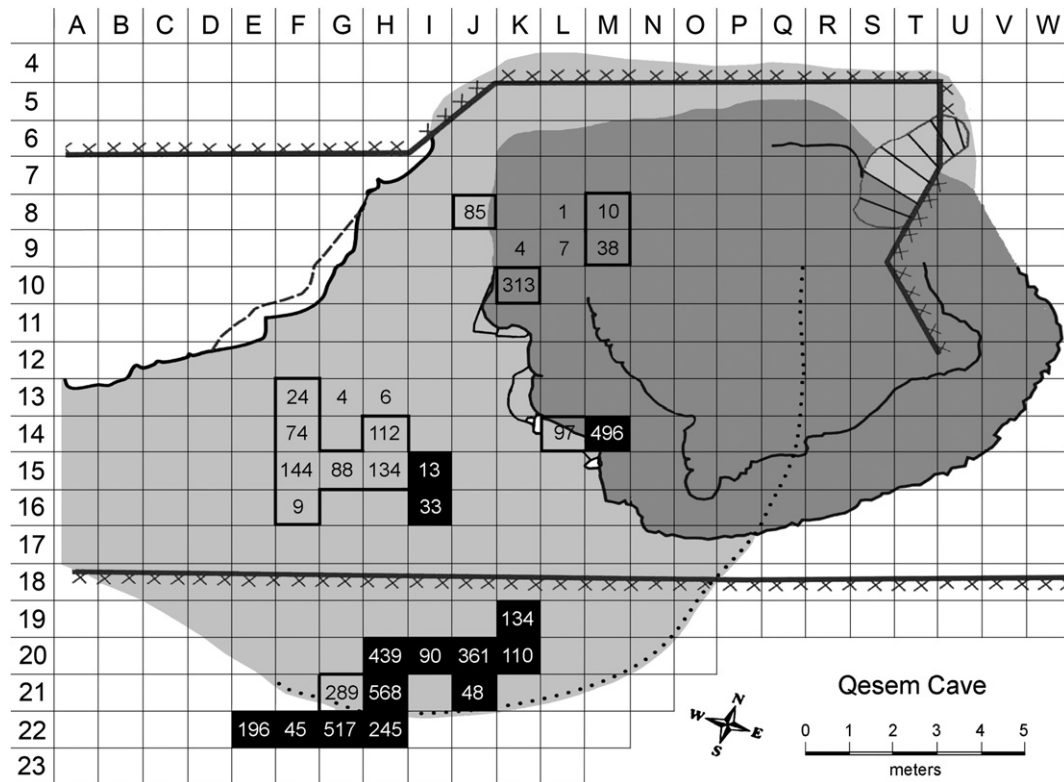


Figure 2. Plan of Qesem Cave, showing estimated outline of former chamber and area of the intact Upper Sequence deposits (dark gray) and Lower Sequence (light gray). Bold-outlined and blackened squares yielded the full set of zooarchaeological samples for this study, with values for identified specimens (NISP) indicated; blackened squares were also sampled systematically for frequencies of burning of unidentified bone splinters through the sediment column; (entrance) approximate location of the former cave entrance during the formation of the oldest layers.

with Layer E of Tabun and partly with layer F at Hayonim Cave, where bones are rare or absent due to unfavorable sediment chemistries (Margaris, 2000; Albert et al., 2000, 2003; Stiner, 2005). Faunal remains are abundant in Qesem Cave, by contrast, and well preserved in lightly to moderately concreted sediments.

The lithic artifact assemblages from Qesem Cave are attributed to the Acheulo-Yabrudian, but most of these are of the Amudian industry, which emphasized a blade blank production system (Barkai et al., 2005, 2009). At least one scraper-dominated Yabrudian assemblage was discovered in 2006 (Barkai et al., 2009), however, testifying to some technofacies variation among layers or horizontal units. Important to interpretations of carcass processing at Qesem is the fact that so many of the tools were made on blade blanks, including backed and retouched blades, end scrapers, burins, and naturally backed knives (Barkai et al., 2005, 2009; Gopher et al., 2005). Scrapers are present but comparatively rare, and handaxes and so-called chopping tools are very rare. A small number of limestone spheroids were found in the Lower Sequence.

Stratigraphic sections in the cave represent a total depth of about 7.5 m (Karkanas et al., 2007). An Upper Sequence and Lower Sequence were distinguished on the basis of sediment composition and structure. These sequences are subdivided further for the purpose of the zooarchaeological study as Units I–II in the Upper Sequence and Units III–V in the Lower Sequence (Table 1). According to Karkanas et al. (2007), the Lower Sequence averages about 3 m in depth and is dominated by clastic sediments deposited within a closed karstic environment. These deposits formed mainly as small-scale, concentrated mud slurries and slow debris flows. However, the incidence of fine abrasion to bones is localized in the site, and severe abrasion and in-situ contortions are very rare. The uppermost meter of the Lower Sequence consists of limestone boulders with some

interstitial clays, whereas essentially intact layers (here called Units IV–V) with mild internal reworking occur below. These oldest layers formed when the cave roof was at its maximum extent. There is little or no evidence of plant root activity and the sediments were well protected from the outside atmosphere. Wood ash remnants are present in well-defined pockets/lenses in Units III, IV and V, though usually in small amounts. Burned bone splinters (unidentified bone specimens, NUSP) are abundant and occur in dense concentrations throughout much of the Lower Sequence (Table 2). Burning damage on the bones was confirmed by a combination of microscopic (Shahack-Gross et al., 1997) and macroscopic criteria (Stiner et al., 1995). There is a notable concentration of well preserved wood ash in the uppermost part of III, where burned bones are also exceptionally abundant.

The Upper Sequence (Units II–I) is different in character and about 4.5 m deep. The stratigraphic transition from the Lower Sequence is marked by several exposed large limestone boulders (Karkanas et al., 2007). Part of the Upper Sequence lies horizontally, and consists of anthropogenic sediment with only moderate amounts of clastic geogenic inputs. Micromorphological and

Table 1

Vertical unit terms and depth ranges (cm below datum) for the Upper and Lower geological sequences of Qesem Cave.

Unit	Depth range (cm)	Sequence	Total NISP
I	150–299	Upper	58
II	300–539	"	1042
III	540–654	Lower	1326
IV	655–774	"	1768
V	775–850	"	540

Table 2
Distributions of burned unidentified bone splinters (% of NUSP) by depth for sampled excavation squares in Qesem Cave.

Depth	Unit	M14	Depth	Unit	I15	I16	K19	H20	I20	J20	K20	G21	H21	J21	E22	F22	G22	H22
345	II	7	540	III		87												
350	II	53	545	III														
355	II		550	III														
360	II	3	555	III														
365	II		560	III		15												
370	II	13	565	III														
375	II		570	III	52													
380	II	27	575	III	91	10												
385	II		580	III	75	4												
390	II	10	585	III	55	31												
395	II	12	590	III	76	62	9											
400	II	20	595	III	69	29			13	10								
405	II	27	600	III	73	12	7		14	9								
410	II	21	605	III	63	59			9	6								
415	II	32	610	III	72	19			19	12								
420	II		615	III	63	39			10	5								
425	II	18	620	III	48	65			8	10								
430	II	23	625	III	30	50			7	6								
435	II	28	630	III	65	50					9							
440	II	11	635	III	69	33			11									
445	II	29	640	III	65	57			13	9								
450	II	16	645	III	28				17	37								
455	II	8	650	III	32	31	6		16								51	
460	II	14	655	IV	58	88			14									
465	II	15	660	IV	29	29	13		27									
470	II	9	665	IV	41	40			31									
475	II		670	IV	59			37	18			35		25				
480	II		675	IV	88			38				55		22			22	20
485	II		680	IV	75			27	14	13		43		15				8
490	II		685	IV	42			23	17			37		19			17	9
495	II	5	690	IV	35			28				54		19				
500	II	8	695	IV	38			24	7			70	16				10	
505	II	11	700	IV					29			11	13				5	
510	II	14	705	IV	18				25			25	14				12	
515	II		710	IV	16				15			46	15				15	
520	II	4	715	IV	23			29	29			53					12	
525	II	5	720	IV	16				17			15	8				15	
530	II	4	725	IV	22				9			19	17				8	
535	II		730	IV	10				27			24					4	
			735	IV	15							24	20					16
			740	IV	24				34			20	20					28
			745	IV	13				13			18	11					
			750	IV	48				11			12	5					11
			755	IV	25							11						7
			760	IV	25							17						4
			765	IV	60							18						5
			770	IV								15						10
			775	V								18						15
			780	V									9					7
			785	V								8						
			790	V								7						10
			795	V														
			800	V								21			23			8
			805	V								7						11
			810	V								11				7		11
			815	V								8				7		6
			820	V								20				7		8
			825	V								9			7	15		5
			830	V								13			9	6		3
			835	V											4	1		10
			840	V								4						
			845	V								10						23

Notes: Depth value represents the top of each 5 cm cut. Unit II is in the Upper Sequence (square M14 only), Units III–V in the Lower Sequence.

isotopic evidence indicates widespread recrystallization of the wood ash that also contributed to post-depositional splitting of skeletal specimens (Karkanas et al., 2007: 202–203). Units II–I are very rich in wood ash, most of which was completely combusted and locally reworked. Burned bones and moderately heated soil lumps associate with the wood ash remains, but the concentrations of burned bone splinters in square M14 (the only deep sediment column in the

Upper Sequence that could be sampled systematically, Table 2) are actually somewhat less than in several Lower Sequence contexts. It is not yet clear if the difference in burned bone frequencies between the Upper and Lower Sequences is explained by the more limited excavation exposures in Units II–I (Fig. 2). The frequent presence of microscopic calcified rootlets in the Upper Sequence indicates that these sediments formed near the former cave entrance, which had

retreated by this time. The deposits of the Upper Sequence were intensively fractured post-depositionally in some areas, but the stratigraphic integrity is not significantly disturbed overall.

The most pervasive indications of fire use in Qesem Cave are burned bones, probably because they are somewhat less vulnerable to diagenesis than wood ash (see Karkanas et al., 2007). Burned materials interpreted as hearth traces have also been identified at older Lower Paleolithic sites (see Jelinek, 1981; Tsatskin, 2000; Rolland, 2004; Preece et al., 2006) such as Geshert Benot Ya'qov in the Levant (ca. 780 ka, Goren-Inbar et al., 2004; Alpers-Afil, 2008; Alpers-Afil and Goren-Inbar, 2010) and Beeches Pit in the British Isles (MIS 11; Gowlett, 2006). At Qesem Cave, the distribution of burned bone splinters through a deeply stratified deposit indicates that fire-building was a major activity throughout the occupation sequence. The burned identified bones and bone splinters also reveal a strong, consistent spatial connection between fire use and carcass processing in the cave (below).

Materials and methods

The zooarchaeological findings are based principally on a sample of 4734 identified skeletal specimens (NISP, Table 3a) taken from many excavation squares in the cave (Fig. 2); 2808 of these specimens could be identified to species (Table 3b). About 78% of these identified remains were examined in detail for tool marks, cone fractures, gnawing, weathering, and other surface damage characteristics. In addition, 38,976 non-diagnostic bone and tooth splinters (unidentified specimens or NUSP) were examined for burning damage, cut marks, cone fractures, and the density of specimen occurrence in the sediments. Although the splinter sample represents less than half of the entire collection and cannot address all areas of the site equally, several deep sediment columns were examined systematically to reveal general spatial variations in the distribution of burned bone in particular. The skeletal samples were recovered by 5 cm depth increments within layers and, horizontally according to 1 × 1 m squares in the salvage excavation and 50 × 50 cm sub-squares in all later excavation seasons. All sediments were screened through fine mesh (2.4 mm) to capture skeletal specimens of all sizes; areas yielding microfaunal remains were water-sieved through 1 mm mesh (see Maul et al., in press).

The zooarchaeological analyses address several themes about bone assemblage formation and hominin subsistence at Qesem Cave: (1) the relations between geological and anthropogenic site formation processes, (2) evidence of fire based on burned bones, (3) primary and secondary agents of bone collection and modification, (4) prey selection by the hominins based on species composition, mortality patterns, and seasonality, (5) *in situ* decomposition of skeletal materials, and (6) patterns of carcass transport and processing that relate to economic efficiency, delayed consumption, and food sharing. The methods of analysis follow published standards for mortality patterns, taphonomy, body part representation (Binford, 1978; Lyman, 1994; Stiner, 1994, 2005; Stiner et al., 1995, 2001b, and references therein), density-mediated bone attrition (Lyman, 1994; Lam et al., 1999; Stiner, 2004), and analytical units and coding procedures (Grayson, 1984; Lyman, 1994; Stiner, 2005: 235–240). The analysis of tool marks builds upon existing methods for recognition and recording but offers a novel approach for tracking variation in cut mark orientations that relates to posture variation during butchering.

The zooarchaeological results for the five consecutive assemblages from Qesem Cave are compared to Middle and Upper Paleolithic fauna records from Hayonim (Stiner, 2005), Mishiya (Yeshurun et al., 2007), and Kebara caves (Speth and Tchernov, 2001, 2007) in the southern Levant. The cave sites occur over a total distance of about 100 km north-south along a narrow strip defined by the coast and the western slope of the Mediterranean Hills (Fig. 1b). These faunal series in

combination with the Qesem series form a nearly complete sequence of hominin subsistence for the later part of the middle Pleistocene through the late Pleistocene in the study area (Fig. 3). Data from Uçagızlı Caves I and II in the northern Levant (Kuhn et al., 2009; Stiner, 2009) are brought to the comparisons of tool mark patterns, as these assemblages are most comparable with respect to dominant prey species, bone condition and surface visibility.

Prey species abundance in Qesem Cave is principally an indication of hominin prey choice, but these data also contribute to our understanding of the regional biochronology of large mammals during the middle Pleistocene. The latter is a dynamic story on account of the unique geographic position of the Levant between Africa and the rest of Eurasia (Tchernov, 1992). Hominin subsistence during the Acheulo-Yabrudian is examined according to several dimensions of predatory econiche (Stiner, 2002a), including the antiquity of habitual large game hunting, the range of species and prey body sizes commonly hunted, carcass handling practices, and how supplementary sources were used to fill gaps in the availability of preferred large prey.

The analysis of prey age selection uses mortality patterns determined from states of eruption and wear apparent on isolated teeth. Fragmentation is severe in some of the Qesem assemblages, and this condition may reduce the visibility of some types of teeth more than others. This problem is overcome for deer, pigs and bovinds by cross-checking counts, condition and formation states of contiguous dental elements. This approach was less successful for equid teeth, owing to their highly laminar or platy structure.

The possibility of *in situ* bone attrition—loss of material to mechanical decomposition—may compete with behavioral explanations for biases in prey body part representation. This issue is examined at Qesem Cave through comparisons of observed skeletal representation to control data on inherent variations in the density of skeletal structures and by comparing the representation of similarly dense portions across the skeleton. The standards are taken from Lam et al. (1999) and Lyman (e.g., 1984, 1994), and the data are organized according to fine portions-of-elements following Stiner (2002b, 2004).

Hominin transport and processing tactics are interpreted from bone damage patterns and body part representation in relation to food utility indexes (following Binford, 1978; Metcalfe and Jones, 1988). Although bone surface visibility is sometimes obscured by calcite concretions, tool marks, old green-break edges and diagnostic fracture, forms were readily visible and examined in relation to prey size classes and body part representation, among other variables. Additional, specific procedures are presented by analytical section below.

Results

Community turnover

Mammal communities of the southern Levant are the product of ever-shifting mixes of Eurasian, Afro-Arabian, Turanian, and endemic influences. Several distinct zoogeographic zones fold about one another in this part of the world (Fig. 4). Their undulating borders have shifted frequently in the past, enhancing species diversity through biotic exchange and periodic isolation (Tchernov, 1992; Horowitz, 2002). Invasions of the Levant by xero-tropical or Afro-Arabian mammals were facilitated at times by a widening of the southern arid grassland belt that linked the Levant to lowland biomes of Ethiopia. The most famous example of this situation is represented by the early Pleistocene faunas of the 'Ubeidiya formation in the Jordan Valley (ca. 1.4 Ma; Tchernov, 1992; Martínez-Navarro, 2004). The archaeofaunal record at Geshert Benot Ya'qov at about 780 ka (Goren-Inbar et al., 2000; Rabinovich

Table 3

Prey frequencies based on the number of identified skeletal specimens (NISP) by vertical unit in Qesem Cave: (a) counts by taxon-specific and body size classes combined; (b) taxon-specific percentages for mammals and tortoises.

(a)	I	II	III	IV	V
Taxon/body size class	NISP	NISP	NISP	NISP	NISP
Lacertidae	–	4	–	–	–
<i>Testudo cf. graeca</i>	1	15	15	29	28
Medium bird	–	–	1	1	4
Large bird (e.g. Strigidae)	–	1	1	–	1
<i>Hystrix indica</i>	–	7	2	8	6
Small ungulate	2	–	4	3	4
<i>Capreolus sp.</i>	–	1	1	–	–
<i>Capra aegagrus</i>	–	–	2	1	–
<i>Dama cf. mesopotamica</i>	33	524	579	731	236
<i>Sus scrofa</i>	–	9	22	20	4
<i>Equus hemionus/hydruntinus</i>	–	1	4	7	–
Medium ungulate	8	322	430	718	199
Cervidae	1	36	23	43	25
<i>Cervus elaphus</i>	–	12	13	1	2
<i>Equus caballus</i>	–	26	53	39	1
<i>Bos primigenius</i>	9	46	56	76	13
Large ungulate	–	25	61	55	12
<i>Dicerorhinus hemitoechus</i>	–	6	16	14	1
Megafauna	–	4	2	2	–
Medium mammal	4	1	29	14	4
Hyaenidae	–	2	12 ^a	1 ^a	–
Total:	58	1042	1326	1768	540

(b)	I	II	III	IV	V
Taxon	%	%	%	%	%
<i>Testudo cf. graeca</i>	2	2	2	3	9
<i>Hystrix indica</i>	0	1	<	1	2
<i>Capreolus sp.</i>	0	<	<	0	0
<i>Capra aegagrus</i>	0	0	<	<	0
<i>Dama mesopotamica</i>	75	76	73	75	75
<i>Sus scrofa</i>	0	1	3	2	1
<i>Equus hemionus/hydruntinus</i>	0	<	<	1	0
Cervidae	2	5	3	4	8
<i>Cervus elaphus</i>	0	2	2	<	1
<i>Equus caballus</i>	0	4	7	4	<
<i>Bos primigenius</i>	20	7	7	8	4
<i>Dicerorhinus hemitoechus</i>	0	1	2	1	<
Hyaenidae ^a	0	<	1	0	0
Total taxon-specific NISP	44	685	793	970	316

^a Of these counts, 5 specimens from Unit III and 1 from Unit IV are hyena coprolites.

et al., 2008), also in the Jordan valley, may represent the tail-end of this biotic exchange.

Although the Eurasian and African continents connect via the Levant, the region was not always open to north-south biotic exchanges (Horowitz, 2002). Many endemic forms arose during periods of partial or complete geographic isolation caused by expansion of a desert barrier. Two southward invasions of the Levant by Eurasian Palearctic mammals associate with periods of climate cooling over the last 1.5 Myr (Tchernov, 1992). The second of these occurred during the middle Pleistocene and altered the character of faunas after roughly 0.7 Ma (during the Acheulean). By marine oxygen isotope stages (OIS) 7–6, biotic exchanges were generally greater east-west than north-south (Tchernov, 1992), and a variety of open-land genera such as *Camelus*, *Equus*, *Dicerorhinus*, and *Struthio* (ostrich) inhabited the inland basins of Syria (Tchernov et al., 1994; Reynaud Savioz and Morel, 2005).

The savannah conditions that dominated the Levant after roughly 700 ka allowed Palearctic mammals to be increasingly successful. Tchernov et al. (1994) suggest that this effect intensified through the Acheulo-Yabrudian culture period, based on the mammalian records of Oumm Qatafa, Zuttiyeh, and Tabun F-E. The exclusively Palearctic mammal spectrum of Qesem Cave is consistent with this assessment and implies that the southern Levant was

a biogeographic cul-de-sac towards the end of the Lower Paleolithic, bounded on the south by an impenetrable Saharan belt.

The situation reversed quickly in the Mediterranean Levant with the onset of the early Middle Paleolithic. Evidence from Hayonim Cave (Stiner, 2005) and Misliya Cave (Yeshurun et al., 2007) reveals a distinct northward invasion of Afro-Arabian mammals, particularly mountain gazelles (*Gazella gazella*), by 170+ ka or early in MIS 6 (Fig. 3; Stiner, 2005; Mercier et al., 2007). Gazelles may have been in the Jordan rift earlier than this time, but they were absent or rare in the coastal hills during the Acheulo-Yabrudian. Once established in the hill zone, gazelle proportions continued to rise relative to other ungulate species, particularly deer (Fig. 5), through the late Pleistocene and Holocene (e.g., Speth and Tchernov, 2001, 2007; Stiner, 2005).

The incursion of mountain gazelles must relate in some way to climate oscillations, though random historical events could also have played a role (Groves, 1991; Tchernov, 1992, 1994; Blondel and Aronson, 1999). Dorothea Bate's (1937a,b) gazelle-fallow deer index represents an early attempt to track environmental change in the

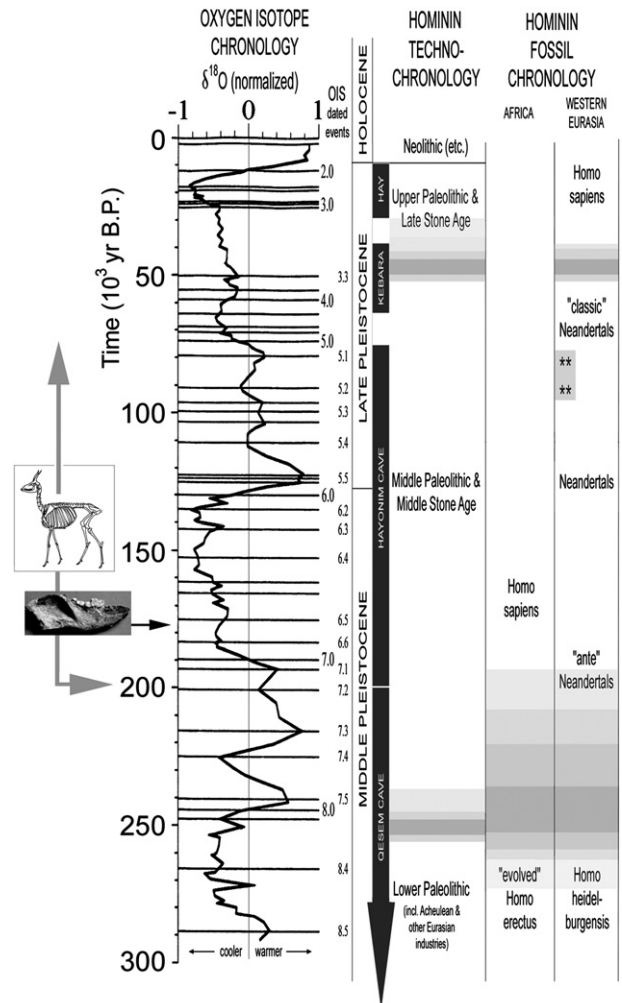


Figure 3. Context of the faunal series from Qesem, Kebara, and Hayonim Caves according to geochronology and the cultural and paleontological chronologies for Old World Paleolithic cultures in Eurasia and Africa. Mountain gazelles (*Gazella gazella*) re-enter the Mediterranean Hills study area in great numbers ca. 200 ka. The only known case of *Lycaon* outside of the African continent in this time frame occurs in Hayonim Cave ca. 170 ka. MIS (OIS) curve based on Martinson et al. (1987). Graduated shading indicates variable timing by region, unclear dating results, or both; (**) Early occurrences of *Homo sapiens* fossils outside Africa (i.e., the Levantine cave sites of Qafzeh and Skhül).

southern Levant based on the relative importance of mountain gazelles and Mesopotamian fallow deer (*Dama [dama] mesopotamica*). She proposed that an increase in the proportion of gazelles relative to deer signaled greater aridity. Tchernov (e.g. Tchernov, 1992) likewise viewed gazelles as an important paleoclimate signal of vegetation changes and Afro-Arabian influences in large mammal communities of the Levant.

Interpretation of variation in the gazelle-fallow deer index during the Pleistocene is complicated by the fact that only two or three species dominate Levantine ungulate faunas. A decline in one almost always means an increase in the other (Davis, 1982). Detrended analyses of gazelle, deer and tortoise data have been used to address this issue for the Hayonim Cave faunas (Stiner, 2005: 137–139). The approach demonstrates that fallow deer frequencies do not control the appearance of the trends from ca. 200/170 to 11 ka, and that gazelle frequencies shift independently for the most part. Other lines of evidence lend further support to Bate's interpretation of the gazelle-fallow deer index. Speleothem records from Soreq and Peqiin Caves (Bar-Matthews et al., 2003) indicate cooler, wetter conditions between 250–185 ka in the Levant and for the eastern Mediterranean as a whole. This interval is followed by a marked shift to arid conditions between ca. 200–170 ka. Significantly, the only example of *Lycaon* (Cape hunting dog) documented outside of Africa in the middle Pleistocene or later (Martínez-Navarro and Rook, 2003) makes its appearance at Hayonim Cave early in this aridification trend (Fig. 3; Stiner et al., 2001a). Stable carbon and oxygen isotope values ($\delta^{13}\text{C}$, $\delta^{18}\text{O}$) of gazelle and fallow deer tooth enamel (bioapatite) yield $\delta^{18}\text{O}_{\text{SMOW}}$ values with a range of +26.2 to +34.9‰ (Rowland, 2006). Though significant temporal gaps exist in the sample, average $\delta^{18}\text{O}_{\text{SMOW}}$ values increase by $\sim 4\%$ over the last 300 k yr. and confirm a trend of increasing aridity. Microfaunal studies at Qesem have only just begun (Maul et al., in press) and are also expected to bear on the environmental history of the cave and surrounding area.

The rather abrupt appearance of gazelles, *Lycaon*, and ostrich egg shell in the earliest MP (late middle Pleistocene) may associate with a threshold-like expansion of open land habitats and fragmentation of Mediterranean forests in the coastal Mediterranean hills. The Qesem series immediately pre-dates this important biotic shift.

Prey spectrum

Signs of hominin activity dominate the Qesem faunas, and there is surprisingly little variation in the prey spectrum through time (Table 3). Fallow deer (*Dama cf. mesopotamica*) were the main prey (73–76% of specimens identified to species), supplemented by aurochs (*Bos*), horse (*Equus*, caballine form), wild pig (*Sus scrofa*), tortoise (*Testudo cf. graeca*), red deer (*Cervus elaphus*), and wild ass (*Equus cf. hydruntinus*). Rhinoceros (*Dicerorhinus hemitoechus*), porcupine (*Hystrix indica*), and small ungulates (goat [*Capra aegagrus*] and roe deer [*Capreolus capreolus*]) are present, but rare, in the assemblages. Gazelle is virtually absent.

The meat diet of the hominin occupants was narrow in its focus on large game. The central importance of ungulates in the meat diet suggests that the Qesem hominins were accomplished large game hunters. Tortoises were the only small prey animal of any importance. A few bones of a predatory bird and partridge (probably *Alectoris chukar*) occur in the older layers (Units III–V), but they are very rare and their connection with the hominin occupations is unclear. Medium mammal remains are mainly of porcupine (*Hystrix indica*), and there is no evidence of small mammal hunting. Hyenas, another potential bone collector in caves, are represented by sparse skeletal remains (I_3 , P_3) only in Unit III of 1–2 adolescent/young adult individuals. A few hyena coprolites are scattered among the vertical units (5 coprolites in Unit III, and 1 in Unit IV) but no latrines were found.

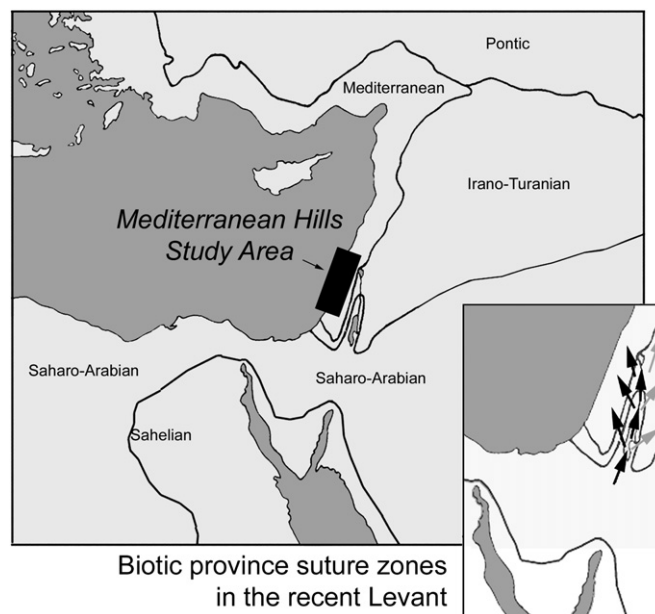


Figure 4. The complex inter-digitation of biotic suture zones in the Levant, and the inferred route (arrows in inset image) of re-entry of Afro-Arabian large mammals ca. 200 ka into Mediterranean Hills study area (base map adapted from Blondel and Aronson, 1999).

Finally, 3 hominin anterior teeth are part of the study sample. These specimens were recovered from Square G22 at 685–710 cm below datum. More cranial elements have been recovered elsewhere during recent excavations (Hershkovitz et al., in press).

The Qesem species spectrum most closely resembles the Acheulo-Yabrudian fauna from the Adlun Caves in Lebanon (Garrard, 1983). The near or total absence of gazelles places these two cases at the Palearctic extreme of the biotic continuum. Because Qesem Cave is located well to the south of Adlun (Fig. 1a), its uniformly Palearctic composition for macromammals indicates a deep penetration of cooler conditions and/or a distinct precipitation regime into the southern Levant. The singular dominance of fallow deer though the entire Qesem sequence is also striking.

Bone modification and assemblage formation

Lithic artifacts co-occur consistently with bones that were damaged by tools, fire or both. The faunal remains generally are well preserved (Fig. 6), and tool marks are present on the surfaces of many of the bones (Table 4) but particularly on limb shaft fragments (Table 5). Cut marks are simple types with V-shaped cross-sections made by slicing motions (Potts and Shipman, 1981; Noe-Nygaard, 1989; Fisher, 1995). These marks occur on 9–12% of the ungulate bone fragments (Table 4), except for the very small sample from Unit I. Cone fractures from stone hammers, typical of marrow extraction from limb bones and mandibles (Binford, 1978; Potts, 1988; Blumenschine and Selvaggio, 1998), occur on 19–31% of ungulate bone fragments; they are somewhat more frequent in the older layers. The incidence of tool marks is comparatively high in the Qesem ungulate faunas, at least twice that observed for a wide range Mediterranean Middle and Upper Paleolithic cave faunas with similar patterns of body part representation (Table 6; Stiner, 1994, 2005). Hacks marks are rare in the Qesem sample, and long axial scrape marks known from MP and later sites are entirely absent. The hack marks associate with limb-sectioning and marrow processing.

Gnawing damage from carnivores and hyena coprolites are present in some of the Qesem assemblages, but they are quite rare

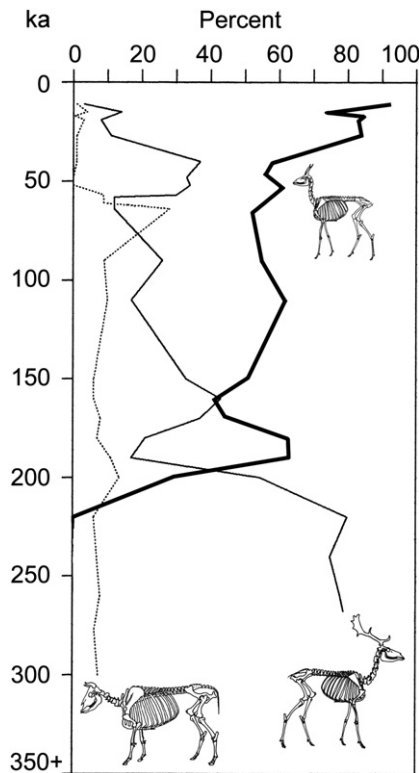


Figure 5. Frequency variation in three important ungulate species (mountain gazelle, fallow deer and aurochs) in the Mediterranean Hills region from the late Lower Paleolithic through Epipaleolithic, based on the archaeofaunal series from Qesem cave, Hayonim cave, Kebara cave, and Meged Rockshelter.

(Tables 2 and 4). No rodent gnawing damage was found, although some porcupine bones are present. Burning damage is common on the remains of ungulates and tortoises (12–19%, Table 7) and demonstrates the economic importance of these animals to the hominins. Burning damage occurs at lower frequencies on porcupine bones (“large rodent” in Table 7, 8%), and it is possible that some or all of these were prey of hominins. The bones of large birds (probably owl) and hyenas were never burned, probably because these animals were occasional visitors to the cave rather than hominins’ prey.

Many of the breaks on bones are from butchering and marrow processing by the hominins. Much additional fracturing occurred after the organic fraction of the bones had decomposed, but long before the cave was opened by roadwork. Like many other Paleolithic sites in the Levant, Qesem Cave occurs in a geological formation that is rich in springs (Bar-Matthews et al., 2003; Frumkin et al., 2009). Thin-section analyses of sediment blocks reveal that micro-cracks and pores of the bones were infiltrated by precipitating calcium compounds (Karkanas et al., 2007: 201–203). Crystallization of these compounds propagated further splitting and cracking of the bones and teeth.

Articulated skeletal specimens in the Qesem deposits (Table 8) are confined to the most resistant joints, namely teeth in jaws and unions of the radius and ulna of deer. Articulated specimens are fairly common in the small sample from Unit I (12%) but uncommon (1–2%) in all other units. Some scattering of materials may have occurred after the bones were discarded by hominins. The scale of post-depositional disturbances is further qualified by burning and anatomical evidence below.

Weathering damage from exposure to the sun is rare overall (Table 4) and mild where it occurs, suggesting widespread protection by the cave roof, rapid burial or both. In fact, weathering

damage is restricted to areas of the excavation thought to represent the cave entrance, the position of which shifted generally N-NE with time. The presence of calcified rootlets places the cave entrance at the far SW end of the site during the formation of the Lower Sequence (Karkanas et al., 2007: 199), and the concentrations of mildly weathered bones in squares H20–21 of Unit III–IV and in square E22 of Unit V support this conclusion. Large quantities of fallen rock testify to the migration of the cave entrance thereafter. Weathered bones in Unit II of the Upper Sequence concentrate in squares J8, K10, L14, and M14 (see Fig. 2). No weathered bones were encountered in Unit I.

As explained above, intact hearth features thus far are rare in Qesem Cave (Karkanas et al., 2007), but burned unidentified bones (splinters or NUSP) occur in patchy distributions throughout the stratigraphic sequence (Table 2). In square I15, between 570 and 665 cm below datum, up to 91% of the splinters are burned and 16% calcined. Up to 88% of splinters are burned and 33% calcined between 540 and 765 cm in square I16. Other “hotspots” include cut 650 in square G22 (51% burned, 16% calcined), and between 600 and 800 cm in square G21 (up to 70% burned, 25% calcined).

Of the bones that could be assigned to species or body size group and element (NISP), 12–15% are burned in Units I–III and 8–10% are burned in Units IV–V. The higher frequencies of burning damage to unidentified bones in Qesem are typical in archaeological cave sites. Burning increases the brittleness of bones and teeth, such that traffic or compression generates smaller pieces with fewer diagnostic features. Small items that stay where they fall are also prone to secondary burning by fires built repeatedly in the same location (Walters, 1988; Stiner et al., 2001b), even if the bones are shallowly buried (Stiner et al., 1995). Extensive burning may also result from the use of bones as fuel (Théry-Parisot, 2002) or from cooking (Cain, 2005; Speth, 2006). None of these explanations can be rejected *a priori* for Qesem Cave. It is significant, however, that carbonization is often complete, and calcined bones are common in some locations (up to 33% of NUSP). Such high concentrations of calcined bone in the Qesem deposits testify to intense or long-burning fires.

Perhaps most important for our discussion is the fact that burned bones are much more abundant in the Lower Sequence than preserved wood ash traces would predict. The low incidence of the latter seems to be explained by poor ash preservation rather than absence of fire technology in the behavioral repertoire of the hominins. Also interesting is the observation that the distribution of burned bone trends horizontally in a manner akin to weathering damage and the drifting position of the cave entrance with time. This is especially the case for calcined bone fragments, which are produced only in the hottest zone of a campfire. The co-occurrence of weathering damage and concentrations of burned bones near the cave entrance makes sense with respect to ventilation.

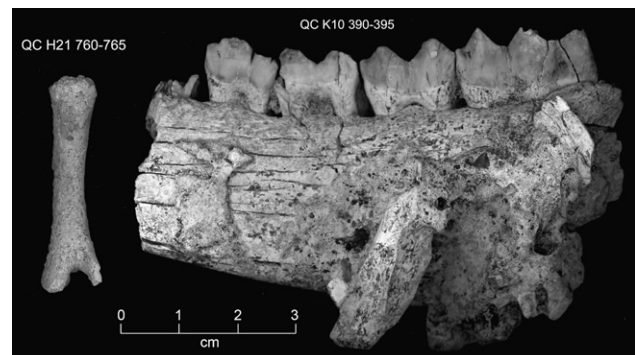


Figure 6. Examples of the quality of preservation of faunal specimens: (left) humerus of fetal ungulate; (right) deer mandible with weathering damage.

Table 4
Frequency of damage types on ungulate bones (% of NISP) by vertical unit.

Damage type	I %	II %	III %	IV %	V %
Burning	4	19	13	12	12
Cone (percussion) fractures	0	20	19	31	25
Cut marks	2	9	11	12	10
Gnawing traces	0	<	<	<	0
Articulated elements	12	2	2	1	2
Atmospheric weathering	0	1	1	1	1

Teeth are excluded from consideration. (<) present at less than 1% of NISP.

Prey age selection and seasonality

The mortality patterns of the Qesem fallow deer (Table 9) speak to the hunting capabilities of early hominins and the development of prime-age-focused harvesting, a uniquely human predator–prey relationship (Stiner, 1990). Ungulate mortality patterns are mediated foremost by how a predator approaches its quarry. A fundamental division exists between the death patterns produced by long chase hunters (wolves, wild dogs, cheetahs, spotted hyenas), which tend to kill young, old or weak individuals and produce attritional or U-shaped mortality patterns, and stalk-and-ambush hunters (lions, tigers, leopards) that are generally less selective and whose large prey kill patterns are more likely to resemble the structure of the living prey populations. The contrasting ways that chasers and stalkers interact with a prey population in the same environment reduces interference competition and reflects a long legacy of niche differentiation (MacArthur and Levins, 1967; Pianka, 1978: 189–199, 260). Humans are ambush predators, but they are somewhat more selective than other predators in this strategy group, producing mortality patterns in artiodactyl ungulates that range from nonselective to a bias to prime adult animals. In terms of averages, a mild bias to prime animals has been noted in a variety of recent and prehistoric contexts, and the human species is ecologically unique in this respect (Stiner, 1990, 1994). The nearly universal character of this human adaptation begs information about its antiquity.

To set the Qesem results in evolutionary context, broad prey age selection patterns are generalized by predator type in Fig. 7b as averages of many cases (following Stiner, 1990). Expectations for nonselective and selective hunting patterns are modeled in tripolar format based on the relative proportions of juveniles, prime adults, and old adults that are killed (Fig. 7a). This approach exposes niche-level differences between non-human and human predators, wherein the distances that separate means (or groups of means) are as important as their location in the graph. The mean values generated by humans are consistent across periods and

Table 5
Burning, cut mark and cone fracture frequencies on medium-sized ungulate bone fragments in Qesem Cave by skeletal element (NISP = 1528) for all units combined.

Element(s)	% Burned	% with cone fractures	% with cut marks
Crania	9	0	1
Mandibles	14	8	6
Axial elements	13	1	1
Scapula	6	0	6
Humerus	23	43	18
Radius	19	41	7
Ulna	21	2	2
Femur	17	19	17
Tibia	22	41	16
Large tarsals	25	0	6
Metapodials	25	34	7
Phalanges	13	6	0

Axial elements include neck, thoracic, lumbar and sacral vertebrae, rib and pelvic parts. Teeth are excluded from consideration.

Table 6
Frequency ranges (% of NISP) for cut marks and cone (percussion) fractures in ungulate assemblages from Mediterranean Paleolithic cave sites in Italy, Turkey and Israel.

	Qesem Cave, Acheulo-Yabrudian	Middle & upper paleolithic caves
Cut marks	9–12%	1–4%
Cone fractures	19–31%	4–18%

Sources of comparative data are Stiner (1994, 2005, 2009) and Yeshurun et al. (2007). Small sample from Qesem Unit I is excluded.

technologies, and all of the human means are distinct from those of the non-human predators. The averaged mortality pattern for the five fallow deer assemblages from Qesem Cave is consistent with MP through recent means. Clearly, the recent human pattern was already developed in hominins 400 ka, if not earlier.

Moving to a higher level of resolution in the data, Fig. 8 represents the full gamut of variation in artiodactyl mortality patterns generated by recent humans and Middle, Upper and Epi-Paleolithic foragers in Israel, Italy, Turkey, and Lebanon (Kersten, 1987; Stiner, 1994, 2005; Speth and Tchernov, 1998; Yeshurun et al., 2007). The five Qesem assemblages are highlighted in this graph, and their distribution is consistent with that of the MP and later cases. All of the Qesem fallow deer mortality patterns are poor in old adults (Fig. 9), somewhat more so than some of the other Paleolithic comparison cases. One may wonder whether this is evidence of over-hunting or the result of fallow deer herd composition and season of hunting (Kersten, 1987: 121; Stiner, 1994, 2005: 207–210; Steele and Weaver, 2002). The latter explanation is supported by the presence of ungulate fetal and neonate remains; at least some adult females and their young were hunted during the spring (3 infant specimens from Unit III, 6 from IV, and 3 from V). The rarity of antler fragments in the Qesem deer assemblages is also notable. Assuming that hunters would not avoid male prey, the paucity of deer antler points to seasons of occupation that included late winter through early summer. Other suggestions of seasonal occupation include the very similar wear stages of some deer teeth (e.g., Fig. 10), implying that these individuals died not only in the same year of life but also at the same time of the year.

Finally, it is interesting and unusual that only the posterior teeth of the mandible are exceptionally well-represented in the medium ungulate remains from Units III and IV (Fig. 11). Of concern for the mortality analysis is whether the molar biases in III and IV have substantively altered the mortality patterns. Hence a comparison of profiles based on fallow deer premolars only (dLP4-LP4) and premolar-molar sets (dLP4-LM3) was undertaken. The comparisons (Table 10) confirm that an emphasis on the premolar-molar set results in a greater proportion of prime adults in the results. Still, all of the premolar- and molar-based patterns fall within the total range of living-structure and prime-dominated patterns; they are not greatly different from one another. It is difficult to retreat to an argument of poor preservation or counting error to explain the higher representation of lower molars in relation to other cheek teeth for deer, since upper molars generally are no less dense or recognizable than lower molars. It is possible that some posterior mandibles were separated from the anterior mandible before arriving to the site during the formation of Units III and IV (but not in other layers). Biases to metapodial elements in the bone assemblages are also greatest in these units (see below).

Carcass transport and processing on-site

Although well-defined hearth features are rare or absent in the cultural layers, the condition of the bones nonetheless testifies to

Table 7
Burning damage percentages for various animal groups by vertical unit in Qesem Cave.

Taxon	I		II		III		IV		V		All Units
	NISP	Burned NISP	NISP	Burned NISP	NISP	Burned NISP	NISP	Burned NISP	NISP	Burned NISP	% by group
Tortoise	1	1	15	5	15	3	29	6	28	2	19%
Bird	0	0	1	0	2	0	1	0	5	0	0%
Large rodent	0	0	7	2	2	0	11	0	6	0	8%
Medium ungulate	41	1	892	146	1004	142	1463	142	439	37	12%
Large ungulate	10	0	129	7	222	24	218	22	53	5	9%
Megafauna	0	0	5	0	23	2	17	0	1	0	4%
Large carnivore	0	0	2	0	12	0	1	0	0	0	0%
% for all taxa		12%		15%		14%		10%		8%	

strong, consistent links between carcass processing and fire-building over the full span of the hominin occupations. To better understand the causes of this spatial association, the frequency and intensity of burning damage was examined by body part for deer and other medium-sized ungulates—the most abundant prey size group. Bones of the skull, axial column (spine, ribs, pelvis), scapula, and ulna are less often burned than the large limb bones that possess large medullary cavities (Table 5), a seasonally rich source of consolidated bone marrow. Intense burning damage—calcination—is also most frequent on limb bones (Table 11; Chi-square 54.6, df 16, $p < 0.0001$).

Burning damage is least common on skull parts, even though roasting would have been the simplest and most efficient way to prepare ungulate heads for consumption. The equivalent frequencies of crania and mandibles in this site indicate that skulls were often carried to the site in a relatively complete state. The equal rates of burning on crania and mandibles may mean that the skulls were roasted whole, and the low rate of burning may be because the tissue covering shielded the fresh skull bones and teeth from the flames and coals of the hearths.

Speth and Clark (2006: 20–24) were able to relate the frequency of burning damage on deer and gazelle bones in late Middle Paleolithic Kebara Cave (ca. 60–50 ka) to marrow utility rather than meat utility. These authors also found that many of the lower limbs, the elements most often burned, sustained greater heat damage on the shafts and specifically on their exterior surfaces. This pattern of burning suggests gentle heating of the lower limb bones in preparation for marrow removal in the manner not unlike the practices of some recent foraging peoples (e.g., among the Nunamiut; Binford, 1978). The distribution of burning by skeletal element for fallow deer in Qesem Cave resembles that observed for the Kebara. The only exception concerns toe bones, which are abundant and frequently burned in Kebara but rarely present and seldom burned

Table 8
The percentage of damaged specimens for ungulate remains by element(s) in Qesem Cave (all units combined).

Element(s)	% burned	% calcined	% weathered	% articulated	% Gnawed
Crania	9	1	0	13	0
Mandibles	13	1	4	25	1
Axial elements	13	0	0	0	<
Scapula	6	^a	6	0	0
Humerus	22	1	1	0	0
Radius	18	3	5	3	1
Ulna	21	0	2	5	2
Femur	17	1	0	0	1
Tibia	22	0	1	0	0
Large tarsals	25	0	0	0	0
Metapodials	25	1	2	0	1
Phalanges	15	0	1	0	0

Calcined bones are a subset of burned bones. Teeth are excluded from consideration. Axial elements consist of the vertebrae, ribs and pelvis.

^a small sample makes calculation suspect.

in Qesem. Greater burning damage to limb bones in Qesem Cave suggests that late-stage processing and discard of these elements normally occurred in the vicinity of hearths.

While burning biases by skeletal element at Qesem do suggest deliberate heating in connection with marrow processing, there is at least one other important modifying process in evidence. The ends and shafts of ungulate limb bones in Qesem are burned at similar rates. The limb bones do not appear to have been used as supplemental fuel (compare Théry-Parisot, 2002), since grease-rich limb ends were burned no more often than limb shafts. Rather, the indiscriminate burning of disparate limb bone portions merely indicates that the fragments tended to remain in hearth areas after disposal and were prone to random post-depositional burning.

Of the small prey animals in the Qesem faunas, tortoises are both more abundant than birds or small mammals and much more frequently burned (19% on average). The degree of burning damage is consistently mild, and it is more frequent on the plastron or belly plate of the shell than on the carapace or limbs (Table 12). A similar pattern was observed for the early Middle Paleolithic faunas from Hayonim Cave (Stiner, 2005: 98–99). This bias may reflect the method of roasting.

Differential transport versus *in situ* attrition Ungulate body part representation in caves ideally reflects the transport decisions of hominins and the contexts of carcass processing and consumption. Greater travel distances are expected to discourage the transport of low utility (Binford, 1978) or very heavy parts (Metcalf and Barlow, 1992). Unfortunately biases arising from *in situ* decomposition of softer bones can produce body part patterns in faunal records that are similar to those caused by transport preferences. In Qesem Cave, the problem of *in situ* attrition is largely a matter of fragmentation, not chemical decomposition or gnawing by carnivores or rodents. Because crushing and splitting may reduce the visibility of fragile skeletal parts disproportionately (Brain, 1969; Lyman, 1984, 1991), a first test for this effect compares the representation of dental versus bone elements of the skull for deer (Stiner, 1994: 99–103). The assumption is that bones and teeth of the crania and/or mandibles will tend to be moved together in the hands of foragers. In Qesem Cave, the highest dental MAU values (minimum anatomical unit; Binford, 1978) are

Table 9
Three-cohort mortality patterns for fallow deer. Sample (N) is based on the dP4–M3 dental series, usually the dP4–M3 set, and combines right and left sides.

Unit	Juveniles	Prime adults	Old adults	N
I–II	0.42	0.53	0.05	38
III	0.42	0.52	0.06	31
IV	0.27	0.65	0.08	40
V	0.24	0.67	0.09	21

Fetal and neonate bones are not included in the calculations. A maximum limb element MNE for fetal or neonate individuals is 3 for Unit III, 6 for Unit IV, and 3 for Unit V.

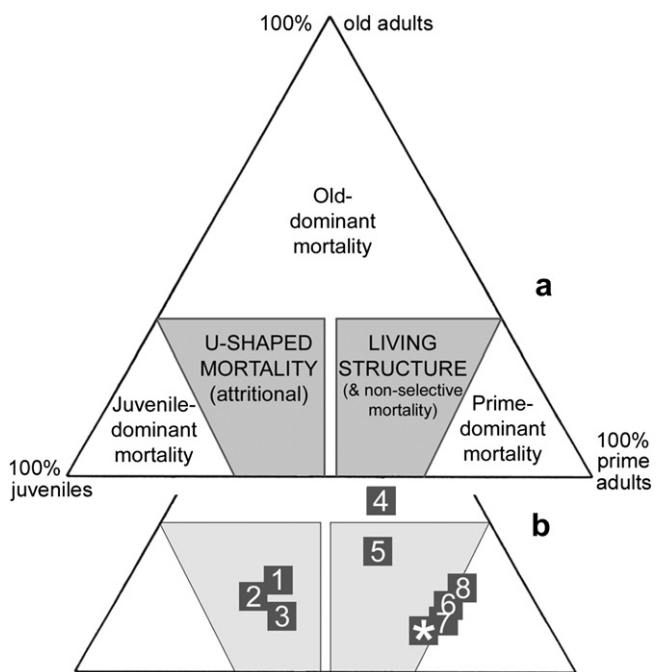


Figure 7. Modeled (a) and observed (b) artiodactyl ungulate mortality patterns generated by large predators: (b) means for recent (1) spotted hyena, (2) wolf, (3) Cape hunting dog, (4) tiger, (5) African lion, (6) Holocene and recent human hunters, (7) Mediterranean Epipaleolithic and Upper Paleolithic hunters, (8) Mediterranean Middle Paleolithic hunters, (*) average for the Acheulo-Yabrudian fallow deer assemblages from Qesem Cave.

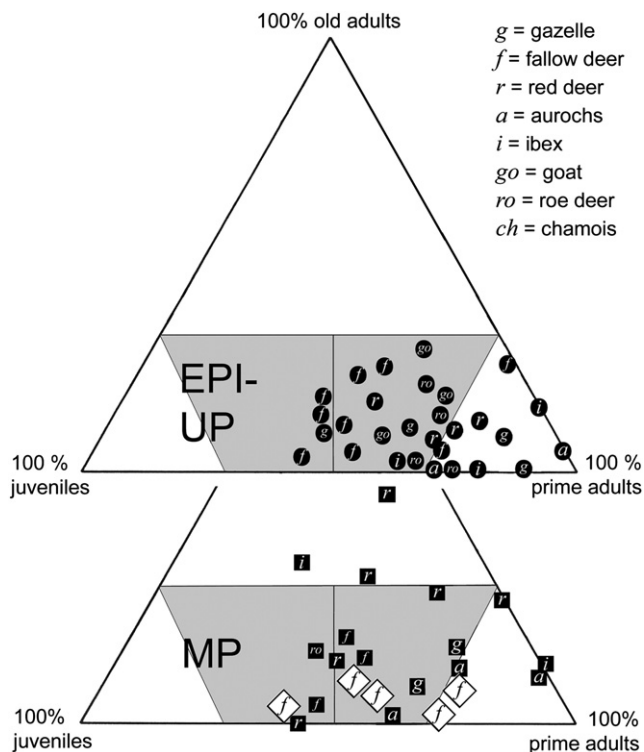


Figure 8. Observed mortality patterns in artiodactyl prey from Mediterranean Epipaleolithic (EPI), Upper Paleolithic (UP) and Middle Paleolithic (MP) assemblages from Israel (Hayonim Cave, Meged Rockshelter, Kebara Cave), Lebanon (Ksar ‘Akil), Turkey (Üçağızlı I Cave), and various cave sites in west-central and northern Italy. Acheulo-Yabrudian (late Lower Paleolithic) cases from Qesem Cave appear as open diamonds.

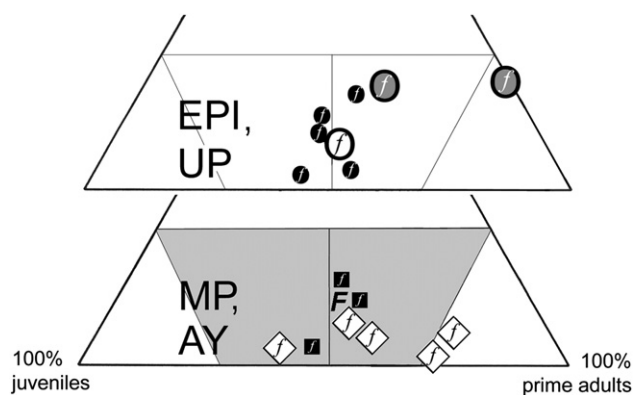


Figure 9. Detail of mortality patterns for fallow deer across periods. (AY) Acheulo-Yabrudian assemblages from Qesem Cave. (F) Mean living-structure value for modern fallow deer population (*D. dama*, Chapman and Chapman, 1975).

two times greater than the highest bone-based MAUs in each unit (slope = 0.43, Fig. 12; Table 13); the situation is slightly worse in Unit III and somewhat better in Unit IV than predicted by linear regression. Clearly fragmentation has taken a toll on the recognition of bone elements relative to dental elements in the Qesem faunas.

Portion-of-element representation for medium ungulate leg parts tells a related story. A plot of limb MAUs based on unique, dense shaft features versus small epiphyseal features yields a slope of 0.578 (Fig. 12), meaning that shafts are nearly twice as abundant overall. Deviations from the regression line (residuals) expose a noisy relation, however, with an r^2 of only 0.495 (N portion pairs = 21). The proximal radius, for example, is a major outlier to the distribution in that proximal ends are more abundant than shafts and this element is much more abundant than other limb elements. Metapodials are also disproportionately common in the assemblages (see below); they could not be considered in this comparison due to the lack of countable shaft features, but their structural densities are not substantially different from many other parts of the lower leg.

The observed biases in body part representation can be compared systematically to independent bulk density standards for members of the deer family (Cervidae), based on photon densitometry (PD) technique for *Odocoileus* (Lyman, 1994) and computed tomography (CT) for *Rangifer* (Lam et al., 1999). Application of the CT standards includes adjustments made for the voids within large tubular bones (BMD₂; Lam et al., 1999). We note that PD standards for *Odocoileus* and CT standards for *Rangifer* are in close agreement to each other for limb bone portions considered in this study,

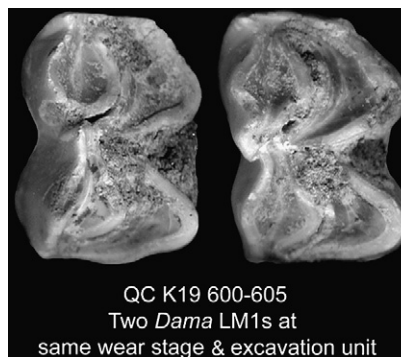


Figure 10. Similarly worn teeth of two individual fallow deer, indicating that they probably died around the same time of year.

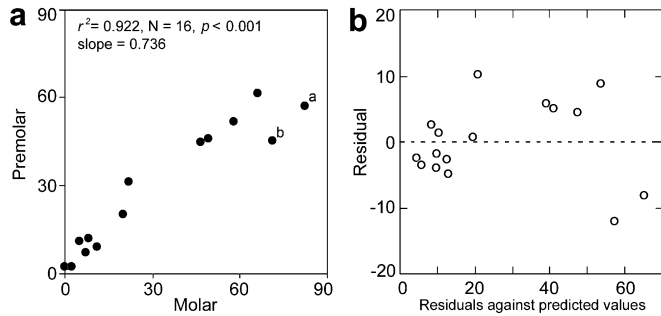


Figure 11. Comparison of the relative representation (degree of parity) of permanent premolars and molars in the upper and lower jaws of medium and large ungulates. Major outliers are (a) medium ungulate LP to LM in Unit IV; (b) medium ungulate LP to LM in Unit III.

($N = 17$, $r = 0.871$, $p = 0.0001$), but less so if other parts of the skeleton are included ($r_s = 0.674$, $p = 0.001$). For the range of body parts represented in the Qesem faunas, PD and CT density standards are strongly correlated, as one would expect, but there is only about 45% agreement between the two standards. This discrepancy between the control sets is mildly problematic and cannot be resolved here, but the standards remain useful as one of several approaches to questions about bone survivorship.

Correlation results presented in Table 14 indicate that *in situ* destruction has the potential to explain 18–34% of the variation seen in body part representation among units in Qesem Cave if PD standards are used, but only 4–19% of the variation if CT standards are used. Unit V may have been most affected by *in situ* attrition and Unit IV least affected. We conclude that preservation biases could partly account for the low frequencies of fragile vertebrae and ribs in Qesem Cave. None of these results explains, however, the low frequencies of dense pelvic features, proximal femur, distal tibia, and phalanges in the Qesem assemblages. In other words, the anatomical content of the ungulate faunas was also strongly influenced by hominin transport biases.

Correlation to bone density standards helps to identify the possibility of density-mediated effects, but these tests seldom can exclude other potential influences on body part representation (Lyman, 1991; Beaver, 2004). To circumvent biases that may have been introduced by density-mediated destruction, the next comparison uses parts (portions-of-elements) with similar inherent densities throughout the prey skeleton (Stiner, 2002b, 2004). Small, compact features on bones are favored for counting elements and portions-of-elements. Most of these portions coincide with Lyman's PD scan sites (1994: 234–250), which are also the basis for the CT data produced by Lam et al. (1999). The numbers of skeletal elements (MNE) are grouped into nine anatomical regions and standardized to a complete skeleton model (standardized MNE, Stiner, 1991; or MAU, Binford, 1978) by dividing the observed MNE for a group of elements (body region) by the

Table 10

Comparison of mortality pattern results in three-cohort format based on premolar sets versus premolar-molar series of the upper and low jaws of fallow deer in Units III and IV.

Dental set used for ageing sequence	Young	Prime adults	Old adults	Total MNE
Unit III:				
dLP4-LP4	0.63	0.3	0.07	27
dLP4-LM3	0.48	0.52	0	46
Unit IV:				
dLP4-LP4	0.45	0.55	0	20
dLP4-LM3	0.27	0.65	0.08	40

Table 11

Variation in burning frequencies for the major elements of medium-sized ungulates, based on standardized deviates from all units in Qesem Cave.

Element	Burning, standardized deviate
Cranium	-2.7517
Lumbar-pelvis	-2.6122
Phalanges	-2.2131
Ribs	-1.3797
Mandible	-1.2859
Scapula	-1.0959
Cervical vertebrae	-0.8433
Thoracic vertebrae	-0.2607
Radius	-0.1534
Astrag-calcaneus	-0.0576
Ulna	0.3758
Femur	0.4999
Tibia	0.8434
Metapodial, indet.	1.0205
Humerus	1.1469
Metacarpal	1.7440
Metatarsal	3.8213

(Chi-square 54.6071, df 16, $p < 0.0001$, NISP = 1781). Rare skeletal elements and very small elements are eliminated from consideration. Negative values indicate burning frequencies lower than expected, positive values higher than expected.

expected MNE. If skeletal representation is complete, the standardized values for all regions will be equal, making biases among the anatomical regions readily apparent. To correct for the greater durability of teeth in fossil records, only bony features of the skull are used to estimate the number of crania and mandibles for this analysis.

Medium and large ungulates in Qesem Cave are represented mainly by limb bones and head parts (Fig. 13). The metapodials, humerus, radius, femur and tibia are particularly common (Fig. 14), whereas vertebrae, ribs, pelvis, and toe bones (phalanges) are under-represented to a notable extent. The differential representation of similarly dense portions across the anatomy confirms that the biases are the result of hominins' decisions of what to carry from kill sites to the cave. The patterns of body part representation for deer in Qesem Cave are consistent among the vertical units, suggesting that the hunters used the cave in a generally similar manner visit after visit. The patterns of body part representation for deer are similar to those observed for deer and mountain gazelle in the early MP sites of Misliya Cave (Yeshurun et al., 2007: 665) and Hayonim Cave (Fig. 15; Stiner, 2005: 184–192).

Deer body part representation in Qesem Cave correlates (positively) only to the marrow utility index (Units II–V, Table 14). Clearly, the presence of medullary marrow in bones was an important condition for transport of body parts to the cave. The hominins' decisions were not determined entirely by marrow value, however, as this utility index can explain no more than 25% of the variation in body part representation in Unit II, 35% in III, 59% in IV, and 31% in V. Marrow was merely the most consistent residual value of the transported parts. Many of the transported

Table 12

Frequency of burning damage on tortoise shell and limb specimens (NISP) in Qesem Cave, all units combined.

Element	Not burned	Partly blackened	Fully blackened	Slightly calcined	Partly-fully calcined	Percent burned
Carapace	36	5	1	0	0	14%
Plastron	21	6	3	1	0	32%
Limbs+	14	1	0	0	0	7%
Total NISP	71	12	4	1	0	88

Burning gradient codes follow Stiner et al. (1995); (+) limb parts include pectoral girdle elements.

skeletal elements associate with large muscle masses in life, and the utility correlation results show that it is very unlikely that all meat was removed from the bones in the field. Whether all or just some of the meat remained on the bones at the time of transport is not known. What we do know is that the bones have many cut marks on them and the patterns do not suggest efficient processing. Rather, the cut marks indicate a protracted set of cutting actions. If meat was still attached to the transported bones, then we may conclude that hominins delayed consumption of some high-value food until after it had arrived in the cave. The fact that hominins also carried heads of deer and other ungulates to the site could be explained by the presence of hearths in the cave, since heads have considerable food value but require lengthy processing, usually by slow roasting.

Butchering patterns and hearth-centered processing Interpretations of cut mark form data normally rely on three or four variables—tool mark forms or morpho-types, tool mark orientations, abundance, and the distributions of the marks on prey skeletons. This study considers all of these variables and, in addition, the amount of angle variation within clustered cut marks as a measure of “disorder.” The basic patterns of carcass transport and processing at Qesem Cave do not differ substantially from those noted for a variety of later Paleolithic cave faunas, nor do the dominant orientations of the cut marks (Table 15). These patterns fall within the range normally associated with full butchering of ungulate carcasses, including

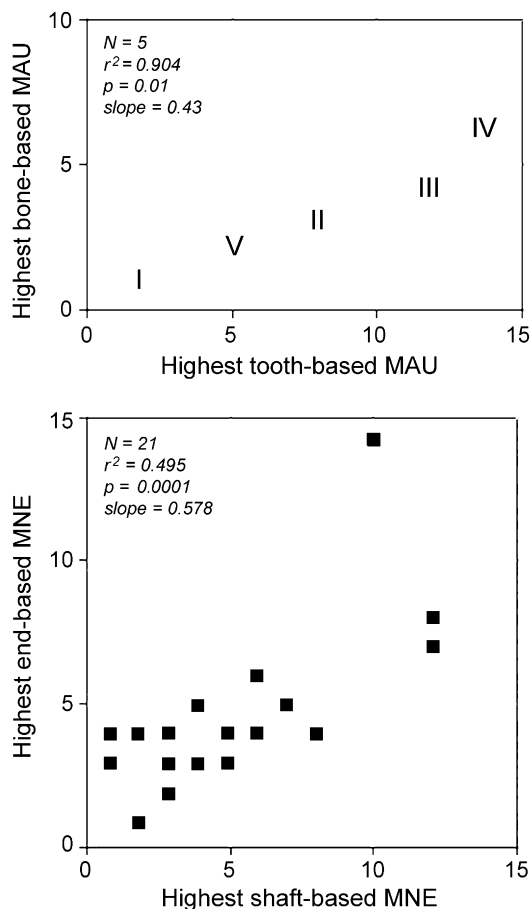


Figure 12. Plots of highest bone-based skull MAU against highest tooth-based MAU for medium ungulates (mainly fallow deer) in each vertical unit of Qesem Cave, and highest end-based and shaft-based MNEs for major limb bones of medium ungulates (mainly deer, elements are scapula, humerus, radius, ulna, femur, and tibia). Metapodials and phalanges are excluded because they lack unique, countable features on their shaft; many points overlap in the plot.

Table 13

Highest MAU estimates and regression residual values for bones versus teeth of medium ungulates by unit in Qesem Cave.

Unit	Highest bone-based MAU	Highest tooth-based MAU	Standardized deviate
I	1	1.67	0.320
II	2.87	8	−0.525
III	4.25	11.83	−0.787
IV	6.75	13.67	0.923
V	2.25	5.17	0.069

basic skinning work. The anatomical placements of most cut marks in the Qesem fauna—mainly on limb shafts—are also generally consistent with those in the MP and UP comparison assemblages.

The Qesem faunas are peculiar for the relative “disorderliness” of the cut mark orientations on limb shaft specimens that possess multiple marks (Stiner et al., 2009). Many of the shaft fragments from upper limb bones display loose aggregations of cut marks (3–44 strokes; Fig. 16a, Table 16a). The high incidence of crossed marks and the diverse angles of the cut marks on the Qesem bones (Fig. 16b) are peculiar if compared to MP and UP faunas from Mediterranean cave sites (Stiner, 1994, 2005). One potential explanation for this contrast is that the marks on the Qesem bones are actually palimpsests of hominin butchering marks and geological scratches (cf. Tchernov et al., 1994). If scratching were the cause of the relatively chaotic marks, there should be stray marks on most elements; scratching from small-scale sediment movements or trampling (Behrensmeier et al., 1986; Fisher, 1995) should not be very selective with respect to body part. In fact, the great majority of the cut marks in the Qesem faunas are concentrated on just a few meat-bearing elements, primarily the humerus, femur and tibia (Fig. 17; Table 16b). These marks lack the morphological diversity of scratches and evidence of sequential polishing. The possibility that some bones with multiple marks were used as palettes or percussors was also considered (Chase, 1990), but the specimens in the study sample do not show evidence of repeated tapping or striking against a stone edge.

Unfortunately, there are no systems-level analogs for evaluating the behavioral significance of cut mark data. Inter-assemblage variation in cut mark frequencies is the most problematic variable (see Lyman, 2004: 303–315; 2005), because frequencies may differ as a function of the technological system, prey type, environmental circumstances, carcass state, and processing investments (Binford, 1978, 1988; Gifford et al., 1980; Bunn and Kroll, 1986; Lupo and O’Connell, 2002). Archaeofaunal variation in cut mark abundance is further complicated by variation in body part representation (Stiner, 1994: 138–139; Domínguez-Rodrigo and Yravedra, 2009), observer bias (Abe et al., 2002), specimen counting conventions (compare Stiner, 2005: 10; Speth and Tchernov, 2007), and bone surface preservation.

Table 14

Spearman’s rho (r_s) correlations of normed MAU data for medium ungulates from Qesem Cave to density standards and utility indexes.

	QCII	QCIII	QCIV	QCV
Marrow	0.516*	0.617**	0.766***	0.477*
Grease	0.408	0.193	0.381	0.141
MGUI	−0.140	−0.307	0.048	−0.240
Meat	−0.174	−0.233	0.003	−0.183
PD density	0.564**	0.461*	0.427*	0.586**
CT density	0.305	0.330	0.203	0.435*

Utility indexes from Binford (1978); PD density standards for *Odocoileus* from Lyman (1994); CT-BMD_{1,2} density standards for *Rangifer* from Lam et al. (1999). (*) weak correlation, $p = 0.02$ – 0.05 ; (**) moderate correlation, $p = 0.01$; (***) strong correlation, $p = 0.001$. N portion types observed = 22–25, depending on assemblage. Data for Unit I are too few for comparison.

Cut mark orientations and anatomical placements are more useful in that they have been linked in ethnoarchaeological contexts to skinning, dismemberment, defleshing, filleting (removal of whole or large muscle masses), and other butchering actions. Binford's (1978, 1981) model, developed mainly from ethnoarchaeological work among the Nunamiut Eskimo, is widely applied by archaeologists and notions of its general usefulness have withstood the test of time. The Nunamiut system for butchering carcasses is exceptionally complex, however, causing Binford (1981, 1988) and others (e.g., Nilssen, 2000) to question the wholesale use of these patterns for interpreting pre-modern hominin subsistence behaviors. Other ethnoarchaeological studies conducted in African contexts (e.g., Bunn et al., 1988; Yellen, 1991; Lupo, 1995, 2006; Lupo and O'Connell, 2002) expose much diversity in how carcasses may be treated by people and how the bones will be marked by tools. There is wide agreement that cut marks on the shafts of "meaty" bones will generally reflect defleshing actions. The relation between the effort expended removing residual tissue and numbers of cut marks that may be generated is more controversial (compare Shipman and Rose, 1983; Bunn and Kroll, 1986; Bunn et al., 1988; Bunn and Blumenschine, 1987; Lyman, 1987, 1994: 299–303; 2005; Binford, 1988), and must be approached with caution in the case of Qesem Cave.

Because hominin and prey anatomies vary less across time and space than do ecological circumstances, we can expect basic consistencies in the mechanical features of butchering and tool marks wherever and whenever certain classes of hand-held stone tools are used. Biomechanical analogs in particular may have widespread applicability owing to common physical constraints, quite unlike analogs that involve complex goal-driven socioeconomic strategies. Experimental butchering has assisted in development of the former (e.g., Bello et al., 2009), but only to a point, since the underlying

economic and social goals of early hominins are not known. Some of the mechanical implications of the patterns, such as cut mark orientations, are within reach, assisted by comparisons to suitable MP and UP cases.

An important source of control for this study of cut marks is consistency in the observer (M.C.S.) and methods of observation, site and environmental situation (caves at the coastal plain–hills interfaces, Fig. 1b), prey types, concretion effects, and quality of preservation. Ecologically, the mammals represented in Middle Pleistocene Qesem Cave have much in common with the northern Levant (southern Turkey) during the late Pleistocene. The MP and UP comparison samples from Üçağızlı II and I, respectively, are from this region and formed under similar climatic and geological environments. These sites also contain the same or similar prey and body parts (Kuhn et al., 2009) and have a degree of surface preservation and visibility comparable to that of the Qesem sample. Counting cut marks can be a problem in Levantine cave faunas, owing to the severity of calcite concretions—the early MP from Hayonim Cave is avoided as a comparator for this reason (Stiner, 2005: 83) and the Üçağızlı II MP and Üçağızlı I early UP reference samples used instead. All of the sites contain multiple stratigraphic layers and faunal assemblages, and the cut mark samples represent time-averaged patterns.

It is interesting that cut marks in the Qesem faunas occur at roughly 3 times the rate observed in a variety of MP and early UP cave faunas (see Table 6), even though the observer was always the same. Cone fractures also occur at a much higher rate in the Qesem faunas. This is equally strange since the comparison faunas are also rich in limb bones, and these elements were thoroughly processed for medullary marrow (Stiner, 1994, 2005; Munro, 2004; Yeshurun et al., 2007). If fewer hammer strikes to a long bone element (and hence cone fractures produced) are sufficient to open marrow

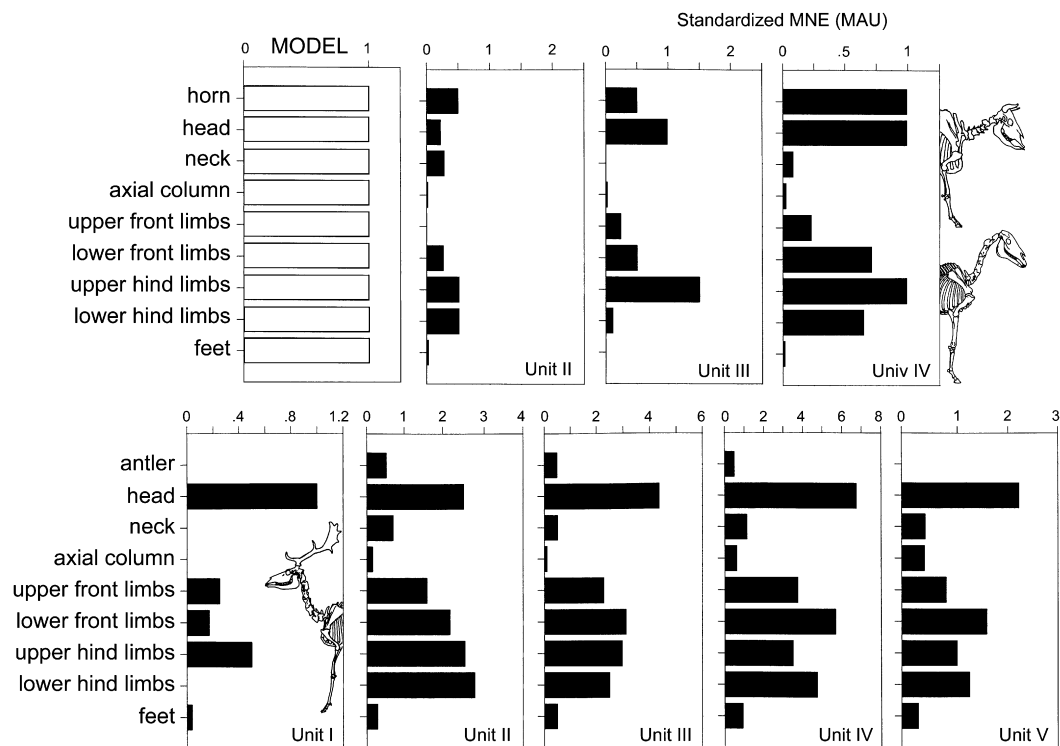


Figure 13. Standardized skeletal element frequencies (observed/expected) by anatomical region for large (top) and medium ungulates (bottom) and stratigraphic unit in Qesem Cave. Unevenness in the anatomical profile indicates biases in body part representation relative to the complete animal anatomy (Model). Dental elements were not used for the calculations of cranial parts. MU is predominantly fallow deer but may include small amounts of pig, goat, and wild ass; LU is mainly aurochs, along with some horse and rarely red deer.

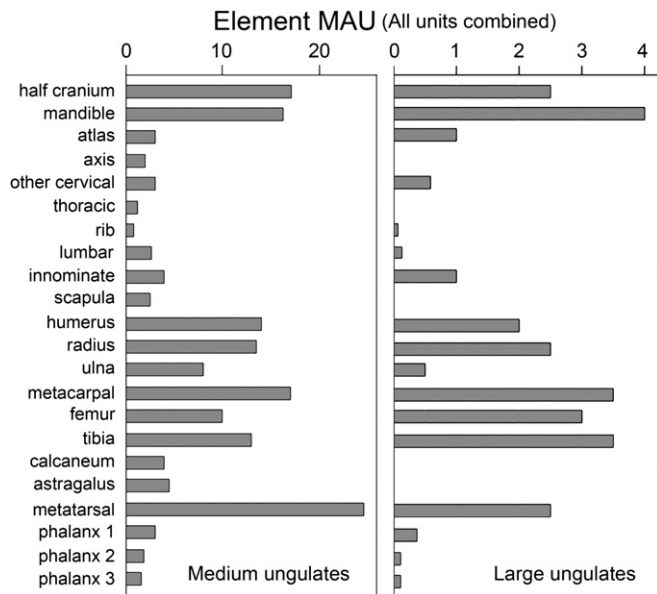


Figure 14. MAU values for each major element of medium and large ungulates from all units combined.

cavities during the MP or UP periods, then the Qesem pattern appears to have been less efficient, or less discriminating, in the use of force (see also Bello et al., 2009 on handaxe use at Boxgrove).

The types of tool marks on the Qesem ungulate bones indicate a narrower range of flesh cutting and removal activities than in the MP and UP comparison assemblages; specifically, axial scrapes and long cuts are absent at Qesem Cave. The most common cutting tools in the Amudian deposits of Qesem Cave were unmodified blades (Barkai et al., 2005; Gopher et al., 2005; Lemorini et al., 2006) and small flakes (Barkai et al., 2010), and tool edges seldom were renewed. Use-wear data on a spatially limited sample of blades from square K10 (Lemorini et al., 2006) suggest short use lives for the majority of these artifacts.

There is also the matter of the chaotic appearance of some of the cut mark orientations. A quantitative comparison of variation in cut mark angles tests the possibility of greater disorder in the Qesem assemblages relative to MP and early UP cases from Üçağızlı Caves II and I, respectively (Stiner et al., 2009). Here the cut marked specimens are exclusively compact bone fragments from limb shafts, many but not all of which could be attributed to skeletal element. Bone specimens with multiple cut marks were extracted from each

Table 15

Incidence of the dominant cut mark orientations on cut marked bone specimens (% of cut marked NISP) for ungulate remains from Üçağızlı Caves I and II and Qesem Cave.

Site	Period	% Axial	% Diagonal	% Perpendicular
UCI	Early UP	29	71	0
UCI	Initial UP	17	71	12
UCII	MP-upper	12	70	18
UCII	MP-lower	10	74	16
Qesem	AY-II	12	76	12
Qesem	AY-III	4	80	16
Qesem	AY-IV	12	69	19
Qesem	AY-V	12	61	27

assemblage in the order in which they were encountered during general zooarchaeological analysis and therefore are representative. Low-level microscopy (up to 20×) was used to identify tool marks. Measurements of cut mark angles were made on high-resolution digital images, with the natural long axis of the bone oriented vertically.

The sequence in which marks were made by hominins is not known, and hence marks were recorded following a nearest-neighbor rule. Angle measurements on each bone specimen began at the lower left area of the image and advanced to the next closest mark until the angle of every stroke was recorded (Fig. 18). The differences in angles between adjacent cut marks were calculated for the bone specimen—always between 0 and 90°, since the start and finish of each stroke is not known—followed by calculation of the mean of these angle differences. This second statistic, called the "mean difference of adjacent angles"—or MDAA—is the main parameter used to estimate the amount of variation in cut mark angles per specimen. Given that fragment surface areas could affect the number and average orientation of cut marks (Rapson, 1990; Abe et al., 2002), we also estimated fragment surface areas (cm²) by multiplying the length by the width.

A comparison of MDAA values is presented in Fig. 19. Each point represents one bone specimen with multiple cut marks on its surface, and the results are ordered by increasing value to show general tendency for each faunal assemblage. The MDAA per specimen clearly is more variable in the LP. This is true in spite of the fact that fragment sizes (surface areas in cm²) are smaller in the LP sample, and greater on average in the later samples (Table 17). The negative relation between surface area and MDAA is the opposite of what one would expect if lesser surface area had reduced the chance of detecting multiple (multi-oriented) strokes on a given bone specimen. Although the cut mark orientations in the Qesem faunas are indeed more chaotic than in the later cave faunas, it would be an

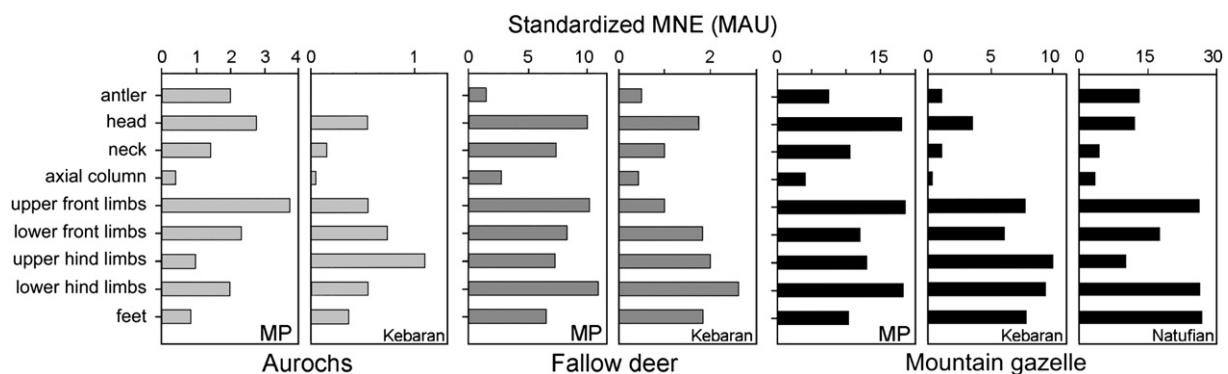


Figure 15. Body part profiles for aurochs, fallow deer and mountain gazelle from the early Middle Paleolithic, Kebaran and Natufian layers of Hayonim Cave, Israel (adapted from Stiner, 2005).

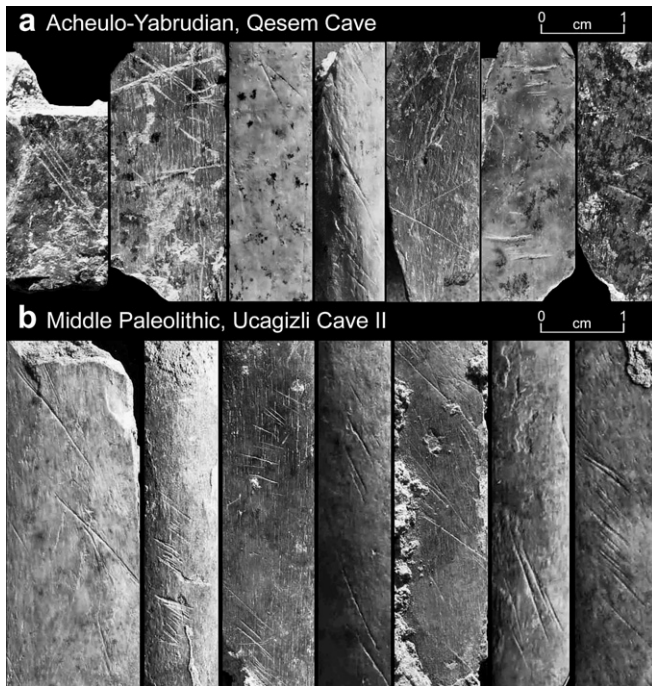


Figure 16. Examples of clustered cut marks on ungulate limb shaft fragments from (a) late Lower Paleolithic Qesem Cave and (b) Middle Paleolithic layers of Uçagızlı Cave II.

exaggeration to claim that the Qesem cut marks are entirely haphazard. This is not the case; MP and UP cut mark samples merely exhibit greater regularity, with careful or lighter use of tools and more consistent orientations of cut marks over small areas of bone. The diverse cut mark orientations suggest that butchering postures, or the ways of holding a body part while cutting away the meat, may have been more varied at Qesem Cave. Wider comparisons to other sites are needed to fully evaluate this phenomenon in the late LP, but the observed differences among the study samples are highly significant (see Stiner et al., 2009 for a complete statistical analysis).

Discussion

The Qesem results present three themes, each with its own set of surprises. The first of these concerns the rather “modern” appearance

Table 16

Percentages of specimens (NISP) with few or many cut marks (a) for all ungulates and medium-sized ungulates from all units combined, and (b) by element for medium-sized ungulates.

(a) Ungulate body size group	NISP sample w/tool marks	% with few cut marks	% with >4 cut marks
All	289	34	3
Medium only	263	28	10

(b) Element(s)	Sampled NISP	% with few cut marks	% with >4 cut marks
Crania	92	0	0
Mandibles	112	4	3
Axial elements	181	1	0
Scapula	16	6	0
Humerus	92	13	5
Radius	74	5	3
Ulna	55	2	0
Femur	89	10	8
Tibia	114	13	5
Large tarsals	25	8	0
Metapodials	416	5	2
Phalanges	60	0	0

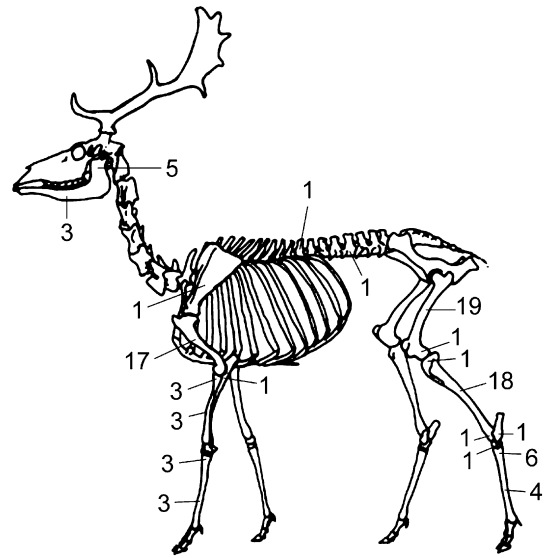


Figure 17. Anatomical distribution of cut marks on medium ungulate bone specimens (NISP counts) from all units of Qesem Cave. Only specimens that could be identified to element are presented in this figure. Right and left sides are combined for paired elements. Note that axial elements are poorly represented in the assemblages. Cut mark distributions do not vary substantially among vertical units.

of several hominin patterns or animal exploitation. The second theme instead focuses on late LP hominin behaviors that seem to contrast with those of the earliest MP though UP. The final theme is biogeographical and relates to the prevailing conditions of climate and the large mammal community during the late LP. These biogeographical indications imply an origin for the hominin population as well.

Modern behavior has both deep and shallow roots

Large game hunting is frequently appealed to as a definition of “modern” human behavior. This monolithic generalization has little ecological traction in theory, and is eroded increasingly by data on the Middle Paleolithic. Attention is now turned back to the LP, an admittedly vast period. The possibility of large game hunting during the LP has up to now been investigated mainly from patterns of carcass access, using data on body part representation and tool marks. In the Levant, cut marks on fallow deer at the Acheulean open site of Gesher Benot Ya’aqov indicate primary access to carcasses, and it seems likely that these deer were hunted by hominins rather than simply scavenged. A case for hunting may also be made for the MIS 13 occupations at Boxgrove in England (Parfitt and Roberts, 1999). Ungulate body part patterns and contextual data from the late middle Pleistocene sites of Hayonim (early MP), Misliya (early MP) and Qesem (late LP) in the central Levant, and at least two sites in Germany, the early MP at Wallertheim and the late LP of Shöningen (Gaudzinski, 1995; Thieme, 1997), all provide strong evidence for large game hunting.

Prime-age-biased prey selection at Qesem Cave adds further support for large game hunting by late LP hominins and extends the history of this niche characteristic back to at least 400 ka. Habitual prime-age-focused hunting of artiodactyl ungulates is ecologically unique to humans, differing as it does from the common patterns of prey age selection by sympatric canids, felids, and hyaenids. The behavior certainly was present in human systems of the early MP, and it was practiced throughout the Old World by Upper Paleolithic times. Just how pervasive or long-standing prime-age-biased prey selection was during the LP is not known. Comparisons to archaeofaunas greater than 1 Ma in East Africa, for example, are prevented

by the low incidence of head parts in the sites, which in itself may testify to important differences in predatory tactics between the early and late LP (see Potts, 1984; Bunn and Kroll, 1986; Brantingham, 1998; Klein, 1999: 243). Given what is known at present, however, we may expect to find significant transitions in predator niche between 1 Ma and 500 ka (Stiner, 2002a).

The Qesem results are essentially the same as the Levantine early MP in the pattern of prey age selection for large game. Another similarity is found to the MP (but not the UP) with respect to small game hunting in that these prey are only slow moving types characterized by high return rates, mainly tortoises (Stiner, 2001, 2005).

The Qesem hunters delayed consumption of some high quality meaty and marrow-rich parts until these items could be moved to the cave. This behavior is widely expressed in the MP and later Paleolithic as well. Ethnographically, foragers' decisions about which prey body parts to transport depend upon food value, weight and travel times between kill sites and safe havens. In the absence of grease-rendering technologies, greater distances are expected to discourage the transport of low utility or very heavy parts to camps. Although the efficiency of the processing technologies is a mediating factor in transport decisions (e.g., grease-rendering), LP and MP processing technologies were less elaborate. To Qesem Cave, hominins transported head parts and high quality upper and lower limb segments of their prey, and they left most of the axial and foot bones behind at kill sites. There is, in addition, a consistent bias against low utility body parts. The consistency of the bias in the Qesem sequence suggests that these hunters were mobile as a rule.

Hearths clearly were magnets for carcass processing activities upon arrival to the cave. Burning damage on bones is pervasive and

often intense. Roasting accounts for only a fraction of this damage, since burning frequencies differ by skeletal element but not by element sub-portions, and specimens generally are charred through-and-through. The first observation indicates intentional and highly preferential redistribution of prey parts in relation to hearths. The other observations indicate indiscriminate (i.e., accidental) post-depositional burning of debris, probably from frequent hearth rebuilding and burning-over of debris that was never cleared away.

The zooarchaeological results from Qesem Cave seem to raise the uniquely human metaphor of “hearth and home,” as there is evidence for deferred benefits, divided foraging efforts from a central place, cooking, and presumably meat sharing. What does such a foraging base at 400–200 ka imply for hominin social evolution? There is no information on the intentions of the hominins who carried meat to Qesem Cave. However, it would have been very difficult to avoid sharing meat at a small central destination, even if the foragers were attracted mainly by the advantages of processing meat at a facility with a reliable heat source. Intentions in this context matter less from an evolutionary standpoint than the outcomes of meat distribution among group members.

Meat sharing is a central feature of recent hunter-gatherer societies (Hawkes et al., 1991; Kelly, 1995; Winterhalder, 1997; Binford, 2001; Gurven, 2004; Bird-David, 2005; Ichikawa, 2005; Layton, 2005). Meat sharing is a powerful social gesture, because meat (especially meat that contains fat) is a high quality food and among the most difficult of resources to harvest in large packages. Meat sharing behavior should therefore signal important evolutionary developments in hominin social relationships (e.g., Hawkes et al., 1991). G. Isaac (e.g., Isaac, 1978) proposed that clustered bones and stone artifacts in East Africa were evidence of food-sharing at home bases as early as 2 Ma—reciprocity at a central place made divided labor and resource pooling increasingly worthwhile. Isaac's application of the model to early hominins has since been rejected in favor of simpler explanations such as transporting food to safe places in order to buy processing time (Potts, 1984, 1988). Recently, this stimulating question has been reframed around the issues of when and how food processing hubs may have also become selective forums for complex social maneuvers and cooperation. For Wrangham et al. (1999), fire technology is the key, as fire was simultaneously a means for extracting energy from food and the environment more efficiently and a artificial forum that pulled the possibilities for social evolution onto a new path (Foley and Gamble, 2009). As such, fire became both an aid and an anchor in social networking (Gamble, 1999). Gowlett (2006) argues, for example, that some kind of division of labor was needed to

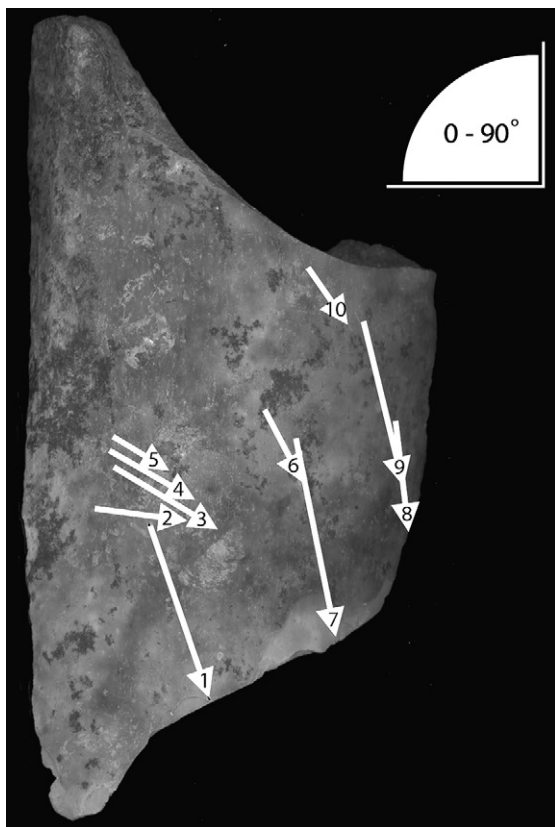


Figure 18. Method for recording orientations of multiple adjacent cut marks on limb shaft fragment surfaces. Specimen orientation is always relative to natural axis or grain of bone. Angle measurements are taken on bone specimen images, beginning at lower left corner, advancing to next closest mark until all strokes have been recorded.

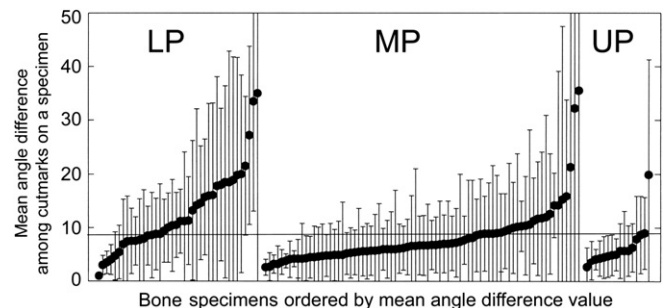


Figure 19. Cut mark angle differences (means and sd) for limb shaft samples from the Acheulo-Yabrudian (late Lower Paleolithic, LP) of Qesem Cave in comparison to a Middle Paleolithic (MP) sample from Üçağızlı Cave II and an early Upper Paleolithic (UP) sample from Üçağızlı Cave I. Each point represents one bone specimen with multiple cut marks on its surface; specimen means are arranged in order of increasing value. Horizontal line represents the mean value for all specimens from all periods.

Table 17
Cut mark angle variation results for Qesem Cave (late Lower Paleolithic), Üçağızlı Cave II (Middle Paleolithic) and Üçağızlı Cave I (early Upper Paleolithic).

Site	Period	N specimens	Group mean angle difference	Mean specimen surface area (cm ²)
Qesem	LP	38	13.4 ± 7.5	6.0 ± 3.7
Üçağızlı II	MP	78	8.1 ± 5.4	12.3 ± 6.5
Üçağızlı I	UP	16	6.4 ± 4.0	14.5 ± 8.3

Group mean is a mean of means for the site and period.

maintain fire and a more extensive social network to reclaim it if a hearth went cold.

Dunbar's social brain hypothesis (e.g., Dunbar, 2003) is most explicit about the mechanics of selection in constrained social spaces. In cultural systems, ecological challenges are increasingly solved socially in day-to-day interactions. Building upon the Theory of Mind concept (Premack and Woodruff, 1978; Churchland, 1984; Dunbar, 1998), Dunbar shows how these social solutions require more elaborate networks built on empathy and an ability to model the intentions of other individuals. Such mental processes put heavy demands on the neocortex area of the brain, the part that underwent rapid expansion in archaic humans between ca. 500 and 250 ka. Increases in group size, or perhaps just more complex social negotiations among individuals, produced an intense selective environment that was bound foremost by its energetic efficiency, in spite of the rising social costs.

Fire technology may have emerged well before 500 ka, but the record of fire makes a considerable leap in ubiquity only after this time. Perhaps Isaac's home base emerged in the later Middle Pleistocene. Whether sharing was intended or unavoidable in hearth-centered social spaces early on is less important than the realization that sheltered spaces were intensely social spaces that posed a unique set of selective conditions. Social roles and contracts could change rapidly under these conditions.

Qesem provides support for the "social brain" hypothesis. The Qesem faunas formed well before AMH are known to have been present in the study area (see Bar-Yosef, 2000). However, human dental remains from Qesem Cave studied recently show close morphological resemblance to the Skhul and Qafzeh hominins (Hershkovitz et al., in press), thus leaving this point open. Clearly the late Middle Pleistocene was a very dynamic phase in hominin behavioral evolution and some so-called modern behaviors have deep roots.

Not so modern

The archaeological and geological evidence from Qesem Cave supports a scenario of repeated short-term, probably seasonal, visits by the hominins. A similar situation is suggested for the late LP occupations of Tabun Cave (Clark, 2008) on the basis of greater technological repetition in the Acheulo-Yabrudian lithic industries than in the MP. The patterns of variation in the late LP seem to have been mostly about the position of the site within the overall territory and the frequency of visits.

Butchering activities in Qesem Cave involved a limited range of tasks, mainly simple defleshing and marrow extraction. The types of tool marks and their anatomical placements on the ungulate bones are redundant, abundant and heavy-handed. There is no evidence of specialized or multi-staged butchering procedures, in marked contrast to the early MP through UP. Most of the cut marks occur on upper limb shaft fragments, areas associated with large masses of soft tissue in live prey. All of the major bone cavities were opened for marrow, and lower limb bones were burned more often than any other skeletal part. When cut marks occur in patches on limb shaft fragments in the Qesem faunas, the orientations are

somewhat more chaotic than expected. The MP and early UP samples instead exhibit a "surgical" quality, with careful use of tools and much consistency in cut mark orientations.

The diverse cut mark orientations at Qesem suggest that butchering postures, or the ways of holding a body part while cutting away the meat, varied a great deal. The cut mark patterns of the MP and early UP samples exhibit greater regularity, with more consistent orientations of cut marks over small areas of bone. The Qesem tool users also appear to have been less precise, or less concerned with precision, in their efforts to separate soft tissue from the bones. Their goals and contingencies may have differed as well.

Among recent humans, the butchering of large animals nearly always involves a chain of focused tasks performed by one or just a few persons, and the butchering process tends to produce well-aligned marks on bone surfaces. These observations have social significance in that butchering procedures guide many of the formalities of food distribution and sharing that follow. Whereas few hard and fast rules about field butchering and body part transport exist among recent foragers (Lyman, 1994; Lupo and O'Connell, 2002; Domínguez-Rodrigo and Yravedra, 2009), the social valuation of meat sharing is universally high and the chains of transfer are often complex.

As a matter of procedural efficiency one individual in these circumstances will tend to produce series of aligned marks, as long as their posture remains constant—so the mean difference between adjacent angles will be low. Given that a skillful modern butcher can take apart a deer carcass with minimal tool damage to bone surfaces, most cut marks on bones from prehistoric sites are probably incidental to or errors in the butchering process. Some errors must be due to variation in individual skill. Additionally, the consequences of chipped stone tool edges meeting bone may vary from neutral to costly with respect to raw material availability, investment in tool production, tool maintenance or some combination of these factors. The degree of redundancy and the cumulative pattern of errors in an archaeological culture therefore may reveal something about the organization of the technological system and costs, not to mention the social interactions of which the technology was a part.

The butchering patterns at Qesem Cave are somewhat at odds with what we are accustomed to finding in the faunas generated by foragers of later Paleolithic periods and suggest a distinct method of communal feeding. Hypothetically, we may be seeing evidence of a simpler or less evolutionarily derived pattern of meat consumption that was social but less canalized than those typical of MP and later humans. The evidence for procedural interruptions or diverse positions while cutting flesh at Qesem Cave might reflect, for example, more hands (including less experienced hands) removing meat from any given limb bone, rather than receiving shares through the butchering work of one skilled person. Several individuals may have cut pieces of meat from a bone for themselves, or the same individual may have returned to the food item many times. Either way, the feeding pattern from shared resources appears to have been more individualized than is typical of later cultures, with limited or no formal "apportioning" of meat.

The differences in cut mark angle variation between the LP and later samples in this study are statistically robust. Only continued comparisons can confirm (or disconfirm) the differences we suggest for the mechanics of meat sharing between the late LP and the rest of the Paleolithic. The Qesem results also beg for a conceptual unpacking of terms such as "systematic" butchering and "dexterity" from an evolutionary point of view. It is too easy at present to reach opposing conclusions from the same or very similar kinds of data on carcass processing. This is less a problem of observation and recording than it is one of the frameworks used for

interpretation. Experimentation and ethnoarchaeology have proved their value for exposing the sources of possible variation and its causes, but only within the limits of modern human tendencies. Basic biomechanics and anatomy represent the few common threads through time that may allow us to draw inferential links to ancient tool use, even if the hominins were physically stronger and the prey bigger or smaller in the past. If the tendencies noted at Qesem Cave for tool mark patterns prove to be widespread, the data may expose subtle but potentially important differences in the practical and social mechanics of meat sharing between the late Lower Paleolithic and the Middle Paleolithic.

Biogeography

The Acheulo-Yabrudian faunas of Qesem Cave formed when Palearctic animals dominated the Mediterranean coastal hills region. By ca. 400 ka, when the Qesem series began to form, the Afro-Arabian species once common to the southern Levant had all but disappeared. In fact the taxonomic spectrum of the Qesem faunas most closely resembles those of the Acheulo-Yabrudian and early MP faunas of the Adlun Caves, located 150 km to the north. The strictly Eurasian character of the Qesem macrofaunas represents a compositional extreme in the biochronology of the southern Levant.

The monotony in prey species composition through 7.5 m of cultural strata in Qesem Cave could be taken either as evidence for relatively short intervals of cultural accumulation within the framework of a longer geological chronology or long-term consistency in environmental conditions. However, speleothem data suggest that cool-moderate conditions may have characterized the entire span from 400 to 200 ka; the later part of the faunal series seems to fall within MIS 7 (Gopher et al., 2010), a long “interglacial” stage preceded and followed by moderate glacial conditions.

The large mammal community of the Mediterranean hills area underwent another significant change around the time of the Lower-Middle Paleolithic transition, apparently with the close of the Qesem sequence. A sudden influx of mountain gazelles between 200 and 170 ka coincides with the early MP at Hayonim and Misliya caves. The success and growing numbers of gazelles in the study area thereafter suggests an expansion of open land habitats and fragmentation of woodlands. Environments of the Jordan Rift valley to the east and arid grassy basins to the south must have re-joined at this time.

Qesem presents us with a distinct combination of “modern” and pre-modern socioeconomic behaviors in late LP hominins. The biogeographic evidence tells us that these developments unfolded in a distinctly Eurasian biotic context, independent of the influx of Anatomically Modern Humans that soon followed.

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