

Taphonomy and zooarchaeology of a high-altitude Upper Pleistocene faunal sequence from Hovk-1 Cave, Armenia

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ABSTRACT

The Caucasus is a key region for the study of hominid evolution and Neanderthal ecology. Taphonomic and zooarchaeological studies of sites from this region are few and only focused on sites at low-to-mid altitude zones with evidence of relatively intensive hominid occupation. This study focused on the taphonomic and zooarchaeological characteristics of a high-altitude site from the Upper Pleistocene – Hovk-1 Cave – looking at diachronic change in both natural and cultural processes which shaped the faunal assemblage. Results best fit a model in which the bones of most large mammals, mainly ungulates (wild goat, *Capra aegagrus* and red deer, *Cervus elaphus*) and cave bears (*Ursus spelaeus*) accumulated naturally through pitfalls, with minimal input from human or carnivore activity. This accumulation is characterized by a high frequency of complete ungulate and carnivore bones, a bear assemblage which is dominated by young-adults and a wild goat assemblage that includes juvenile and young-adult individuals. Our taphonomic reconstruction serves as a point of reference for comparative studies of palaeoenvironments and human subsistence patterns of Middle and Upper Palaeolithic sites in the Caucasus and broadens our perspective on hominid occupation and ecological adaptation in other high-altitude world regions.

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1. Introduction

Current research on Upper Pleistocene archaeofaunal assemblages is biased towards anthropogenic assemblages in low-altitude regions (<1500 m above sea level (asl)). Most of these assemblages represent the debris of daily hunting and gathering activities and often show abundant evidence for human modifications, such as cut marks and burnt bones. Such human-produced faunal accumulations indicate cultural and social preferences for certain prey taxa, hunting habitats and food-procurement activities. Whereas hominid-produced assemblages provide a wealth of information on prehistoric lifeways and the evolution of human hunting and subsistence behavior, they offer an incomplete picture

of the palaeoenvironments of Palaeolithic societies. On the other hand, faunal assemblages in high-altitude regions can provide a more complete picture of the palaeoenvironment and, because these locations seem to have been little exploited throughout most of human history, these assemblages also provide an important perspective on hominid ecological adaptations during the Upper Pleistocene and late expansions to new environmental zones (Aldenderfer, 2006; Bernard-Guelle, 2002; Pacher, 2004, 2008; Tillet, 2002).

Hovk-1 Cave is a high-altitude site (2040 m asl) in the Lesser Caucasus Mountain Range with a stratigraphic sequence which was formed during Marine Isotope Stages (MIS) 5–3 (~115–35 ka BP). The deposits contained a small number of lithic artefacts associated with a Mousterian industry as well as several ash spreads. These artefacts and fire spots indicate that the site was visited sporadically by small and mobile groups (Pinhasi et al., 2008, 2011). Whereas no human fossil remains have been discovered at Hovk-1 Cave or surrounding areas, the hominid groups that occupied Hovk-1 Cave and neighboring regions during the Middle Paleolithic were most likely Neanderthals. This is based on the fact that so far

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Middle Palaeolithic fossils which have been recovered from the northwestern slopes of the Greater Caucasus, from the sites of Mezmaiskaya, Barakaevskaya and Monasheskaya, and from the southern slopes of the Greater Caucasus from the sites of Djrchula, Bronze Cave, Ortvale and Ortvale Klde, and a partial in western Georgia were all taxonomically attributed to Neanderthals (Gabunia et al., 1978; Golovanova et al., 1999; Liubin, 1989).

After several decades of research on the prehistory of the Caucasus only a handful of projects have produced faunal assemblages from well-controlled chronological contexts, which have undergone systematic and detailed taphonomic analysis. A number of large scale excavations of stratified cave sites during the last two decades have produced high-resolution chronologies for Upper Pleistocene deposits and included in-depth analyses of rich faunal assemblages. These include Dzudzuana and Ortvale Klde caves in western Georgia at the southern slopes of the Caucasus (Adler et al., 2006; Bar-Oz and Adler, 2005; Bar-Oz et al., 2007; Bar-Yosef et al., 2011) and Mezmaiskaya Cave, Northwestern Caucasus (Cleghorn, 2006; Golovanova et al., 2010). Additional ongoing and promising projects include excavations at Azokh Cave in Nagorno-Karabakh, i.e. in the south-eastern part of the Lesser Caucasus (Fernandez-Jalvo et al., 2010), the open-air site of Kalavan-2 in Armenia (Ghukasyan et al., 2011), Bondi Cave (Tushabramishvili et al., 2012) and Undo Caves in western Georgia and the caves of Lusakert-1 and Aghitu-3 in Armenia.

The emerging picture of subsistence strategies in the Caucasus is that both medium and large-sized ungulates (mainly wild goat and Caucasian bison) were actively hunted by both Middle and Upper Palaeolithic hominids (Adler et al., 2006). Some of the most important evidence is an abundance of butchery marks on skeletal remains of various prey taxa and mortality profiles that show clear selection of prime-age individuals (Adler et al., 2006; Bar-Oz and Adler, 2005; Baryshnikov and Hoffecker, 1994; Cleghorn, 2006). Some variation among sites in the frequency of prey types appears to reflect seasonality in prey abundance and scheduling of resource exploitation activities as well as choice of hunting habitat (Bar-Oz et al., 2007; Cleghorn, 2006; Hoffecker and Cleghorn, 2000; see

also Bar-Oz et al., 2009). The evidence from the southern Caucasus faunal record appears to support models that imply similarities in the ecological niches of Neanderthals and Modern humans (Adler, 2009; Adler et al., 2008; Adler and Tushabramishvili, 2004) but it remains unclear how different populations adapted to and utilized resources in their variable environments and particularly in high-altitude mountainous regions.

Hovk-1 yielded a series of well-preserved faunal samples from four major chronological phases. In previous publications (Pinhasi et al., 2008, 2011), we provided a taxonomic analysis of the micro faunal remains and a preliminary overview of the macrofaunal remains from this cave, and their interpretation and comparison with palaeovegetational and palynological data in an attempt to reconstruct palaeoenvironmental changes through the depositional sequence of the site. Here, we provide a detailed taphonomic analysis of the faunal assemblage to address questions regarding modes of faunal accumulation, level of human involvement in formation of the faunal assemblage and implications for hominid palaeoenvironments and ecological adaptation during the Upper Pleistocene.

2. Site and excavation

Excavation at Hovk-1 was carried out in five seasons between 2005 and 2009. The Hovk-1 geology, lithic assemblage, and chronostratigraphy have been described in detail by Pinhasi et al. (2008, 2011). The cave is situated within the Lesser Caucasus Mountains of northern Armenia (north-easterly Tavush Province, 20 km east of Dilijan, on the southern flank of the Ijevan mountain range) (Fig. 1). The cave is a karstic cavity 2–3 m wide and 14 m long with two galleries (Fig. 2a–b). Faunal assemblages discussed here derive mainly from the excavation of its main gallery. Faunal remains were systematically collected using a grid of 1 m squares and spits of 5–10 cm, while the spatial attributes of each bone were recorded using a Leica Total Station. All excavated sediments were wet-sieved through 1 mm mesh and the dried sediments were hand-picked for small bones.

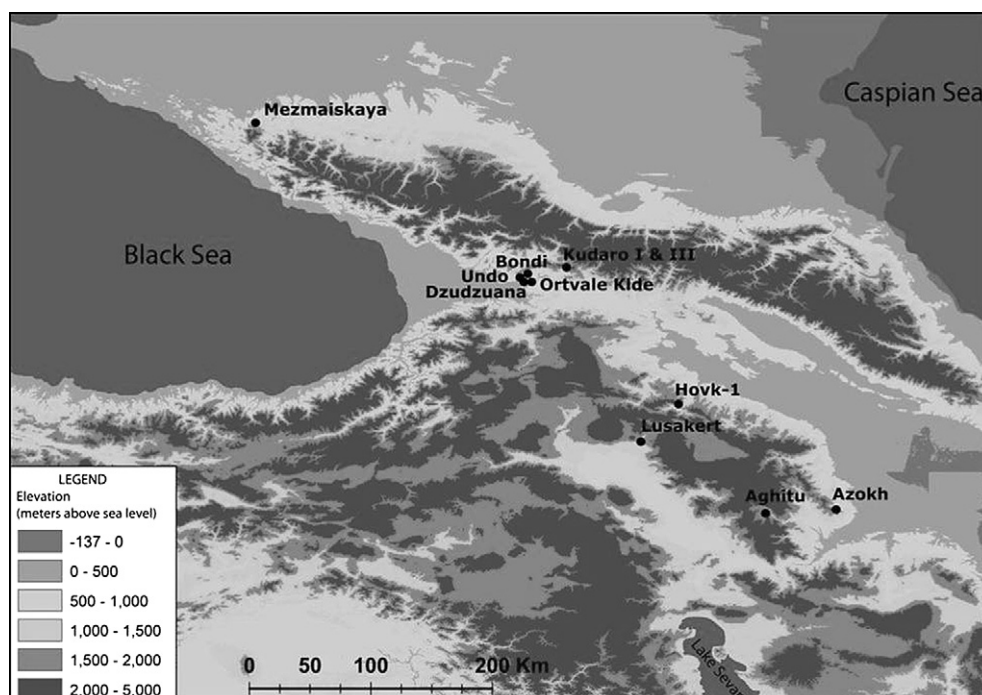


Fig. 1. Location map of Hovk-1 Cave.

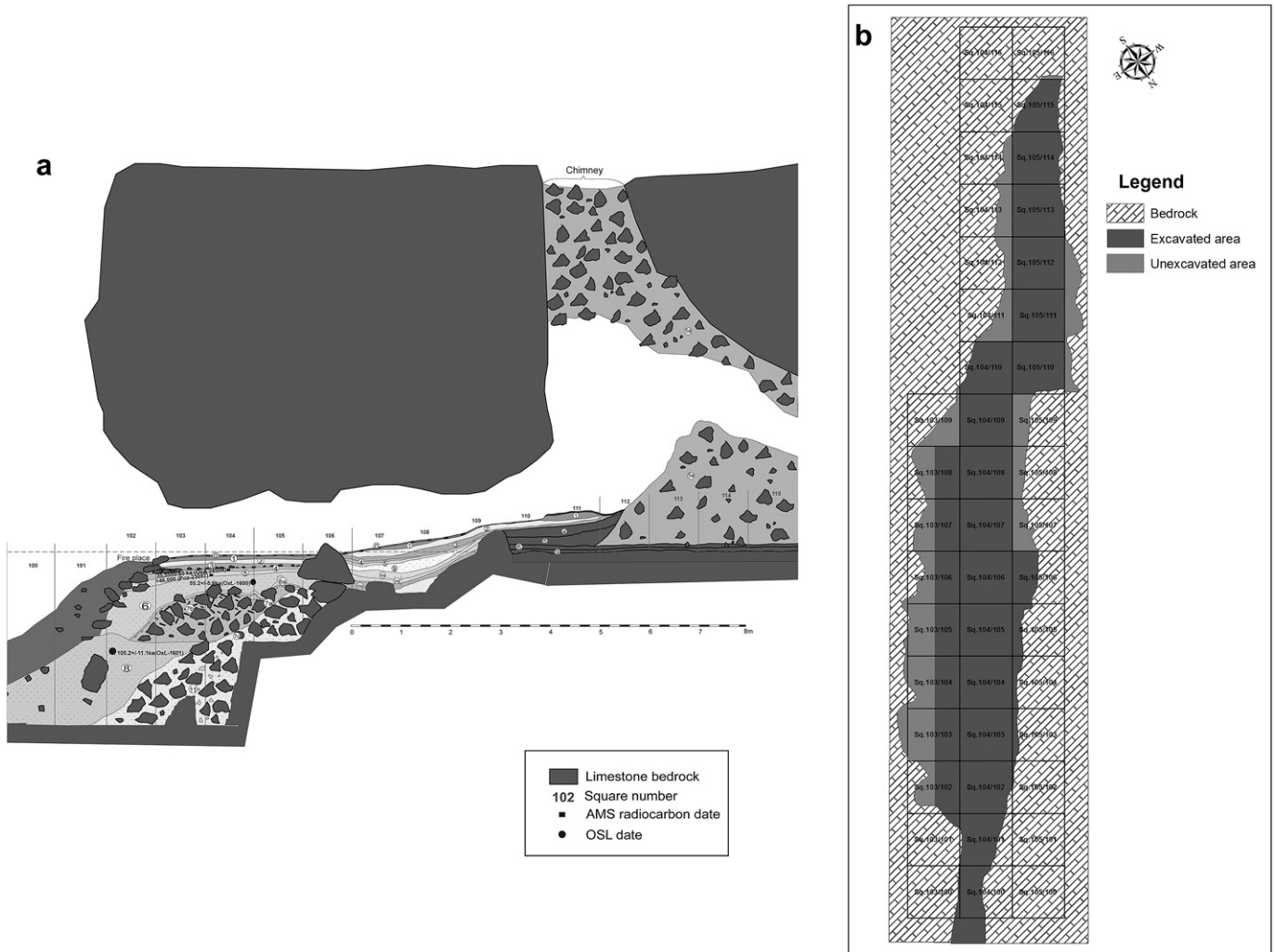


Fig. 2. Plan of Hovk-1 Cave (a) and its section (b).

The depth of the Upper Pleistocene deposits in the main gallery of Hovk-1 is ca. 3.5 m and is divided to 12 stratigraphic units (Table 1). Animal remains were recovered predominantly from Units 8–4 representing the Upper Pleistocene sequence. Units below this sequence (units 11 and 12) were mainly formed from a series of roof collapses and weathering of the cave walls and roof ('cave earths'). Units 10a-c and 9 are also of Pleistocene age but were only detected in the rear part of the cave (Pinhasi et al., 2011).

The uppermost units (Units 3–1) are of late Holocene age based on the presence of Iron Age beads and medieval ceramic fragments did not yield sufficient faunal samples to warrant analysis. The absolute age of units in the stratigraphic sequence is based on U-series, OSL and AMS radiocarbon dates (Table 1) and described in Pinhasi et al. (2008, 2011). A karren was discovered on the steep slope in front of the cave and was filled with colluvial sediments transported from the front section of the cave. Detailed evidence on the geological

Table 1
Summary of chronostratigraphy and geological characteristics of Hovk-1.

Unit	Dating Method	Lab Code	Chronometric Age	MIS Stage	Culture
1	–	–	Late Holocene	1	Iron Age beads and Medieval pottery
2	–	–	–	–	–
3	–	–	–	–	–
4	AMS ¹⁴ C	OxA 24504	35.55 ± 0.65 ka BP ¹⁴ C	3	–
5	AMS ¹⁴ C	Poz-23097	> 46 ka BP ¹⁴ C	3	Late MP
5a	–	–	–	–	–
6	OSL	OxL-1000	54.6 ± 5.7 ka BP ^{OSL}	Early 3	Late MP
6a	U–Th	BIG-UTH-A243	94.2 ± 4.9 ka BP ^{U–Th}	4	–
7	–	–	–	–	–
8	OSL	OxL-1001	104 ± 9.8 ka BP ^{OSL}	5	Early MP
9	–	–	–	–	–
10	–	–	–	–	–
11	–	–	–	–	–
12	–	–	–	–	–
Karren (karstic shaft)	–	–	–	–	–

and sedimentological regime at the cave is provided in Pinhasi et al. (2008).

The evidence for Middle Palaeolithic human presence at Hovk-1 is based on a small number ($n = 50$) of Mousterian artefacts, flakes and lithic debris, some of which were made from local limestone but others ($n = 26$) were made of non-local obsidian and chert. This include four unretouched limestone Levallois points, a limestone flake and a limestone tool fragment in unit 8 (cf. Pinhasi et al., 2008). While the total number of lithics is low, the Levallois points have clear typological similarities with assemblages from the Kudaro-Djrchula group (cf. Meignen and Tushabramishvili, 2006). In addition, several ash spreads were excavated in Pleistocene Units 12–8, 6–4, although no burnt bones or burnt lithic artefacts were recovered. While most of the lithic artefacts were recovered in proximity to some of the animal bones, it was not possible to directly associate any of these and hence to claim that any of part of the faunal assemblage is anthropogenic (see below). Nonetheless, the presence of firepots and lithic artefacts in the various layers indicate that the cave was utilized by hominids in several occasions, which may have comprised several short visits to this high-altitude region.

3. Faunal analysis

We collected zooarchaeological and taphonomic data using coding procedures previously described in Bar-Oz and Adler (2005) and Bar-Oz et al. (2007) and briefly presented below. Specimens were analyzed by excavation spit and stratigraphic unit. Initial identification of skeletal elements and broad taxonomic categories was carried out in the field using a virtual comparative collection of recent skeletons as well as osteological catalogues (Schmid, 1972; Hillson, 1999). Finer taxonomic identifications of closely related species were conducted with the comparative collection of the Yerevan Zoological Institute and the assistance of Prof. Nina Manaseryan, Head of the Department of Mammalogy at the Institute. Identification of remains of cave bear was based on morphological and metrical attributes of cheek teeth (following Baryshnikov, 1998, 2006; Stiner et al., 1998). In general, skeletal elements that could not be assigned to species were grouped according to body size classes. We calculated the number of identified specimens (NISP), minimum number of skeletal elements (MNE) and the minimum

number of individuals (MNI) (following Grayson, 1984; Klein and Cruz-Urbe, 1984; Lyman, 1994).

Skeletal modifications of specimens were inspected macroscopically using a low-resolution magnifying lens ($\times 2.5$). We recorded modifications caused by humans (butchery, burning, and bone fragmentation), animals (rodent gnawing and carnivore puncture, scoring and digestion marks) and post-depositional attrition agents (weathering, trampling, bleaching, abrasion and root activity) (e.g., Behrensmeyer, 1978; Binford, 1981; Villa and Mahieu, 1991; Lyman, 1994; Bar-Oz and Dayan, 2003). Long bone shaft fragments with ancient fractures were examined for the morphology of fracture planes. Fracture angle and outline were assessed in order to determine whether the bone was fractured in a fresh or dry condition (see Villa and Mahieu, 1991 for a detailed typological description of bone fractures). The degree of completeness of the long bone shaft circumference was also recorded (i.e., complete, more than half, or less than half of the complete circumference) as an index of fragmentation for bone marrow extraction (following Bunn, 1983).

Data on the age structure of taxa was based on epiphyseal fusion of long bones, and dental eruption and wear of the deciduous fourth premolar (dP4) and the third molar (M3) using aging schemes from Stiner (1998) for bear and Payne (1973) for wild goat.

4. The faunal assemblage

4.1. Taxonomic composition

The Hovk-1 faunal assemblage is composed almost exclusively of ungulate and carnivore taxa, with a total of 847 skeletal elements representing a minimum of 70 individuals (Table 2; Appendix 1). Considerable variability in taxonomic frequencies can be observed among the stratigraphic units. Fig. 3 shows that in units 8, 4, colluvium and karren ungulates outnumber carnivores and constitute more than 60% of total identified bones. In units 5–7, the frequencies of carnivores either outnumber or are roughly similar to those of ungulates.

The ungulate assemblage of Hovk-1 is dominated by wild goat (*Capra aegagrus*), which constitutes over 70% of total ungulates in all stratigraphic units (Fig. 4). Red deer (*Cervus elaphus*) is the second most abundant ungulate taxon with frequencies ranging

Table 2

Numbers of identified specimens (NISP) and minimum numbers of individual (MNI) by taxa and stratigraphic units.

		Unit 8		Unit 7		Unit 6		Unit 5		Unit 4		Karren		Colluvium	
		NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
Ungulate	<i>Capra aegagrus</i>	38	2	13	1	9	1	60	2	109	4	90	2	145	3
	<i>Cervus elaphus</i>	10	1	2	1	2	1	3	2	10	2	31	2	10	1
	<i>Sus scrofa</i>	–	–	–	–	1	1	1	1	–	–	1	1	4	1
	<i>Bison caucasicus</i>	1	1	–	–	–	–	–	–	–	–	–	–	2	1
	<i>Capreolus capreolus</i>	1	1	–	–	–	–	1	1	2	1	–	–	–	–
Carnivores	<i>Ursus spelaeus</i>	5	1	13	1	53	3	29	1	11	1	69	4	6	1
	<i>Canis lupus</i>	1	1	–	–	1	1	–	–	1	1	8	1	1	1
	<i>Vulpes vulpes</i>	2	1	–	–	4	1	8	1	12	1	4	1	9	1
	<i>Meles meles</i>	2	1	–	–	1	1	1	1	2	1	–	–	–	–
	<i>Martes foina</i>	–	–	–	–	–	–	–	–	1	1	–	–	–	–
	<i>Vormela peregusna</i>	–	–	–	–	–	–	–	–	–	–	1	1	1	1
	<i>Felis lynx</i>	–	–	–	–	–	–	–	–	1	1	–	–	–	–
	Unid. Small carnivores	3	1	2	1	2	1	22	–	9	1	–	–	–	–
	<i>Lepus europaeus</i>	–	–	–	–	–	–	1	1	4	1	–	–	–	–
	Other mammals	<i>Tetragalus caspius</i>	–	–	–	–	–	–	1	1	1	1	–	–	1
<i>Fulica atra</i>		–	–	–	–	1	1	–	–	–	–	–	–	–	–
<i>Pelecanus onocrotalus</i>		–	–	–	–	–	–	–	–	–	–	–	–	1	1
<i>Bubo bubo</i>		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Unid. Medium birds		–	–	2	1	–	–	–	–	2	1	–	–	2	1
Total		63		32		74		127		165		204		182	

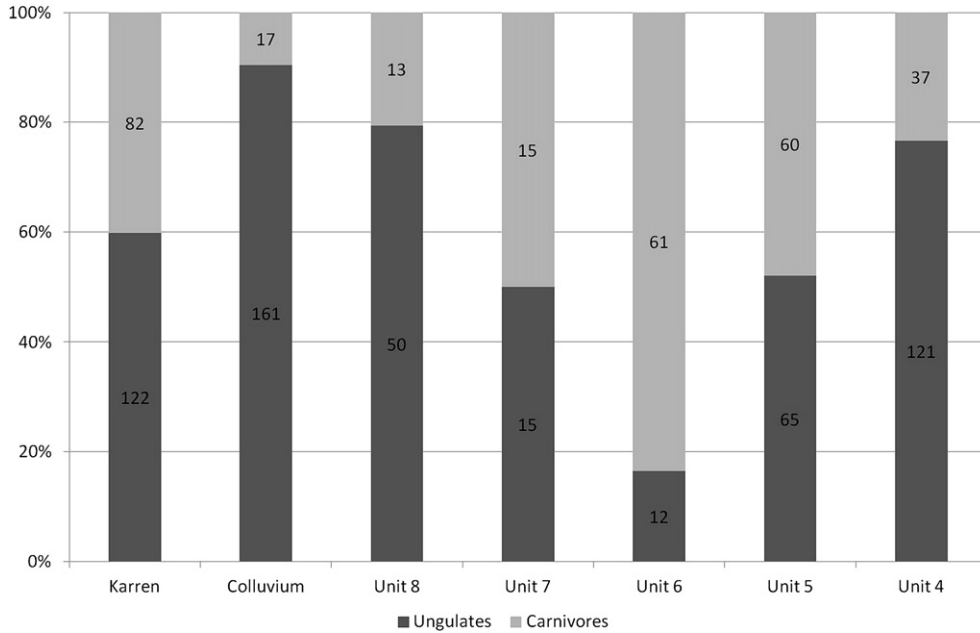


Fig. 3. Ratio of ungulate to carnivore in each of the stratigraphic units at Hovk-1 Cave (NISP is given for each taxa).

between a maximum of about 20% of total ungulates in units 8, 6 and the karren to about 10% or less in other units. Other ungulate species are represented by isolated specimens and include wild boar (*Sus scrofa*), Caucasian bison (*Bison caucasicus*) and roe deer (*Capreolus capreolus*).

Important variations in the frequencies of different carnivore taxa with stratigraphic unit can also be observed in Fig. 5. Cave bear (*Ursus spelaeus*) is the dominant carnivore taxon (>70%) in units 7, 6 and the karren. In all other units the proportion of bear is lower than 50% and there are higher frequencies of small carnivores and wolf (*Canis lupus*). Among the small carnivores the most abundant

is the fox (*Vulpes vulpes*). Other small carnivores include common badger (*Meles meles*), pine marten (*Martes foina*), marbled polecat (*Vormela peregusna*) and lynx (*Felis lynx*).

The cave bear remains from Hovk-1 represent at least 12 individuals, which are widely distributed across the stratigraphic units and intermingled with the remains of other taxa including ungulates and other carnivores. The mean length of upper and lower premolar and molar teeth of cave bear remains is shown in Appendix 2. We did not recover any bear specimens in articulation during excavation although most were uncovered complete and showed no evidence of modification due to human or carnivore

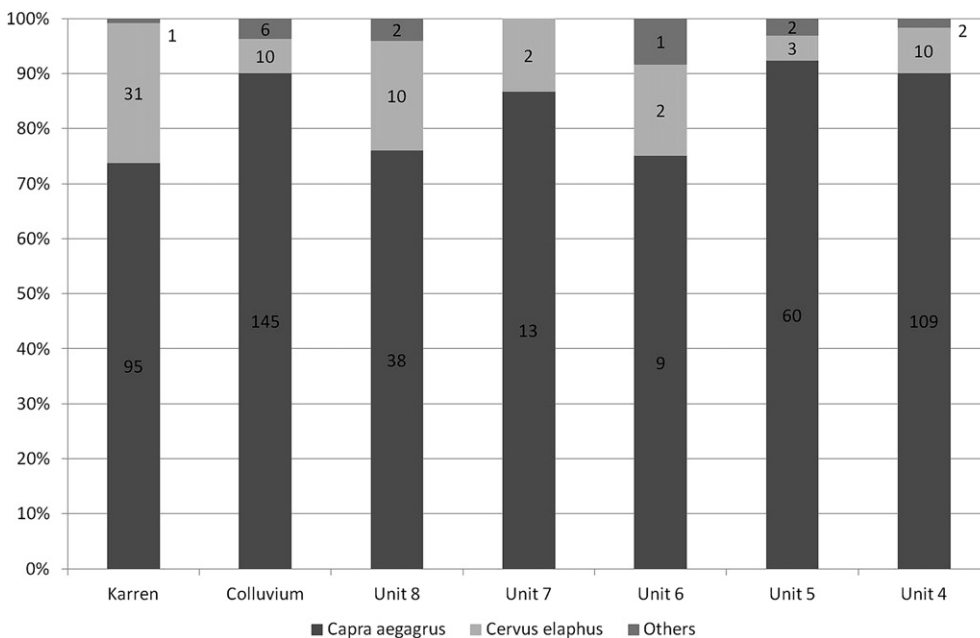


Fig. 4. Relative frequencies of different ungulate species in each of the stratigraphic units at Hovk-1 Cave (others include Caucasian bison, wild boar and roe deer; NISP is given for each taxa).

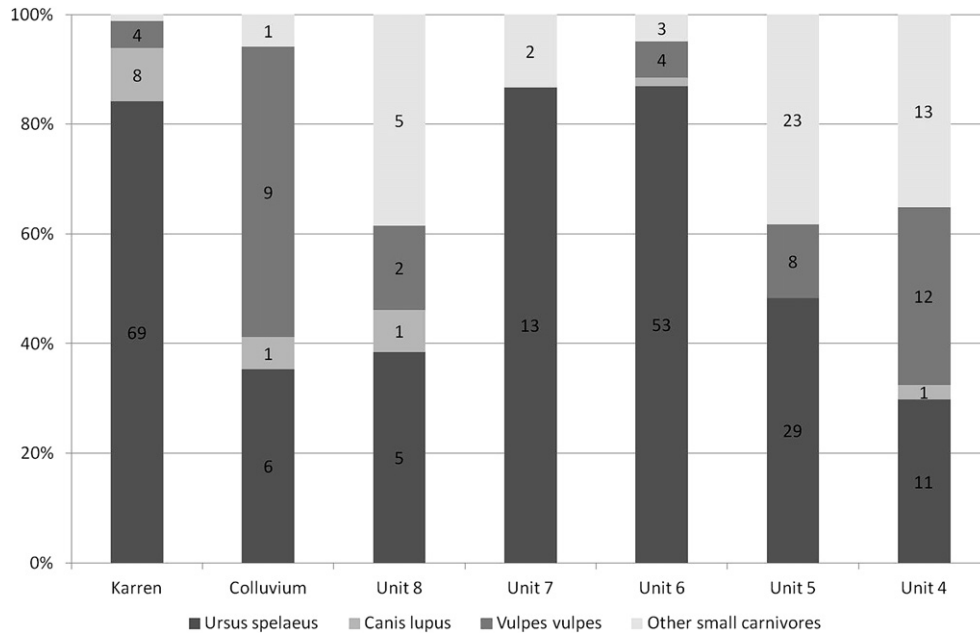


Fig. 5. Relative frequencies of different carnivore species in each of the stratigraphic units at Hovk-1 Cave (others include common badger, pine marten, marbled polecat and lynx; NISP is given for each taxa).

activity. In addition, a few of the bear remains were found in a vertical position (Fig. 6). This suggests that a significant source of deposition was also from above through the chimney rather than through the main entrance.

4.2. Aging of bear and ungulate remains

Data on dental eruption and wear of bear remains are shown in Table 3. Though sample size of ageable teeth is small it appears that all of the remains belong to prime-adult individuals (Fig. 7). In our analysis we separated the sample into three broad age groups: None of the specimens could be attributed to juveniles which we define as the age category between birth and the age at which the deciduous lower fourth premolar normally shed or old adults (i.e., more than half of the lower third molar crown is worn).

Only a small number of wild goat specimens from different stratigraphic units were amenable for aging. Those include equivalent ratio of juvenile and prime-adult individuals and a few specimens belonging to old adults (Table 4). Presence of juveniles in similar frequency to prime-adults in Hovk-1 Cave may also reflect

good preservation conditions and caution is needed in interpretation. Samples from other ungulate taxa were too few to allow reliable aging (Table 4).

4.3. Completeness, preservation and bone fragmentation

The faunal assemblage exhibits exceptionally good preservation in most stratigraphic units (Table 5). Our observations also indicate little variation in preservation conditions among the different taxa. Low rates of *in situ* bone attrition are evidenced by the presence of porous and low density skeletal parts of both immature and adult animals and the fresh appearance of most bone surfaces. Similarly, we found no relationship between the clumped assemblage of wild goat bone survivorship (%MNI) and bone density (data from Lam et al., 1999) (Spearman's $r = 0.35$, $P = 0.12$), indicating that density mediated bias was not a major factor in altering and modifying the skeletal-part representation. Thus, it appears that post-depositional attrition processes did not play a major role in formation of the assemblage. In addition, the rate of bone fragmentation is low and many of the bones are complete (Appendix 1). In addition, striations due to trampling are rare in all stratigraphic units indicating little activity of either humans or other animals within the cave environment.



Fig. 6. Cave bear femur in vertical position (Unit 5a, Sq. 105/112).

Table 3

Teeth eruption and wear of Hovk-1 cave bears divided into three age classes (juvenile, prime-adult and old-adult).

		# Teeth	Juvenile	Prime Adult	Old Adult	Sum
Unit 6	P4 Max	3	0	3	0	
	M1 Max	1	0	1	0	
	M2 Max	2	0	2	0	
	M2 Man	4	1	3	0	
	Sum	10	1	9	0	20
Unit 8	P4 Max	1	0	1	0	2
Karren	P4 Max	2	0	2	0	
	M1 Max	6	0	6	0	
	M2 Max	5	0	5	0	
	M2 Man	3	1	2	0	
	Sum	16	1	15	0	32
		27	2	25	0	54

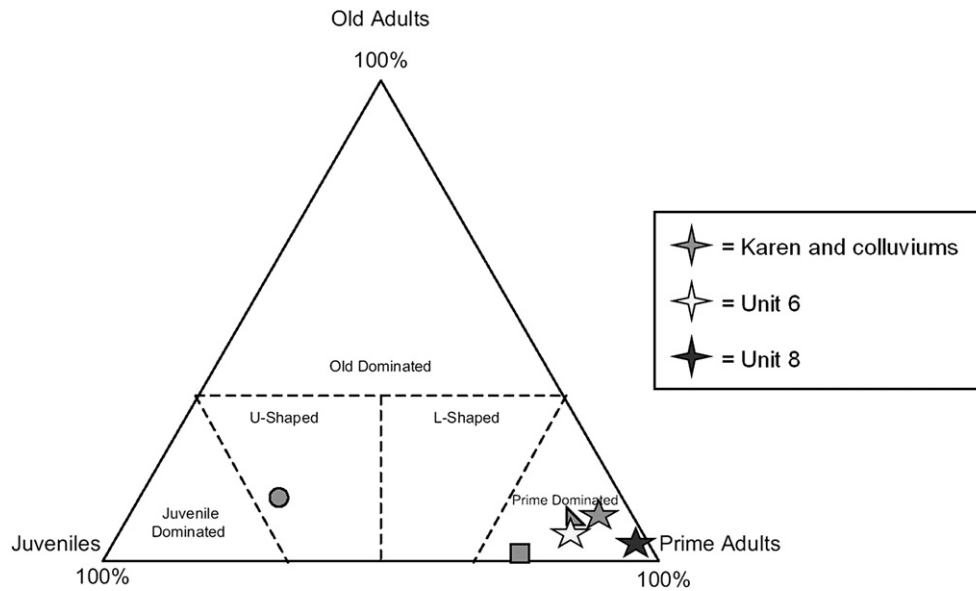


Fig. 7. Ternary plot showing the age profile of Hovk-1 cave bears divided into three age classes (juveniles, prime-adult and old-adult) compared to Yarımburgaz Cave (circle; source: Stiner, 1998) and two natural trap assemblages of black bear (*Ursus americanus*; triangle – Lawson Cave, square – Jerry Long Cave; source: Wolverson, 2006).

The sample of cave bear and wild goat from each of the stratigraphic units is too small to allow the reconstruction of detailed profiles of skeletal element distribution. Nevertheless, it appears that elements of all body parts are represented in the assemblage including cranial and axial elements and long bones as well as toes of both wild goat and cave bears (Appendix 1).

4.4. Modifications due to carnivore activity

Destruction of skeletal elements by carnivores appears to have been minimal. We found only a small number of carnivore gnawing marks including tooth scores, punctures and ragged or crenulated edges on several ungulate and cave bear specimens (Table 5). Sizes of tooth punctures and the overall characteristics of the marks suggest that they were made by both large carnivores such as wolves and small carnivores such as foxes. In addition, the characteristic marker of carnivore accumulated assemblages of chewed long bone epiphyses is not evident in the Hovk-1 material. Many of the long bone specimens of both ungulates and bears retain intact epiphyses. Rodent gnaw marks are absent.

4.5. Modifications due to human activity

The good state of preservation of bone cortical surfaces allowed us to inspect for surface modifications due to human activity in

Table 4

Summary of aging from teeth and bones of wild goat, roe deer, red deer and wild boar from Hovk-1 Cave.

		Juvenile	Prime Adult	Old Adult	Aged NISP
Unit 4	Wild goat	2	2	–	4
Unit 4	Roe deer	–	2	–	2
Unit 5	Wild goat	–	1	–	1
Unit 5	Red deer	1	1	–	2
Unit 6	Wild Boar	–	1	–	1
Unit 8	Wild goat	–	1	–	1
Unit 9	Wild goat	1	–	–	1
Colluvium	Wild goat	3	2	2	7
Karren	Wild goat	1	1	1	3
					22

a relatively large sample of specimens. This analysis demonstrates that butchery and processing marks are absent. Similarly, there is no evidence for hammer-stone percussion due to intentional splitting of bones for marrow extraction and as mentioned above the majority of the bones are remarkably complete. In addition, signs of burning are also absent.

The majority of limb bone fractures are of the old-dry type category (based on Villa and Mahieu's, 1991 typology) indicating that the low frequencies of fragmentation are mainly due to post-

Table 5

Frequencies of bone modifications from Hovk-1 Cave faunal assemblage according to stratigraphic units.

	8	7	6	5	4	Karren and Colluvium
<i>Ungulates</i>						
Burned	0	0	0	0	0	0
Butchery marks	0	0	0	0	0	0
Per percussion marks	0	0	0	0	0	0
Porus and low density bones	+	+	+	+	+	+
Immature individuals	+	–	–	+	+	+
Eroded bones	n 4/42	0	0	1/17	2/77	31/101
	% 10%	0%	0%	6%	3%	31%
Root-marks	n 1/42	0	0	2/17	0	28/101
	% 2%	0%	0%	12%	0%	28%
Weathered (≥stage 2)	n 5/31	0	0	0	0	40/101
	% 16%	0%	0%	0%	0%	40%
Gnawed (carnivore)	n 9/42	0	0	1/17	4/77	5/101
	% 21%	0%	0%	6%	5%	5%
<i>Cave bear</i>						
Burned	0	0	0	0	0	0
Butchery marks	0	0	0	0	0	0
Per percussion marks	0	0	0	0	0	0
Porus and low density bones	+	+	+	+	+	+
Immature individuals	+	–	–	–	–	+
Eroded bones	n 1/5	0	1/53	0	0	17/69
	% 20%	0%	2%	0%	0%	34%
Root-marks	n 0	0	3/53	1/29	0	9/50
	% 0%	0%	6%	3%	0%	18%
Weathered (≥stage 2)	n 0	0	1/53	0	0	16/50
	% 0%	0%	2%	0%	0%	32%
Gnawed (carnivore)	n 0	1/13	4/53	0	0	0
	% 0%	8%	7%	0%	0%	0%

depositional processes (Table 6). The majority of specimens with broken long bone shafts exhibit dry fractures resulting from non-nutritive breakage caused by trampling and/or sediment compaction of bones. Fresh green fractures associated with processing of the bones for nutrient extraction occur in low frequencies in all units in the case of both ungulates (<22%) and cave bears (<11%). These patterns suggest that the majority of bones were broken naturally and post-depositionally. Over 75% of limb bone shafts retained full circumference which implies limited or no intentional breakage and further supports the general lack of clear evidence of human influence on the faunal remains (see Bunn, 1983) (Table 6).

5. Discussion

5.1. Assemblage formation

The archaeofaunal assemblage from the high-altitude site of Hovk-1 Cave shows no direct evidence for the involvement of humans, and includes scanty evidence for carnivore influence on assemblage formation. The assemblage is characterized by an exceptional state of bone preservation with limited damage due to aerial exposure indicating rapid burial and accumulation of the deposits within the cave. High state of completeness of the assemblage is shown by the broad representation of different parts of the skeleton and intact condition of many of the individual skeletal elements of different taxa. The majority of long bone fragments have dry fractures and retain a considerable proportion of the shaft circumference both suggesting low levels of breakage. These data suggest that the bone fragmentation resulted mainly from post-depositional attrition rather than human bone-processing activities. Clear signs of human modification such as burning, percussion and cut marks are altogether absent. This clearly supports interpretations that the few lithic artefacts

represent short-term and highly sporadic human visits to the site during which there was little anthropogenic impact on bone accumulation (Pinhasi et al., 2008, 2011). Hence, the bone accumulation in Hovk-1 was for its most depositional episodes driven by non-anthropogenic accumulation processes.

The lack of observed skeletal modifications resulting from human processing, butchery and consumption is in marked contrast with anthropogenic archaeofaunal assemblages from other Middle and Upper Palaeolithic cave sites in the southern Caucasus where evidence for the role of humans in assemblage formation is abundant. Assemblages from recently studied cave sites including Ortvale Klde and Dzudzuana in western Georgia and Kalavan-2 in Armenia show considerable fragmentation with high proportions of fractures resulting from green-fresh breakage and abundance of butchery marks from all stages of carcass processing and burned specimens (Table 7; full datasets are available in Bar-Oz and Adler, 2005 and Bar-Oz et al., 2007; Ghukasyan et al., 2011). This distinctive taphonomic pattern is associated with the debris from subsistence activities of Palaeolithic hunter-gatherers. It has also been documented in the site of Kotias Klde from the later Mesolithic period in western Georgia (Bar-Oz et al., 2009).

Important clues on the nature and formation of the Hovk-1 assemblage can be gleaned from the taxonomic composition and evidence on mortality patterns of different taxa. The faunal assemblage is dominated by the remains of ungulates, mainly wild goats and red deer, and of cave bears. It includes, in addition, remains of several species of small carnivores, mainly fox. In contrast, other Middle and Upper Palaeolithic faunal assemblages from the Caucasus are typically dominated by one or two prey taxa often including the wild goat and/or steppe bison (*Bison priscus*) or aurochs (*Bos primigenius*) (Adler et al., 2006; Bar-Oz et al., 2007; Baryshnikov et al., 1996; Cleghorn, 2006; Hoffecker and Cleghorn, 2000). Studies of Palaeolithic assemblages from the sites of

Table 6
Frequencies of fracture angle, fracture outline, fracture edge and shaft circumference of ungulates and cave bear bones from Hovk-1.

		8	6	5	4	Karren and Colluvium					
<i>Ungulate</i>											
Fracture angle	Oblique (fresh)	3	14%	–	–	3	18%	5	22%	1	5%
	Right (dry)	14	67%	–	–	8	47%	12	52%	15	75%
	Intermediate	4	19%	–	–	6	35%	6	26%	4	20%
Fracture outline	V-shaped (fresh)	4	19%	–	–	7	41%	3	13%	1	5%
	Transverse	12	57%	–	–	7	41%	13	57%	15	75%
	Intermediate	5	24%	–	–	3	18%	7	30%	4	20%
Fracture edge	Jagged (fresh)	2	10%	–	–	3	18%	2	9%	3	15%
	Smooth (dry)	18	86%	–	–	9	53%	19	83%	13	65%
	Intermediate	1	5%	–	–	5	29%	2	9%	4	20%
Total		21		0		17		23		20	
Shaft circumference	Less than 1/2	0	0%	0	0%	0	0%	1	13%	2	9%
	More than 1/2	1	25%	0	0%	3	27%	0	0%	4	18%
	Complete	3	75%	3	100%	8	73%	7	88%	16	73%
Total		4		3		11		8		22	
<i>Cave bear</i>											
Fracture angle	Oblique (fresh)	0	0%	1	6%	–	–	–	–	0	0%
	Right (dry)	4	80%	14	78%	–	–	–	–	18	90%
	Intermediate	1	20%	3	17%	–	–	–	–	2	10%
Fracture outline	V-shaped (fresh)	0	0%	2	11%	–	–	–	–	0	0%
	Transverse	3	60%	10	56%	–	–	–	–	15	75%
	Intermediate	2	40%	6	33%	–	–	–	–	5	25%
Fracture edge	Jagged (fresh)	0	0%	0	0%	–	–	–	–	0	0%
	Smooth (dry)	5	100%	17	94%	–	–	–	–	14	70%
	Intermediate	0	0%	1	6%	–	–	–	–	6	30%
Total		5		18		0		0		20	
Shaft circumference	Less than 1/2	0	–	0	0%	–	–	0	0%	0	0%
	More than 1/2	0	–	1	20%	–	–	1	33%	3	21%
	Complete	0	–	4	80%	–	–	2	67%	11	79%
Total		0		5		0		3		14	

Table 7

Summary of main taphonomic characters of Hovk-1 assemblage in comparison to other Caucasian zooarchaeological assemblages.

	Hovk-1 Cave	Dzudzuana Cave ^a	Ortvale Klde Rock shelter ^b	Kalavan-2 ^c
Species diversify	High	Low	Low	Low
% Carnivore	High	Low	Low	Low
Main ungulate taxa	Capra	Capra/Bison	Capra	Capra/Bos
Ungulate mortality profile	Attritional?	Prime-dominated	Prime-dominated	–
Ungulate spatial distribution	Some are in vertical position Some in articulation	Most aligned horizontally No articulation	Most aligned horizontally No articulation	–
Ungulate bone fragmentation	Low, most are complete bones	High, most are shaft fragments	High, most are shaft fragments	High, most are shaft fragments
Skeletal element abundance	Full representation	Full representation	Full representation	–
Carnivore impact	Minimal	Minimal	Minimal	Minimal
Butchery marks	Absent	Numerous	Numerous	Numerous
Burning	Absent	Numerous	Numerous	Numerous
Marrow extraction	Absent	Plenty	Plenty	Plenty

^a Bar-Oz et al. (2007).^b Bar-Oz and Adler (2005) and Adler et al. (2006).^c Chukasyan et al. (2011).

Ortvale Klde and Dzudzuana suggest that these patterns are relatively stable through time as they persist throughout the stratigraphic sequences spanning thousands of years as well as across the Middle and Upper Palaeolithic transition in the case of Ortvale Klde (Adler et al., 2006, 2008).

The proportion of carnivores in most of the stratigraphic and spatial units of Hovk-1 is exceptionally high when compared with contemporary archaeofaunal assemblages in the southern Caucasus created largely by hominid activities (Table 7). At Hovk-1 carnivores account for more than 20% of the faunal remains in all units except the colluvium (9.2%) — the latter is the result of massive infilling of exogenous sediments through the chimney. Carnivore proportions are especially high (>40%) in Units 7, 6 and 5 and in the karren. In contemporary anthropogenic assemblages carnivores are generally rare (<6%; Table 7). The Mesolithic site of Kotias Klde, in which there is a high frequencies of brown bear (*Ursus arctos*) remains, is an assemblage which is characterized by clear evidence of bear hunting, including an abundance of skinning and butchery marks on the skeletal remains (Bar-Oz et al., 2009) and is an exception to the general pattern seen in earlier periods.

Age data on wild goats indicate the presence of individuals from a broad range of ages. While data are too scanty to allow the establishment of a mortality pattern they nevertheless do not reveal dominance of prime-age adults that is characteristic of other Middle and Upper Palaeolithic assemblages in the Caucasus (Adler et al., 2006; Bar-Oz et al., 2007; Cleghorn, 2006) and other regions of Eurasia (e.g., Stiner, 1994). Stiner (1990), in her broad synthesis on mortality patterns in ungulate faunal assemblages, linked prime-dominated age assemblages to a targeted hunt of the finest animals in a herd. This pattern is one of the hallmarks of proficient hunter-gatherers of the Upper Palaeolithic and Mesolithic. Prime-dominated mortality patterns have been identified in recent studies in a number of hominid produced assemblages in the Caucasus where wild goats were one of the main prey taxa (Adler et al., 2006; Bar-Oz and Adler, 2005; Bar-Oz et al., 2007; Cleghorn, 2006). In contrast, at Hovk-1 the representation of varied age categories of wild goat throughout the sequence suggests attritional mortality and natural causes of death. A possible cause of death of most ungulates could have been accidental falls into the cave through the chimney which is located at the rear of the cave (Fig. 2). This scenario would agree with the evidence for high skeletal completeness and low frequencies of carnivore modification.

A somewhat different and more complicated picture emerges from age data on cave bear remains. Assemblages of cave bear remains in non-cultural contexts have been described from many sites in western Eurasia from as early as the Middle Pleistocene (e.g., Adler and Tushabramishvili, 2004; Baryshnikov, 1998; Kurten, 1958, 1976; Pacher, 2004; Stiner, 1994, 1998, 1999; Stiner et al.,

1996; Tillet, 2002). Such accumulations are characterized by high proportions of immature and aged individuals. These suggest deaths of the more vulnerable individuals during hibernation which is a high-risk period and an important cause of bear mortality (Gargett, 1996; Kurten, 1958; Lord et al., 2007; Stiner, 1998). Other studies show that cave assemblages that are dominated by young and old-adult cave bears may be due to scavenging carnivore accumulations (Argenti and Mazza, 2006; Gargett, 1996; Niven, 2006).

Age data on the cave bear remains from Hovk-1 show dominance of prime-aged individuals, and together with general lack of evidence of human involvement in assemblage formation suggest a pattern that differs from hibernation assemblages and fits well with characteristics of bear remains in natural traps. Wolverton (2001, 2006) describes such natural assemblages in cave sites with vertical shafts. In these examples, assemblages of black bear (*Ursus americanus*) remains included higher than expected proportions of prime-adult individuals given their frequencies in a stable living population (Fig. 7). According to Wolverton (2001, 2006), the bears are attracted to ungulate carcasses within natural traps and when seeking these they become entrapped themselves. This interpretation of the bear remains combines with the observation that ungulates accumulated through pitfalls and strongly points to a taphonomic history of a natural trap assemblage for the Hovk-1 faunal remains.

Most stable carbon and nitrogen isotope studies of Late Pleistocene cave bears from sites in Europe suggest a strictly herbivorous diet mainly on the basis of observed low ¹⁵N content of bone collagen (e.g. Bocherens et al., 1997, 2006; Lidén and Angerbjörn, 1999). However, a study of isotopic values of cave bears from the cave site of Peștera cu Oase in Romania (Richards et al., 2008) indicate that some of the bears had higher nitrogen values than those usually associated with herbivores. Richards et al. (2008) suggest that a plausible explanation for this observed pattern is that some of the cave bears in this site changed their diet to omnivory with the inclusion of some meat or even of full carnivory. Omnivory among cave bears is also supported by several studies which examined variations in cranial and dental morphology (Figueirido et al., 2009; Mattson, 1998) and taphonomy (Pinto-Llona et al., 2005) among Upper Pleistocene cave bears. Peigné et al. (2009) in a study of dental microwear of cave bears from Goyet (Belgium) showed that during the predormancy period, cave bears' diet is mixed and included bone and meat of ungulates, small vertebrates and invertebrates, as well as plant matter. Whereas these results highlight the potential of future microwear studies to provide more detail on the variation in cave bear diets in different regions and periods, there is a need to study microwear variations among reference bear samples with known diets and with carbon

and nitrogen isotopic data from both temperate and boreal environments (Bocherens, 2009).

Given the taphonomic characteristics of Hovk-1 faunal assemblage with its low anthropogenic impact and distinctive mortality profiles for cave bears and ungulates we suggest that most of the remains result from natural death through pitfalls and natural entrapment. Such faunal assemblages are known worldwide (e.g., Shield Trap Cave: Oliver, 1989; Untermassfeld: Kahlke and Gaudzinski, 2005; Zhoukoudian upper cave: Norton and Gao, 2008; Rantis Cave: Marder et al., 2011). Typical characteristics of such assemblages include little human or carnivore bone modifications, attritional mortality profiles and high bone and skeletal completeness.

5.2. Palaeoenvironmental perspectives

The interpretation of the Hovk-1 faunal assemblage as a natural trap suggests that variations in taxonomic frequencies throughout the sequence have major implications for changing palaeoenvironments, modes of faunal accumulation within the cave or a combination of the two. The large mammal fauna of the site indicate the composition of large-animal communities in this high-altitude region throughout the Upper Pleistocene. Wild goats, bears, boars and wolves are among the most common species above the tree line in alpine environments of western Eurasia (Ivanenko et al., 2004). Other species such as roe deer, red deer, fox and marten typically inhabit forested areas at lower altitudes and only occur in high-elevation environments on sporadic basis. The presence and dominance of the Bezoar wild goat, which commonly inhabits rocky high-elevation areas in relatively dry regions, suggests a distinct association with southern zoogeographic provinces (Vereschagin, 1967). These observations agree with detailed analysis of the micro faunal assemblages of Hovk-1 which highlight the high-altitude nature of the cave fauna as a whole as well as its southern zoogeographic affiliation (see Pinhasi et al., 2011).

Due to the highly complex nature of formation processes of Hovk-1 and complicated nature of faunal–stratigraphic correlation, caution must be exercised in interpreting fine-scale variations in taxonomic frequencies (see also Pacher, 2008). Nonetheless, one striking pattern is the marked reduction in frequency of ungulates, particularly in comparison with the frequency of cave bear remains, in Unit 6. This appears to correspond with observations by Pinhasi et al. (2008, 2011) on the basis of the analysis of lithics and fire spots in Hovk-1, noting that humans visited the cave mainly in two distinct phases: during the formation of unit 8 (early MIS 5, OSL date: 104 ± 9.8 ka BP) and again in while the upper part of unit 5 was accumulating (uncalibrated ^{14}C date: >46 ka BP) and 4 (uncalibrated ^{14}C date: 35.55 ± 0.65 ^{14}C ka BP). The combined evidence from the fauna and stone artefacts may indicate the existence of especially cold conditions and consequent retreat down-slope of the tree line during the formation of Unit 6 (OSL date: 54.6 ± 5.7 ka BP [OxL-1000]). This change is further supported by the relatively high frequency of red deer in the underlying Unit 8 indicating the earlier proximity of forest to the cave. It is likely that a combination of factors including palaeoclimatic fluctuations and the intensity of carnivore presence in the area of the cave influenced human access to this high-elevation location for Middle Palaeolithic populations of the Lesser Caucasus.

6. Conclusions

Our results from the high-altitude site of Hovk-1 fit the general characteristics of early hominid exploitation of other high-altitude regions. Such types of sites have low number of artefacts, they lack evidence for stone-tool manufacture and mostly have low

anthropogenic impact on the faunal remains (cf., Pacher, 2008 and Tillet, 2001 for the European Alps; Bernard-Guelle, 2002 for the Pyrenees). In the Alps, there are around 80 cave sites and rock-shelters which have yielded Mousterian artefacts but only six of these are located at altitudes >1500 m asl: Wildenmanloch (1628 m asl), Chiffon and Tanay (1800 m asl), Chilhöhle (1810 m asl) and Ramesch-Knochenhöhle (1960 m asl), and Salzofenhöhle (2068 m asl) (Tillet, 2001). Many of these sites are also heavily dominated by carnivore remains and often cave bears are the dominant taxa (cf. Pacher, 2008). Together with data from sites in the Alpine region and the Pyrenees Mountains our data from the Caucasus provide a glimpse into the study of short-term Late Pleistocene hominid presence in Eurasian high-altitude zones and the complexities involved in studying the natural and anthropogenic aspects of such sites.

Our zooarchaeological and taphonomic analysis of the Hovk-1 faunal assemblage shows that this is a unique high-altitude Upper Pleistocene site. Skeletal and bone completeness and age data of cave bear and ungulate taxa together with meager evidence of anthropogenic influence show that most of the remains accumulated through natural processes.

On several levels the Hovk-1 faunal assemblage provides new data with which to evaluate the existing mosaic of faunal assemblages from Upper Pleistocene hominid occupations in the Caucasus. We compared the Hovk-1 assemblage with a number of recently studied Middle and Upper Palaeolithic assemblages from well-controlled chrono-stratigraphic and taphonomic contexts, all occurring at altitudes well below 1500 m asl. These assemblages yielded a strong anthropogenic signal and provided clear evidence that both Middle Palaeolithic Neanderthals and later modern humans practiced specialist big game hunting and had distinctive adaptive strategies. In comparison, the Hovk-1 assemblage is characterized by a unique composition of the fauna and an especially high diversity of carnivore taxa.

The view from Hovk-1 provides a broad geographic and altitudinal perspective on hunting adaptations highlighting the distinctness of hominid prey selection strategies and supporting current hypotheses suggesting that the ecological niche of Upper Pleistocene hominids remained stable through time and among separate hominid lineages. Furthermore, the evidence for low-level human presence at Hovk-1 and little if any involvement in exploitation of the fauna indicates that whereas some utilization of high-altitude areas of the Caucasus Mountains did exist during the Middle Palaeolithic it remained minimal.

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Appendix. Supplementary material

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jas.2012.02.014](https://doi.org/10.1016/j.jas.2012.02.014).

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