New data on human behavior from a 160,000 year old Acheulean occupation level at Lazaret cave, south-east France: An archaeozoological approach

Patricia Valensi [a,b,*], Véronique Michel [c,d], Khalid El Guennouni [a], Marie Liouville [e]

[a] Laboratoire Départemental de Préhistoire du Lazaret, CNRS UMR 7194, 33 bis boulevard Franck Pilatte, 06300 Nice, France
[b] Musée de Préhistoire, 171 montée du Château, 06690 Tourrette-Levens, France
[c] Université Nice Sophia Antipolis, Campus Saint-Jean-d'Angély, SJA3-CEPAM-CNRS UMR 7264, 24 avenue des Diables Bleus, 06357 Nice Cedex 4, France
[d] Université Nice Sophia Antipolis, OCA, Géoazur, CNRS UMR 7329, Valbonne, France
[e] IPH, CNRS UMR 7194, MNHN, 1 rue René Panhard, 75 013 Paris, France

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ABSTRACT

The UA 25 archaeostratigraphic unit of Lazaret cave is an exceptional Acheulean occupation level with abundant lithic and bone material and reveals a clear organization of activities carried out in the cave. In this paper, large mammals are studied from an archaeozoological perspective using a variety of methods of analysis, in order to increase our understanding of the behavior, way of life and environment of the Lazaret Acheuleans. During one autumn hunting episode, twenty-three red deer, six ibexes, three aurochs and one roe deer were slaughtered. For the most part, it appears that Anteneanderthals processed these carcasses inside the cave. They then left more than 600 bone remains piled into a heap with a diameter of 80 cm in the middle of the cave. The study of diversity indexes points towards selective red deer hunting, independently of the prey available in the environment. On the other hand, as far as the deer is concerned, hunted animals do not seem to have been selected within the herd on the basis of factors such as age or sex. The presence of the ibex, the second most hunted species at the site, seems to be directly linked to climatic conditions and its relative abundance in the environment.

1. Introduction

The discovery of numerous Acheulean sites across Western Europe has led to the reconstruction of the cultural and morphological evolution of Anteneanderthals (*Homo heidelbergensis*), and to archaeozoological research at reference sites such as El Castillo (Spain) (Klein and Cruz-Uribe, 1994), Kärlich-Seeufer (Germany) (Gaudzinski et al., 1996), Boxgrove (England) (Roberts and Parfitt, 1999) and in France: Biache-Saint-Vaast (Auguste, 1995), Abri des Canalettes (Brugal, 1993), Grotte Vaufrey (Grayson and Delpech, 1994), Caune de l'Arago (Rivals et al., 2002; Lumley et al., 2004b), Terra Amata (Valensi and El Guennouni, 2004; Valensi et al., 2011) and Lazaret cave (Valensi, 2000). These studies examine large game procurement strategies (scavenging, selective or non-selective hunting), carcass processing, and/or the spatial distribution of faunal remains. It is during the Acheulean period that the first

complex structured habitats emerged, as well as selective hunting and sites with diverse functions.

Lazaret cave is a reference site for understanding human behavior at the end of the Middle Pleistocene. The stratigraphic sequence records the cultural Acheulean/Mousterian transition during the course of MIS 6, and selective hunting from the earliest Acheulean deposits onwards, about 190,000 years ago (Valensi, 2000; Cauche, 2012). The multidisciplinary study of each archaeostratigraphic unit brings to light specific aspects of human behavior characteristic of Lazaret cave.

Since Henry de Lumley first began excavating Lazaret cave, 28 human occupation levels attributed to Anteneanderthals (*H. heidelbergensis*) have been discovered. The excavations conducted between 2000 and 2002 focused on the 25th occupation level (archaeostratigraphic unit 25 (UA25)). This outstanding unit yielded abundant faunal and lithic remains and revealed numerous specialized human activity areas. The analysis of UA 25 has been the subject of an important monograph (Lumley et al., 2004a).

The present paper presents the main, largely unpublished results of the zooarchaeological study of the large mammals of Lazaret cave. We chose to base our approach on a variety of analysis

methods: (systematic, taphonomical context, assemblage quantification, animal population structure, bone damage, spatial distribution, and palaeoecology) in order to gain a better understanding of the way the Lazaret Acheuleans hunted.

In the UA25 unit, as in the 24 overlying archaeological layers, the faunal spectrum is mainly composed of red deer with a smaller proportion of ibex (Valensi, 2000). It is important to determine whether the taxonomic composition of the faunal assemblage reflects environmental conditions or if Acheuleans intentionally chose to hunt red deer regardless of the abundance and diversity of other potentially available prey in the biotope surrounding the cave. Different ecological approaches have enabled several hypotheses to be advanced. The exceptional state of preservation of the UA25 unit allows us to identify the different processing stages of large game for culinary or other purposes and also several distinct areas of human activity, the most spectacular being a circular heap, 80 cm in diameter, containing more than 600 large mammal remains.

2. Presentation of the site and characterization of the UA25 archaeostratigraphic unit

2.1. General remarks

The prehistoric cave of Lazaret is situated on the western slopes of Mont Boron to the east of the city of Nice on the French Riviera. Today, the cave is south facing and stands 26 m above sea level, just a few meters from the Mediterranean shore (Fig. 1).

Systematic excavations of the area immediately inside the cave entrance brought to light 28 archaeostratigraphic levels in the CIII stratigraphic unit (from UA1 to UA12) and in the CII upper underlying unit (from UA13 to UA28) (Fig. 2). Taking account of factors such as the association of large mammals and rodents, the evolutionary stage of some taxa, as well as palaeoecological data, these archaeological sediments have been attributed to the last cold period of the Middle Pleistocene

(Valensi, 1994; Desclaux et al., 2000; Valensi and Psathi, 2004; Valensi, 2009). Paleontological data concord with radiometric dating which yields ages between 120 and 190,000 years for the CIII and CII stratigraphic units (Michel et al., 2009, 2011). These ages were determined using the combined ESR/U–Th method on *Cervus elaphus* tooth enamel. The fact that enamel apatite is particularly well preserved at Lazaret cave (Michel et al., 1995) indicates reliable dating.

During human occupation, the cave was located approximately 140 m above sea-level following an important marine regression during MIS 6. The multidisciplinary analyses conducted at this site revealed successive occupations by groups of nomadic large herbivore hunters (mainly red deer and ibex), who set up temporary camps and sometimes occupied the cave for more prolonged periods (Valensi, 1994, 2000; M'Hamdi, 2012). The CII unit contains an Acheulean lithic assemblage with numerous handaxes and some rare Levallois debitage. Above this deposit, the CIII unit is attributed to a Mousterian culture (Cauche *in* Lumley et al., 2004a). More than twenty Anteneanderthalian remains have been discovered, some of which were excavated during the past few years in the upper CII unit, including several teeth, some cranial remains, one humerus and three femurs. One of the most important remains is a sub-adult frontal, discovered in August 2011 in UA28, which presents a transitional morphology between *H. heidelbergensis* and *Homo neandertalensis* (Lumley et al., 2005).

2.2. Archaeostratigraphic unit 25 (UA25)

The abundance of archaeological remains and the rich organic context, made up of a darker, more clay-rich soil than the overlying sediments, made it possible to uncover the entire surface of UA25. By 2002, the excavation extended over a surface of 86 m^2 (Fig. 3). The spatial distribution of the remains revealed several particularly dense concentrations which were later defined as very specific human activity areas. The archaeological material was left *in situ* for almost a year in order to allow for an in-depth observation of the

Fig. 1. Location of Lazaret cave in south-eastern France and view from the cave entrance.
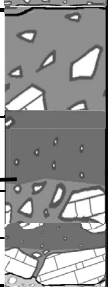
Stratigraphic complex		Archaeo-stratigraphic unit (UA)	Log	Height above sea level (cave entrance)	Lithology	Stone tool industry	Human remains (*de Lumley's excavations*)	Dating (ka)	MIS
E					stalagmitic floor			44 [a] ↕ 108	4
D				26.8 m	breccia closing the entrance				5
C	C III	UA 1 to UA 12			angular blocks and rocks of various sizes in sandy-clayey matrix	Mousterian without handaxes	x	120 [b] ↕ 190	
				24.4 m		Upper Acheulean with rare handaxes	x x x		
	upper C II	UA 13 to UA 24					xxx		6
		UA 25 ←				Upper Acheulean with handaxes	xxxx		
	lower C II	UA26 to UA28					xxxxxxxxxxx		
	C I			21 m			Laz24		
B					beach			< 238 [c]	7
A				19.4 m	beach				9 ?

Fig. 2. Stratigraphic, archaeostratigraphic, typological and chronological context, with the position of the human remains (a. Michel et al., 2011; b. Michel et al., 2009; c. Michel and Yokoyama, 2001).

level and to enhance comprehension of the occupation. In this way, several soil samples were taken and the analysis of the spatial distribution of the remains began before they were studied in the laboratory (Lumley et al., 2004a).

The most impressive concentration of remains was a large heap (80 cm in diameter and 20 cm thick), made up of large mammal bones (area Et, Figs. 3 and 4). Close by, in area E, thirteen whole or fragmented handaxes were found. Many others were also

Fig. 3. The UA 25 archaeostratigraphic unit. A. In the foreground: a heap of large mammal bones, in the background: a corner pocket and the entrance of the cave. B. In the foreground: a small hearth, in the background: the heap of bones, C. The heap of large mammal bones (photos K. Valensi).
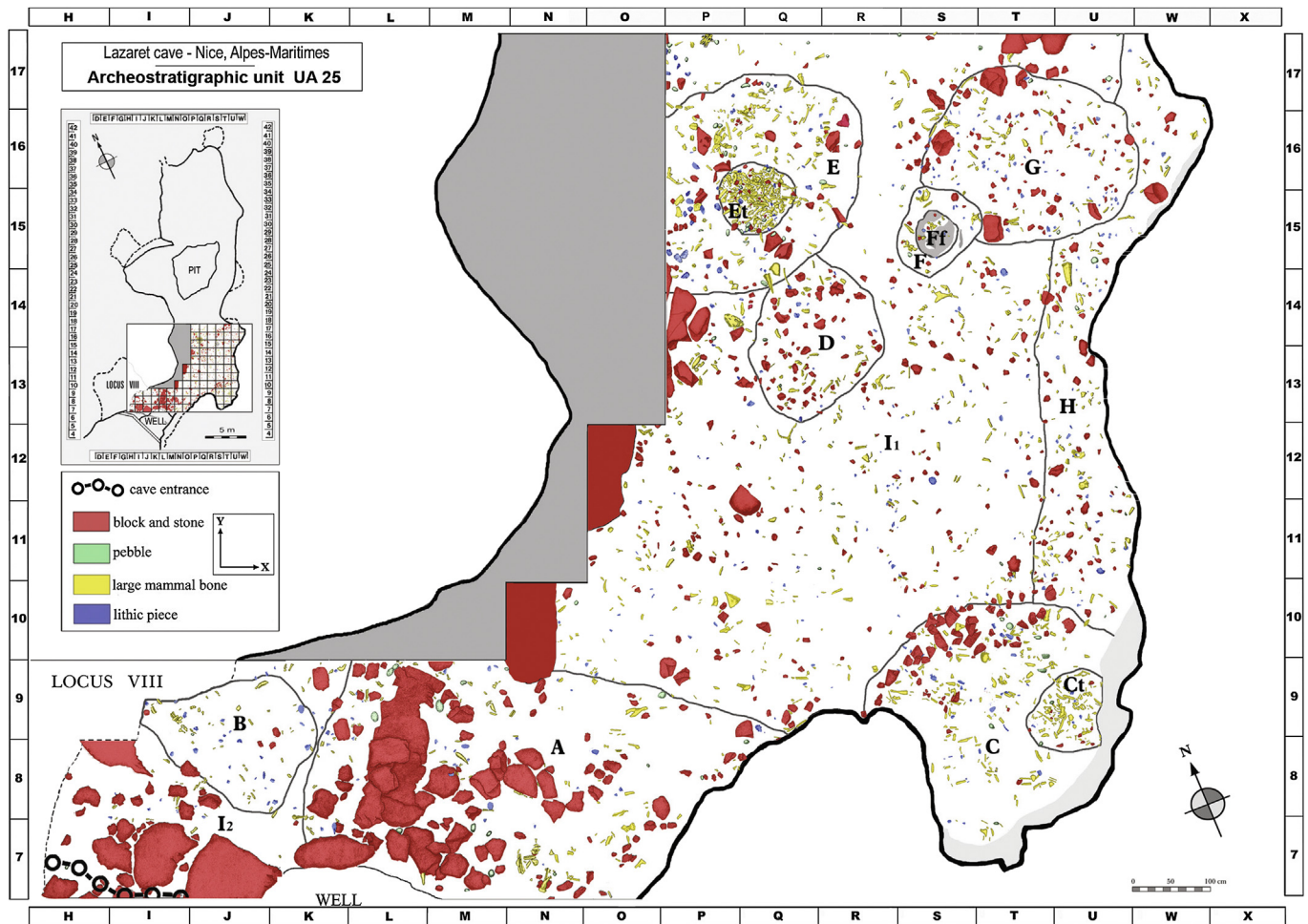
Fig. 4. Plan showing the thirteen distinct concentrations in the UA 25 archaeostratigraphic unit of Lazaret cave (Lumley et al., 2004a,b, modified).

discovered towards the cave entrance (area A). The ashes of a small hearth (area F) underwent micromorphological analysis, revealing the presence of terrestrial and marine plants. Further analysis (morphology, sedimentary compound, micromorphology, magnetic susceptibility, organic macro-remains like algae, marine and land herbs, etc., and analysis of the aromatic elements) revealed that the hearth was used to maintain a smoky fire at low temperature which suggests that its main function was smoking meat from large mammals. Other relevant areas have been also identified, such as a concentration of remains of large herbivores under the east wall (area H), another in a corner of the cave (area C), and a second heap of bones (area Ct). Finally, G area (indicated in Fig. 4) has been defined as an area of roughly-knapped stone chips, large mammal remains and bone splinters. Area B includes numerous lithic items, for the most part large flakes and three handaxes. Areas I1 and I2 contain lower object density although the presence of an abundance of tiny seashells in area I1 led the authors to advance the hypothesis that it was a probable resting area (Lumley et al., 2004a). The presence in area I1 of numerous bone splinters also seems to correspond to a bone breakage area.

3. Materials and methods

3.1. Faunal assemblage

UA25 contains 3260 large mammal remains, of which 1286 have been identified to the species level. Altogether 98% of them are

ungulates and 2% carnivores. The determination rate, defined as the number of taxonomically identified remains compared to the total number of remains, is around 40%, which is high. Compared to the other occupation levels of Lazaret cave (Valensi, 2000), the UA25 assemblage is characterized by an important quantity of large bone fragments, few unidentified splinters, and almost no isolated teeth.

Twenty-two remains have been attributed to carnivores, mainly to wolf (*Canis lupus*). Several bones were gnawed by wolves. Spatial distribution analyses localized carnivore activity areas but these are not taken into account in this paper (wolf activity is confined to before and after the formation of the UA25 layer and is quite marginal) (Valensi *in* Lumley et al., 2004a, p. 426). The herbivores in UA25 are represented by cervids: red deer (*C. elaphus*) and roe deer (*Capreolus capreolus*), and bovids: aurochs (*Bos primigenius*), ibex (*Capra ibex*) and chamois (*Rupicapra rupicapra*). Two elephant molar fragments (*Palaeoloxodon antiquus*) were also discovered. Unlike in other archaeostratigraphic levels of the cave, no *Perissodactyla* remains were identified here.

With 1069 bone and tooth remains, red deer is the predominant species, representing 80.4% of ungulate remains. Red deer remains are present in all sectors of the cave, with an over-representation in the (Et) bone heap (30%). In the same way, 30% of the ibex and roe deer remains are from the Et bone concentration. The aurochs displays a different distribution pattern (Table 1). For each herbivore species, the NISP and MNI are given for the UA25 occupation level as a whole, as well as for the heap of fractured bones (Et area).

Table 1
Lazaret UA25 unit. Number of ungulate remains (NISP and %NISP), by density areas.

Density areas	Cervus elaphus		Capra ibex		Bos primigenius		Capreolus capreolus		Rupicapra rupicapra	Palaeoloxodon antiquus	Canis lupus	Ursus arctos	Lynx spelaea	Felis silvestris	Vulpes vulpes	Total remains	
	NISP	%	NISP	%	NISP	%	NISP	%	NISP	NISP	NISP	NISP	NISP	NISP	NISP	NISP	%
A	70	6.5%	7	6.4%	8	16.3%	3	9.1%	–	–	1	–	–	–	–	99	7.3%
B	18	1.7%	4	3.7%	–	–	1	3.0%	1	–	–	–	1	–	–	27	2.0%
C	94	8.8%	8	7.3%	8	16.3%	5	15.2%	–	–	–	1	1	1	1	131	9.7%
Ct	42	3.9%	5	4.6%	1	2.0%	–	–	–	–	1	–	–	–	–	52	3.8%
D	20	1.9%	3	2.8%	–	–	1	3.0%	–	1	–	–	–	–	–	26	1.9%
E	99	9.3%	6	5.5%	3	6.1%	2	6.1%	–	–	–	–	–	–	–	115	8.5%
Et	329	30.8%	36	33.0%	4	8.2%	13	39.4%	–	–	4	–	–	–	–	388	28.7%
F	9	0.8%	1	0.9%	2	4.1%	1	3.0%	–	–	–	–	–	–	–	13	1.0%
Ff	3	0.3%	–	–	–	–	–	–	–	–	–	–	–	–	–	5	0.4%
G	61	5.7%	5	4.6%	7	14.3%	–	–	–	–	–	–	–	–	–	77	5.7%
H	79	7.4%	7	6.4%	2	4.1%	2	6.1%	–	–	3	–	–	–	–	98	7.3%
I	245	22.9%	27	24.8%	14	28.6%	5	15.2%	1	1	4	2	1	1	1	320	23.7%
Total	1069	100%	109	100%	49	100%	33	100%	2	2	13	3	3	2	1	1351	100%

3.2. Age and sex determination

Seven red deer age categories were defined, grouped into five main age classes for the accurate classification of isolated teeth: immature (Young = Y = 0–27 months), sub-adult (SA = 27 months up to three years), adult (A1 = 3–5 years; A2 = 5–8 years), old adult (OA1 = 8–10 years; OA2 = 10–12 years), and very old adult (VOA>12 years). For immature and sub-adult individuals, the age was estimated on the basis of tooth eruption and attrition (Riglet, 1977; Brown and Chapman, 1991), and also using Klein's calculation method (Klein et al., 1981, 1983).

According to D'Errico and Vanhaeren (2002), the sex of deer can be determined by examining their upper canines. In a previous study, we applied this method to teeth discovered in the upper levels (UA1 to UA21) of Lazaret cave (Valensi and Psathi, 2004), where each archaeological level yielded between 1 and 5 canines. The exceptional quantity of upper canines found in UA25, which is similar to the estimated minimum number of adults, enabled us to calculate the population sex-ratio of an archaeological level in the cave for the first time. Moreover, the wear on each upper canine is determined according to the five wear stages pre-defined by D'Errico and Vanhaeren (2002): from stage 1 corresponding to the youngest adults (between 2 and 4 years old), to stage 5 for very old adults (up to 16 years old).

The red deer hunting season was estimated from the age of immature individuals found at the site. Assuming that the ethology of Pleistocene red deer was very close to that of modern deer, the birth of fawns is expected to occur towards the end of May–beginning of June. Using the young mandibles and teeth found in UA25, we were then able to calculate the hunting season. With this method, precise ages can only be determined for young individuals in their first and second year.

3.3. Skeletal part representation

The analysis of the anatomic elements provides indications regarding meat procurement strategies (hunting or scavenging), and evidence that animals were brought from the kill site to the cave. Transport would have been influenced by factors such as the weight of the animal or the butchered part of the animal and the distance to be covered to bring it to the cave (Perkins and Daly, 1968). Differences in the frequencies of skeletal parts can also be attributed to differential carcass preservation (Klein, 1989) and/or bias due to methodology (choice of excavation area, choice of archaeostratigraphic unit) (Grayson, 1984; Valensi, 2000). Quantifications per anatomic element of the principal ungulates were estimated in terms of NISP, MNI, MNE, MAU and %MAU (for calculation, see Binford, 1978, 1984; Lyman, 1994). Data pertaining to meat procurement and carcass transport were also estimated using Stiner's method. The remains, expressed in terms of MNE, have been grouped in nine anatomical regions: MNI standard = calculated MNE/expected MNE for each anatomical region (Stiner, 1994).

3.4. Palaeoenvironmental study

In order to better evaluate biotope impact on the hunted fauna, we used two indexes commonly utilized in ecology; i.e. richness and diversity factors (Grayson, 1984; Cruz-Uribe, 1988).

The taxonomic richness refers to the number of taxa in the faunal assemblage:

$$R = S - 1/\text{Ln MNI}$$

with S = number of species, MNI = total minimum number of individuals.

The Shannon diversity factor takes into consideration the number of taxa and the comparative frequency of each one:

$$\text{Ish} = -\sum[(\text{MNI sp}/\text{MNI tot})\log_2(\text{MNI sp}/\text{MNI tot})]$$

with MNIsp = minimum number of individuals for each taxon, MNItot = total minimum number of individuals.

This index is calculated for assemblages of at least 25 individuals (MNItot ≥25). A high diversity rate/value can indicate high species diversity and/or an equal distribution of their frequencies.

We used the above indexes to highlight variations in palaeobiotopes. The calculated values are higher during more temperate climatic conditions, revealing a variety of biotopes. In a prehistoric context, these factors also yield information on human subsistence strategies. For instance, low diversity can be explained by the overrepresentation of a single species due to specialized hunting. In order to gain a more accurate interpretation of our data, we calculated these indexes for other types of assemblage: the Lazaret rodents (in order to eliminate the human factor) (Hanquet et al., 2010), the Protomagdalenian level of l'Abri-Pataud, described as a specialized reindeer hunting level (Cho, 1998) and Coudoulous II, a natural accumulation site (Costamagno, 1999).

4. Results and discussion

4.1. Population structure and kill/hunting season

The MNI of each species was estimated taking into account the age and sex of the animals (Table 2). The results are interesting in that the material from the heap of bones is similar to that found throughout the rest of the level (taxonomic assemblage and percentage of number of individuals), which underlines the contemporaneous character of the human activities. The distribution of the anatomical elements and bone refits, described below, also tends to confirm these initial observations.

Table 3
Minimum Number of Individuals (MNI) combined with age classes of red deer from Lazaret UA 25 unit.

Age classes	MNI	Ages
Young	4	6 months, 2× (18 months), 18–20 months
Sub-adult	3	27–30 months and 30–36 months
Adult 1	5	3–5 years
Adult 2	5	5–8 years
Old adult 1	2	8–10 years
Old adult 2	2	10–12 years
Very old adult	2	>12 years

The bone remains indicate the presence of both males and females: antlers attached to skull fragments, skulls with or without pedicles, significant size variability of some post-cranial elements (Liouville, 2007). UA25 also yielded twelve very well preserved upper canines, ten of which were found in the heap of bones. Some were still attached to the premaxilla whereas others were isolated. Just one refit has been observed. The morphological approach enables us to distinguish sexes for the entire assemblage. With the biometry of the tooth roots (width and thickness) it was not possible to distinguish two separate clusters corresponding specifically to males and females, implying that there is not a significant difference in size between male and female canines of the Lazaret population. But the morphological results allowed us to draw up biometrical graphs, taking into account the sex of the animal. In Fig. 7, we integrated the UA25 deer teeth into the whole Lazaret assemblage. The sex-ratio could then be estimated at 67% females.

In Fig. 8, the individuals are divided according to sex and tooth attrition stages. Since the analysis is based on permanent canines, it does not include young individuals. In UA25, stags and hinds seem to be equally represented in all age categories. Only the young adult category is entirely female.

Table 2
Population analysis of ungulates from the UA 25 archaeostratigraphic unit of Lazaret cave: number of identified specimens per taxon (NISP), minimum number of individuals (MNI) and age and sex data. *Abbreviations*: Y: young, immature, SA: sub-adult, A: adult, OA: old animal, VOA: very old animal.

Species	Heap of bones (Et)				Total UA25			
	NISP	MNI	% MNI	Age class	NISP	MNI	% MNI	Age class
Cervus elaphus	329	12	70.6%	3Y, 2SA, 2A, 2OA, 1VOA	1069	23	65.7%	4Y, 3SA, 10A, 4OA, 2VOA
Capreolus capreolus	13	1	5.9%	1A	33	1	2.9%	1A
Capra ibex	36	2	11.8%	1Y, 1A (stag)	109	6	17.1%	2Y, 4A (1 stag)
Bos primigenius	4	2	11.8%	1Y,1A	49	3	8.6%	1Y, 1A, 1ATA
Rupicapra rupicapra	–	–	–	–	2	1	2.9%	1A
Palaeoloxodon antiquus	–	–	–	–	2	1	2.9%	–
Total	382	17	100%		1264	35	100%	

The total MNI for the red deer population was estimated at 23 individuals. For immature and sub-adult individuals, the results obtained with the application of different methodologies match well, since 100% of the values calculated on the D4 (3 teeth) and 80% of the results for the M1 (22 teeth) using Klein's method match Riglet's age categories (Fig. 5). The results reveal that animals were slaughtered during the autumn (in gray in Fig. 5).

The mortality profile for the heap of bones (Et) and the entire UA25 level, using the five main age classes and their subcategories clearly indicates that the adult class is very present in the red deer population of UA25, which in turn is characteristic of a predation profile of middle-sized herbivores (Fig. 6, Table 3).

To sum up, the UA25 red deer population is composed of 23 individuals, of which at least 4 are young animals (about 6 months and 18 months old). Females represent 67% of the adults. The assemblage is clearly the result of hunting activity. Slaughtering occurred in the autumn, during and/or after the rutting period. Hunting deer at that time of the year offers the particular advantage that both sexes are herding for the mating season, leading to the presence of sturdy males and optimizing the energy return for hunters. The autumn hunt precedes substantial male weight loss, which occurs during the rut due to the energy spent in combat, breeding, and tracking.

Altogether, the results for the UA25 red deer population structure (sex ratio and age) are coherent for the season and reflect an autumn herd made up of stags complete with antlers, followed by

Months												Estimated age for each mandible using:			Mandibles from immature and sub-adult red-deer
birth												Tooth eruption method Tooth wear stages (Riglet, 1977)	Crown height method (Klein et al., 1981, 1983) dp4	M1	
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec				
												6 months	6 months 1/2	-	mand + dp2 dp3 dp4 M1
												12-18 months	17 months 1/2	-	mand + dp4 M1 M2
												18-20 months	-	-	mand + I1 I2 di3 dc dp2 dp3
												12-18 months	18 months	-	mand + dp4 M1
												28-30 months	-	-	mand + M2
												28-30 months	-	~30-31 months	mand + dp4 M1 M2

Fig. 5. Seasonality based on lower dental series of immature and sub-adult red deer. The age estimation is based on the tooth eruption method and the crown height method. Shaded areas represent occupation seasons.
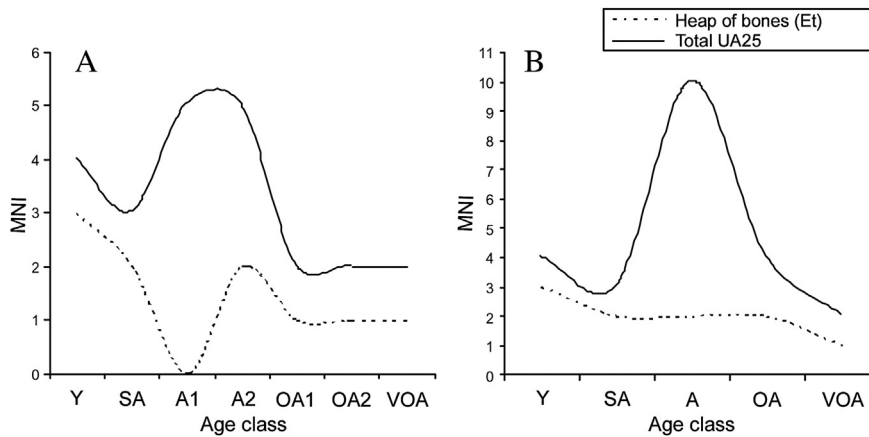
Fig. 6. Mortality profile of red deer from the UA 25 archaeostratigraphic unit. A. Profile established based on detailed age classes. B. Profile established based on main age classes.

several hinds with their one and two year-old fawns (Fig. 9). Thus, the UA25 Hominids did not make a clearly-defined choice concerning which individuals to kill within the herd although they selectively hunted this species. They may have slaughtered either entire herds or single individuals within the herds, without any selection regarding the age or sex of the animals.

4.2. Treatment of slaughtered animals

Quantification (NISP, MNI, MNE, MAU and %MAU), per anatomic element of the principal ungulates is listed in Table 4.
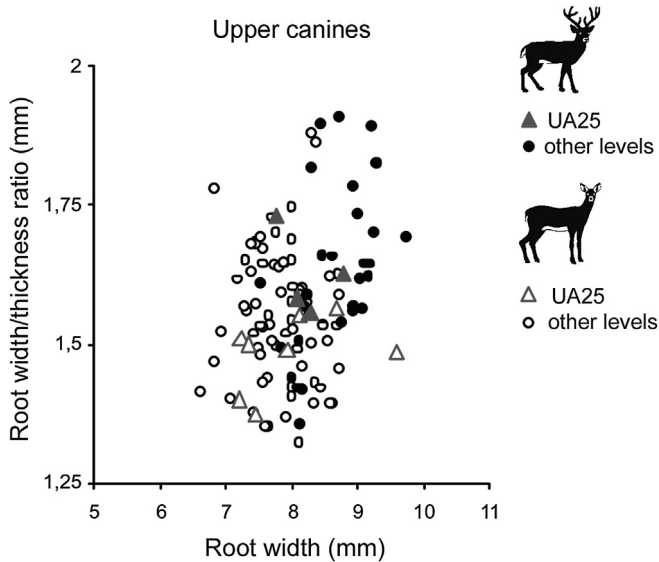
Fig. 7. Root morphology of deer upper canines from the whole Lazaret assemblage. Scatterplot of root width/thickness with root width of canines previously attributed to stags and hinds on the basis of their morphology (after the method in D'Errico and Vanhaeren, 2002).

Fig. 8. Distribution of red deer upper canines according to sex (in black: stag, in grey: hind) and occlusal wear (after the method in d'Errico and Vanhaeren, 2002).

Table 4

Quantification of the main Ungulates, in terms of NISP (number of identified specimens per taxon), MNI (minimum number of individual animals), MNE (minimum number of elements), MAU (minimum animal unit) and %MAU.

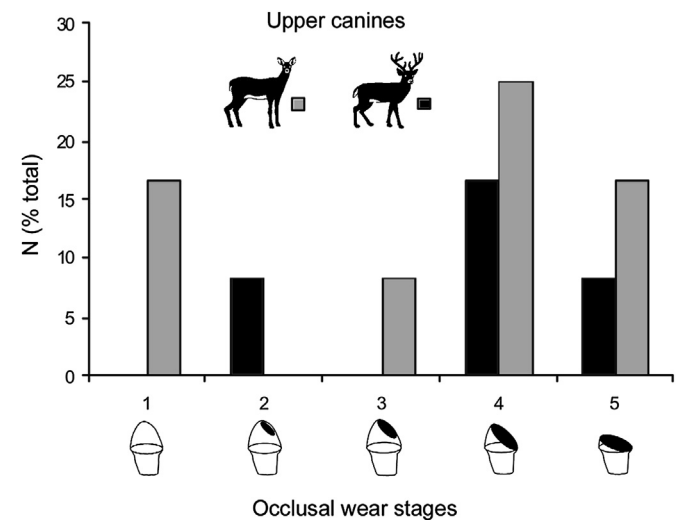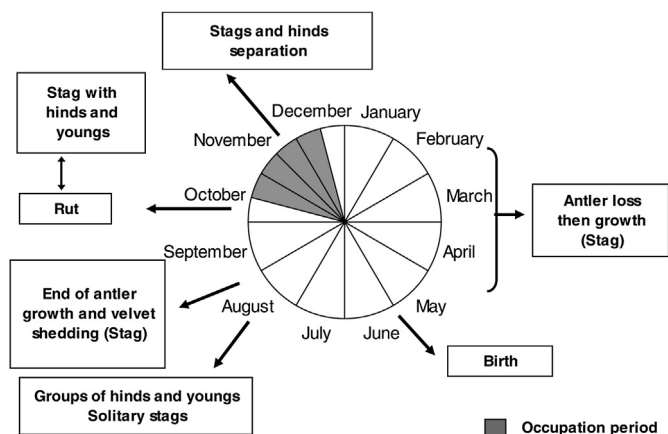| Skeletal element	Red deer					Ibex					Aurochs					Roe deer				
	NISP	MNI	MNE	MAU	%MAU	NISP	MNI	MNE	MAU	%MAU	NISP	MNI	MNE	MAU	%MAU	NISP	MNI	MNE	MAU	%MAU
Antler/horn	20	2	3	1.5	9.38	6	2	3	1.5	42.86	–	–	–	–	–	–	–	–	–	–
Cranium (maxillar)	72 (27)	14	17	8.5	53.13	2	1	2	1	28.57	1	2	1	0.5	33.33	1	1	1	0.5	50.00
Upper isolated teeth	15	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Mandible	112	23	32	16	100.00	10	5	7	3.5	100.00	4	3	3	1.5	100.00	2	1	1	0.5	50.00
Lower isolated teeth	24	–	–	–	–	2	–	–	–	–	1	–	–	–	–	1	1	1	–	–
Not determ. tooth	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hyoid	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Atlas	2	2	2	2	12.50	2	2	2	2	57.14	–	–	–	–	–	1	1	1	1	100.00
Axis	7	6	6	6	37.50	1	1	1	1	28.57	–	–	–	–	–	1	1	1	1	100.00
Cervical	17	3	8	1.6	10.00	1	1	1	0.2	5.71	1	1	1	0.2	13.33	1	1	1	0.2	20.00
Thoracic	20	3	5	0.38	2.40	4	2	4	0.31	8.79	–	–	–	–	–	1	1	1	0.077	7.69
Lumbar	18	1	6	1	6.25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sacrum	1	1	1	1	6.25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Caudal	–	–	–	–	–	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
Sternum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rib	65	1	25	0.96	6.01	9	1	5	0.19	5.49	1	1	1	0.038	2.56	3	1	3	0.115	11.54
Scapula	17	3	5	2.5	15.63	3	2	2	1	28.57	–	–	–	–	–	2	1	2	1	100.00
P humerus	64 (2)	2	2	1	6.25	6	–	–	–	–	10 (1)	1	1	0.5	33.33	1	–	–	–	–
Dia humerus	48	6	7	3.5	21.88	5	1	2	1	28.57	7	1	2	1	66.67	1	1	1	0.5	50.00
D humerus	13	7	13	6.5	40.63	1	1	1	0.5	14.29	2	2	2	1	66.67	–	–	–	–	–
P radius/ulna	69 (18)	5	9	4.5	28.13	2	–	–	–	–	4 (1)	1	1	0.5	33.33	3 (1)	1	1	0.5	50.00
Dia radius/ulna	42	5	10	5	31.25	1	1	2	1	28.57	2	1	2	1	66.67	2	1	1	0.5	50.00
D radius/ulna	9	4	6	3	18.75	–	–	–	–	–	1	1	1	0.5	33.33	–	–	–	–	–
Carpals	9	3	9	0.75	4.69	–	–	–	–	–	–	–	–	–	–	7	1	7	0.583	58.33
P metacarpal	65 (9)	3	6	3	18.75	6	–	–	–	–	1 (1)	1	1	0.5	33.33	–	–	–	–	–
Dia metacarpal	53	5	10	5	31.25	2	1	1	0.5	14.29	–	–	–	–	–	–	–	–	–	–
D metacarpal	10	5	10	5	31.25	4	2	3	1.5	42.86	–	–	–	–	–	–	–	–	–	–
Pelvis	30	6	9	4.5	28.13	2	1	1	0.5	14.29	–	–	–	–	–	2	1	1	0.5	50.00
P femur	92 (7)	5	6	3	18.75	8 (3)	2	3	1.5	42.86	9	–	–	–	–	3	–	–	–	–
Dia femur	69	5	10	5	31.25	5	2	3	1.5	42.86	6	2	3	1.5	100.00	3	1	2	1	100.00
D femur	16	4	7	3.5	21.88	–	–	–	–	–	3	2	2	1	66.67	–	–	–	–	–
Patella	3	2	3	1.5	9.38	–	–	–	–	–	1	1	1	0.5	33.33	–	–	–	–	–
P tibia	142 (18)	8	11	5.5	34.38	13 (1)	1	1	0.5	14.29	10 (2)	1	1	0.5	33.33	1 (1)	1	1	0.5	50.00
Dia tibia	126	9	16	8	50.00	12	3	4	2	57.14	8	1	2	1	66.67	–	–	–	–	–
D tibia	10	3	8	4	25.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Malleole	1	1	1	0.5	3.13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Astragalus	9	6	9	4.5	28.13	2	1	2	1	28.57	–	–	–	–	–	–	–	–	–	–
Calcaneum	4	3	4	2	12.50	2	2	2	1	28.57	–	–	–	–	–	1	1	1	0.5	50.00
Other tarsals	6	2	2	0.33	2.08	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P metatarsal	61 (4)	3	4	2	12.50	7 (2)	2	2	1	28.57	–	–	–	–	–	1	–	–	–	–
Dia metatarsal	55	6	13	6.5	40.63	4	1	2	1	28.57	–	–	–	–	–	1	1	1	0.5	50.00
D metatarsal	5	3	4	2	12.50	2	1	1	0.5	14.29	–	–	–	–	–	–	–	–	–	–
Phalanx 1	30	3	17	2.13	13.28	8	2	7	0.88	25.00	–	–	–	–	–	1	1	1	0.125	12.50
Phalanx 2	26	2	15	1.88	11.72	2	2	2	0.25	7.14	1	1	1	0.125	8.33	–	–	–	–	–
Phalanx 3	15	4	15	1.88	11.72	3	1	3	0.38	10.71	–	–	–	–	–	–	–	–	–	–
Sesamoid	19	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Not determ. metapod	23	–	–	–	–	3	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Others	2	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–

Fig. 9. Period of occupation of the UA 25 archaeostratigraphic unit and red deer ethology.

allow us to estimate the relative importance of differential transport and differential destruction. The low positive correlation obtained between %MAU and bone density (Spearman's rs: 0.33, $P = 0.097$) indicates that the assemblage did not undergo differential destruction. Moreover, there is no significant relation between %MAU and FUI (Spearman's rs: -0.116, $P = 0.5$): the most nutritive skeletal elements are not necessarily the most abundant. This result may be biased by intensive breakage by humans (shaft fragments with high FUI values constitute part of the non-determinable bone remains). Nevertheless, this observation shows that whole carcasses were brought back to the cave, with an overrepresentation of heads. This could indicate the transport of supplementary heads or the removal of carcass parts after processing in the cave. It could also stem from a bias linked to the incomplete excavation of the unit.

The examination of the cortical bone surface reveals a few, rare weathering marks and some animal marks (of rodents and carnivores) on about ten pieces. On the other hand, marks of human origin are varied and frequent (Table 5, Fig. 12). The majority are linked to dismembering and butchering activities: cutmarks and scraping marks made with sharp lithic instruments, to skinning, disarticulation, and to retrieving flesh and tendons. Bones with scraping marks are numerous (especially in comparison to the other archaeostratigraphic units of the cave): 7% of red deer bones ($+12\%$ in Et heap), 10.3% of ibex bones (Fig. 13), 6% of roe deer bones, and, in particular, 21.3% of aurochs bones (limbs only).

All the skeletal parts of red deer and ibex were found to be present in UA25 (Fig. 10), as well as one of roe deer. This distribution is indicative of early access to the carcass and the transport of the whole animal to the cave. For the aurochs, mostly head and femur fragments have been observed, matching a pattern of anthropic accumulation of large-sized adults (Klein and Cruz-Uribe, 1984;

Table 5
Main damage observed on ungulate remains from Lazaret UA 25 unit: butchery marks (cutmarks and scraping marks), percussion marks, bone tools (percussion tools and smooth bones) and carnivore damage. NR = Number of remains. Note: Isolated teeth are excluded in the percentages of total remains.

UA25	Species	NISP	NISP without teeth	Cutmarks		Inner conchoidal scars		Bone tools		Gnawing	
				NR	%	NR	%	NR	%	NR	%
Total	Red deer	1069	1029	72	7.0%	47	4.6%	5	0.5%	7	0.7%
Bone heap (Et)	Red deer	329	316	38	12.0%	10	3.2%	1	0.3%	4	1.3%
Total	Ibex	109	107	11	10.3%	6	5.6%	1	0.9%	1	0.9%
Total	Aurochs	49	47	10	21.3%	6	12.8%	0	0.0%	0	0.0%
Total	Roe deer	33	32	2	6.3%	2	6.3%	0	0.0%	0	0.0%

Valensi, 2000). Other well-represented anatomical elements are the proximal parts of the front limbs and zeugopods (radio-ulna and tibia), which suggest the consumption of high-quality meat and marrow. Most of the elements not represented in this assemblage have a low food utility index. This can be explained by primary access to the carcasses by humans, and selective transport of the most nutritive parts to the cave.

Fig. 11 presents the relationship between red deer skeletal part abundance (%MAU; Binford, 1984) and bone density on one hand (Lyman, 1984, 1985) and food utility index on the other hand (FUI; Metcalfe and Jones, 1988; see also Lyman, 1994). The two plots

Fractures are observed on many of the bones: all the long bones, skulls and mandibles have been broken. For the red deer, most of the long bone shafts are less than half of their original length, with very incomplete circumferences (Fig. 14). This is characteristic of bone breakage of human origin, i.e. the result of direct impact on green bones (Bunn, 1983; Villa and Mahieu, 1991). The same observations apply to aurochs, ibex and roe deer. These results are confirmed by the abundance of percussion pits and striae, inner conchoidal scars and anvil abrasion on the bones, as well as the presence of characteristic compact bone flakes.
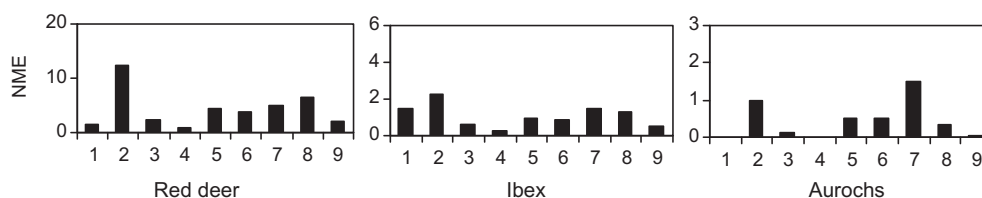

Fig. 10. Anatomical representation for red deer, ibex and aurochs remains from the UA 25 archaeostratigraphic unit of Lazaret cave. X-axis (anatomical regions): 1. horn/antler; 2. head (without teeth); 3. neck (cervical vertebrae); 4. axial (thoracic vertebrae, ribs, sternum, lumbar vertebrae, pelvis, sacrum); 5. upper front limbs (scapula, humerus); 6. lower front limbs (radio-ulna, carpals, metacarpal); 7. upper hind limbs (femur); 8. lower hind limbs (tibia, tarsals, metatarsal); 9. feet (phalanges). Y-axis: stand MNE values (after Stiner, 1994).
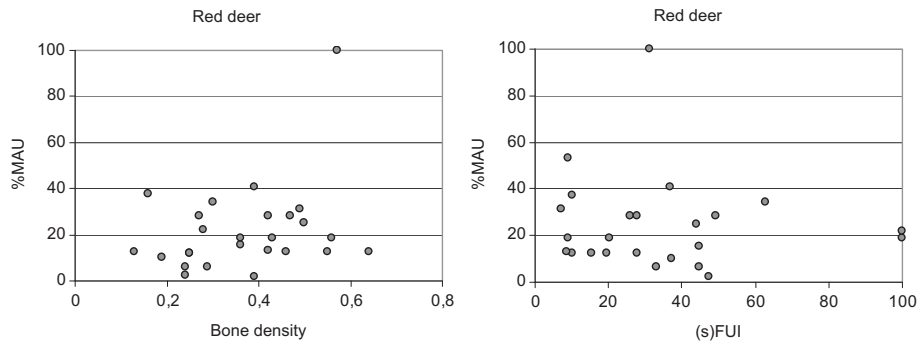
Fig. 11. Scatter plots of red deer %MAU values from Lazaret compared to bone density (Lyman, 1984) and standardized food utility (caribou FUI values) respectively (Metcalfe and Jones, 1988).
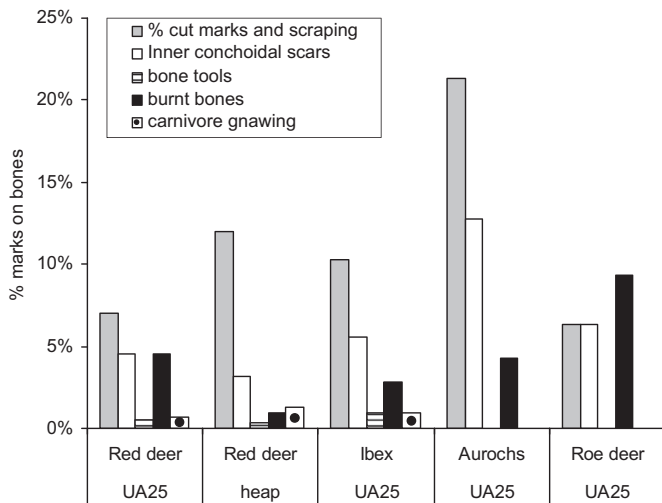

Fig. 12. Proportional frequencies of damage observed on the ungulate bones from the Lazaret UA 25 unit.

Among the long bone fragments, extremities are well represented compared to shafts. For red deer, 25% of the long bone fragments are extremities (Fig. 15). The presence of numerous spongy bone parts can be explained by the excellent conservation conditions and the almost complete lack of carnivorous action, known to be an important source of destruction of spongiosa. Lastly, other marks of human origin were noted, for example burnt bones and a few bones with use marks ("retouchers" and polished bones) (Fig. 16).

4.3. Spatial distribution of the ungulate remains

Thirty-six refitted faunal remains were discovered in Lazaret UA25 (Fig. 17). Occasionally, bone parts from the same individual were found scattered across different areas of the cave. One of the most interesting refits is a red deer mandible found in the bone heap (Et) and M3, located more than 4 m away, in the G area. Other refitted pieces, 3–4 m apart, are also observed between the C area and the H and I1 areas respectively. These refits clearly confirm the integrity of UA25 and the synchrony of the different areas, thereby giving us a better understanding of these bone accumulations. The Et heap of bones in particular contained 13 refitted pieces from red
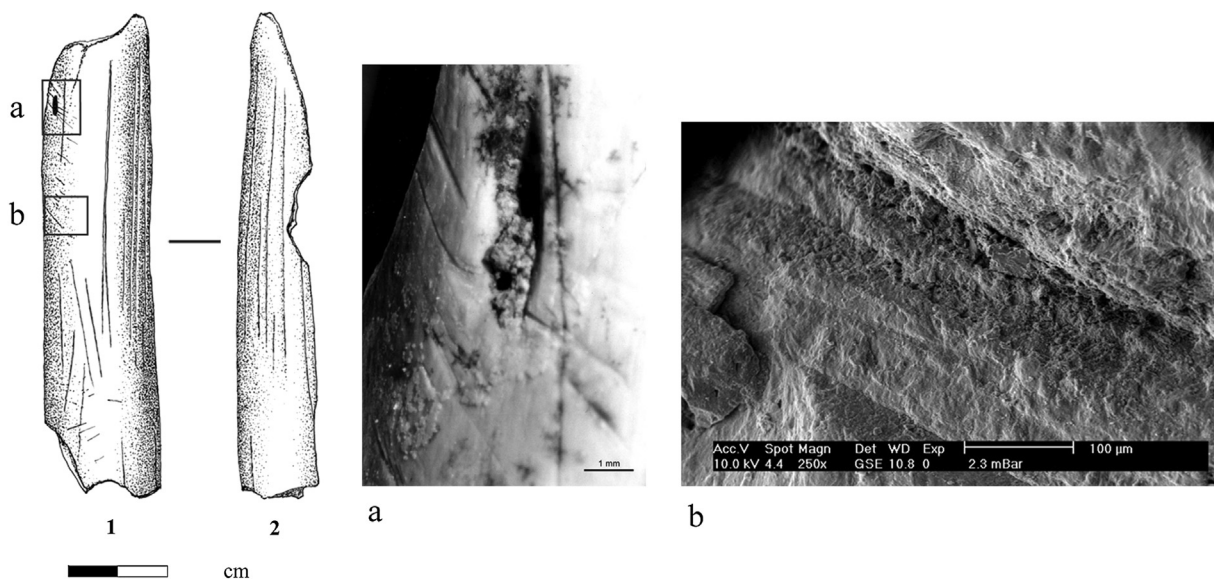
Fig. 13. Left femur of ibex discovered in the UA 25 archaeostratigraphic unit (reference O11-DA80T-2810). The bone shows filleting marks (cutmarks (a) and scraping marks (b)). Percussion mark on lateral view is observed: 1. anterior view, 2. lateral view. a. Detail of cutmarks near the nutritive foramen, induced by muscle removal. b. Detail of a cutmark using the environmental scanning electronic microscopy (ESEM) (photo B. Deniaux, CERP Tautavel).
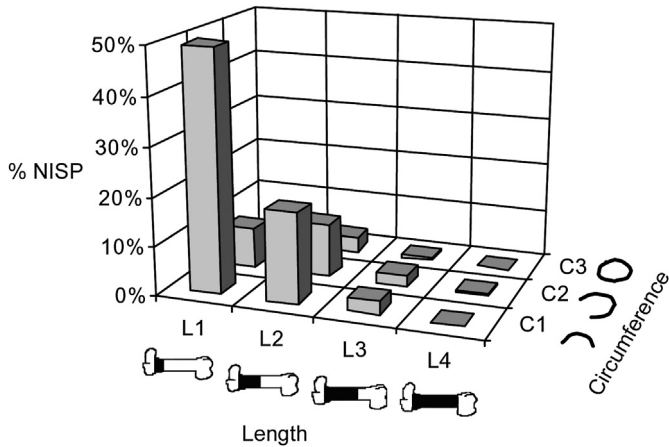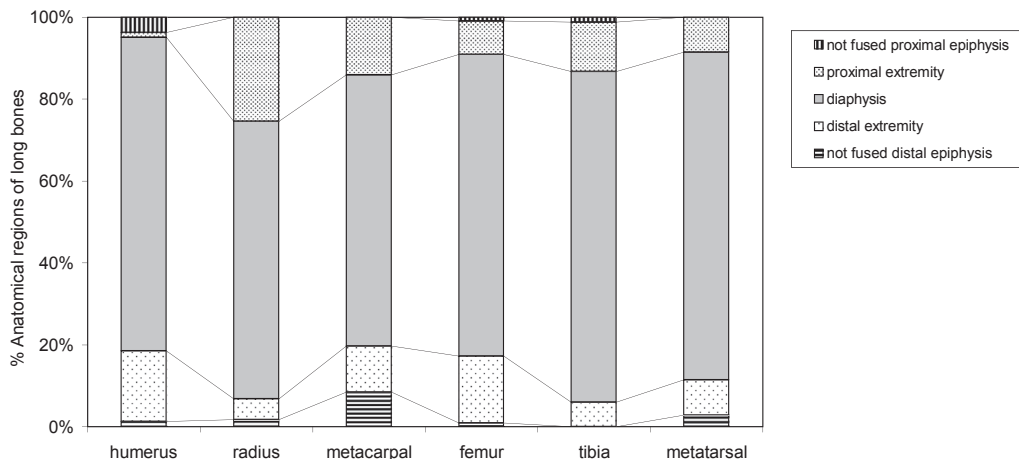
Fig. 14. Three dimensional bar diagrams showing relative frequencies of shaft length by shaft circumference. *Shaft length categories* are l ≤ 1/4 of the original length; 2 = 1/4 to 1/2; 3 = 1/2 to 3/4; 4 ≥ 3/4 or complete. *Shaft circumference categories* are C1 ≤ 1/2 of the original circumference, C2 = more than 1/2 of the circumference and C3 = complete circumference.

deer, 2 from roe deer and 5 from ibexes. Most of these are head elements or connected limb extremities (carpal or tarsal, metapodial, sesamoid and phalanges), others are fragments of the same bone (vertebrae, ribs or pelvis).

The Et heap of bones thus contained two types of large-sized bone waste: untreated bones (limb extremities, portions of the axial skeleton) and culinary remains (fragmented skulls and mandibles, fractured long bones showing numerous butchery marks). Along the east wall of the cave, the G, C and Ct areas are also characteristic of accumulated food waste.

Another specificity of this unit is that some areas reveal a high density of identifiable bones, while in other areas small splinters are predominant. The determination rate (around 40%) oscillates over the entire UA25 surface (Figs. 18 and 19).

- The I2, Ct, D, E and Et areas are richer in identifiable bones compared to splinters, and represent food scraps. In particular, the Et pile of more than 600 bones contains 60% of the identified remains. It is the main area of food remains. The E area also comprises most of the handaxes and pebbles, interpreted here as tools used for animal processing: butchery and bone breaking (Cauche *in* Lumley et al., 2004a).
- On the other hand, the A, B, C, and G areas contain between 60 and 70% of splinters and correspond to bone breakage areas.

Fig. 16. Retoucher from Lazaret UA25. Tibia of red deer used as a direct hammerstone for retouching. Detail of the marks: scanning electron microscope (SEM).

- Area I1, with few large-sized remains but abundant small-sized remains, was a passageway or a specific activity area. It should be recalled that bedding comprised of marine and terrestrial plants was discovered in that area.
- The East rock face (area H) revealed a considerable quantity of material. It was a disposal area, placed out of the way of the passageway.
- The areas of the hearth Ff and its surroundings (F) were found to be poor in bone material and contained only splinters. For the most part, these are burnt shaft fragments (94% burnt bones in the hearth and 40% in the peripheral area). Although these are almost exclusively splinters, the small quantity of material shows that this is not a long bone breakage area. The use of
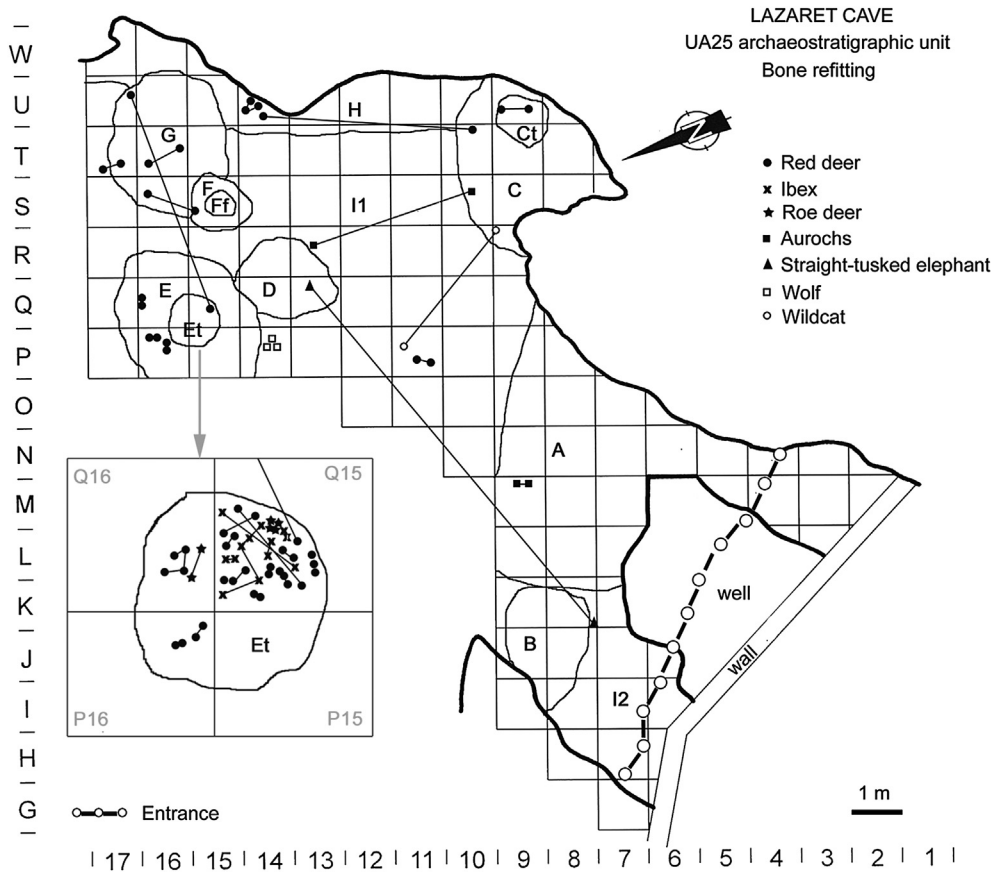

Fig. 15. Frequencies of the different red deer long bone portions from Lazaret UA 25 unit.

Fig. 17. Refitting of faunal remains from Lazaret UA25 unit.

bones as a source of fuel seems to be equally unlikely, since the majority of the pieces are compact in structure and do not burn well.

It can be concluded that the hearth and the immediate surrounding area seem to have been occasionally used as disposal areas for small bone splinters, which do not appear, by the color, to have been subjected to high temperatures (Michel et al., 1998; Munro et al., 2007) (Fig. 20). It is important to recall that a number of studies carried out on the hearth (morphology, sedimentary compound, micromorphology, magnetic susceptibility, organic macro-remains (algae, marine and land herbs, etc. and the analysis

Fig. 18. Frequency of the large mammal bone remains (%NISP/total of remains) and determination rate per density areas from Lazaret UA 25 unit.

of the aromatic elements)) indicate that the fire was slow, therefore produced a lot of smoke and thus served for smoking large mammal meat. As for butchery treatment, it is noteworthy that the scraping marks on long bones are particularly abundant in comparison to the other units of Lazaret cave and can be interpreted as different ungulate processing methods.

The hypothesis advanced by the authors (Lumley et al., 2004a) of a meat curing activity prior to winter, either by drying or by smoking, could explain the quantity of slaughtered and butchered animals, which is not compatible with meat intake over a short time period, i.e. a few weeks. This would thus be the oldest known evidence of food storage. These results are consistent with the faunal and lithic materials, reinforcing the assumption that the occupation period would have been of fairly short duration.
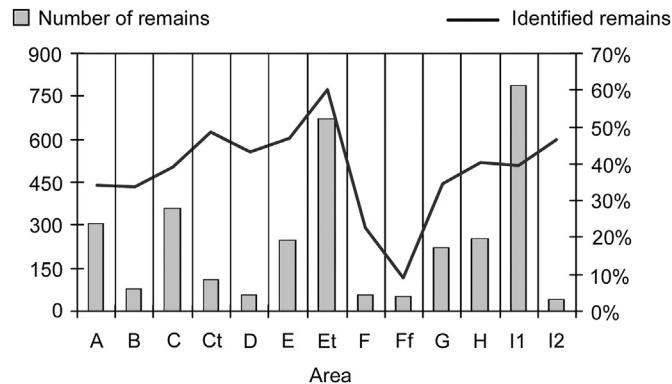
4.4. Palaeoecological analysis and impact of the environment on the choice of the hunted species

The vertebrate fauna allow us to attribute the archaeological sediments (complex C) to the last glacial period of the Middle Pleistocene (MIS6) (Valensi and Abbassi, 1998; Michel et al., 2009; Valensi, 2009). The identified species indicate various biotopes and a cooler and especially damper climate than the present Mediterranean climate.

Some taxa reveal a decrease in temperature at the top of the filling (CIII unit), compared to lower levels (upper CII): reindeer (*Rangifer tarandus*), woolly rhinoceros (*Coelodonta antiquitatis*), and the more widespread presence of the steppe bison (*Bison priscus*). But generally speaking, the so-called "cold" species are almost absent from the assemblage. The notion of a rather temperate
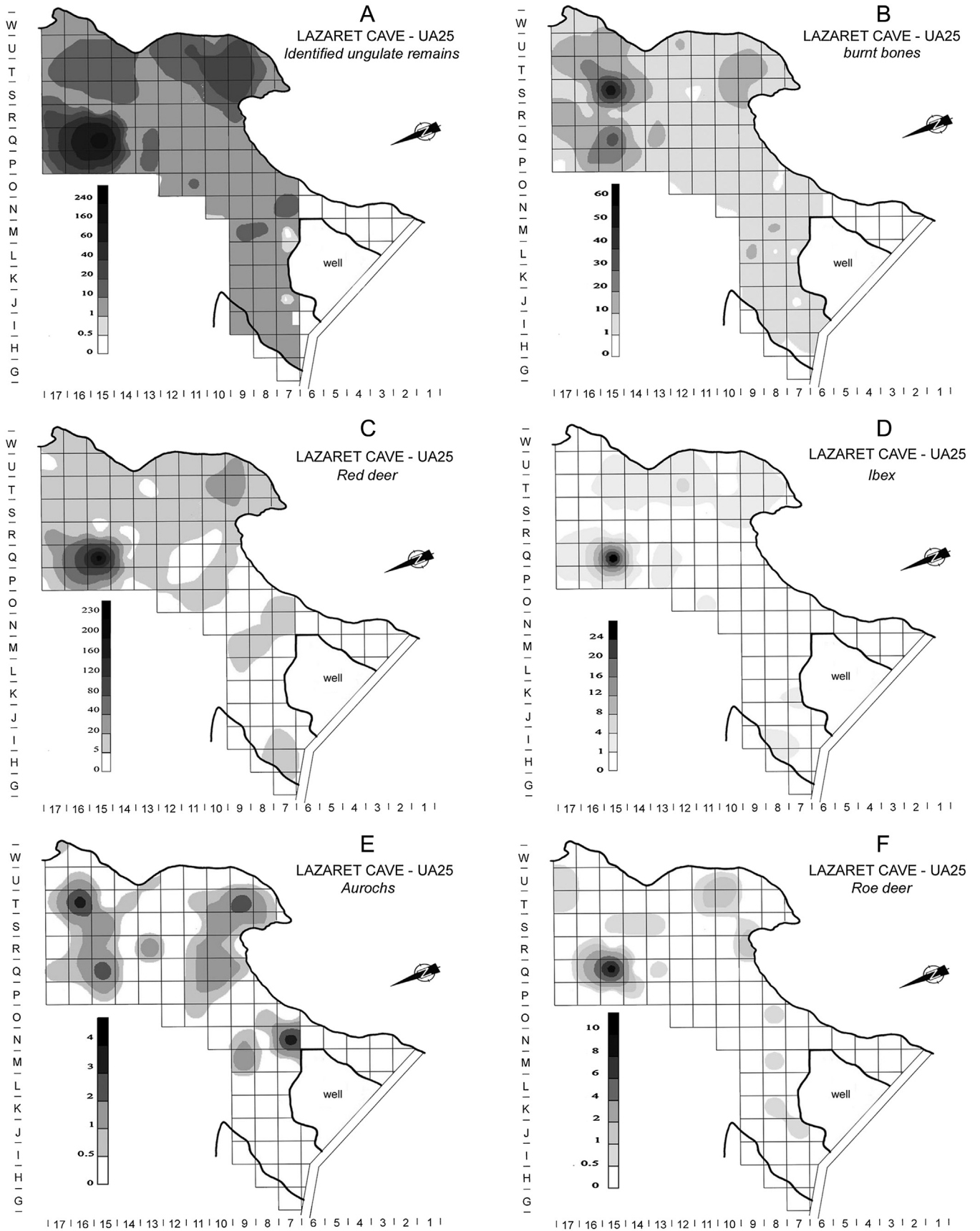
Fig. 19. Density distribution of large mammal remains in the UA 25 archaeostratigraphic unit. A. Identified remains of large mammals (NISP = 1351), B. Burnt bone splinters (Total = 710), C. Red deer remains (NISP = 1069), D. Ibex remains (NISP = 109), E. Aurochs remains (NISP = 49), F. Roe deer remains (NISP = 33).

Fig. 20. Colour and estimated temperature of burnt bones from Lazaret UA25 unit. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
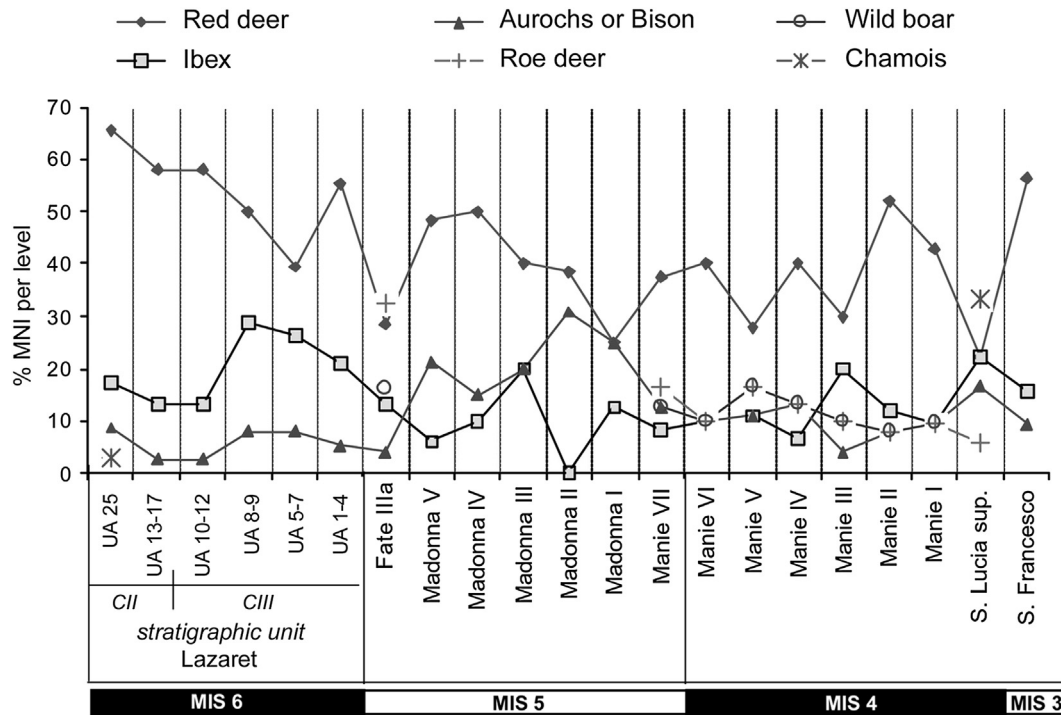
are not reflected in faunal associations. The climatic variations only seem to have affected the richness and relative abundance of some species.

In this region, red deer outnumber all the other large mammal species (Fig. 21). This can be easily explained by the species' natural abundance in the environment, and also possibly by its high rate of representation in terms of hunting, transport and processing. The red deer is found in archaeological contexts during cold as well as during temperate periods, somewhat masking climatic oscillations. On the other hand, the presence of the second most represented species seems directly connected to climate and/or geomorphology of the site. During the cold periods, ibex, bison or chamois are identified as the second species, whereas the roe deer, the wild boar and the aurochs become the second species during temperate periods (Valensi and Psathi, 2004).

In this context, the dominance of red deer and ibex in the Lazaret faunal spectrum corresponds well to a cold period. Despite the human factor, each spectrum accurately reflects site topography and climatic conditions at the time of accumulation.

Richness and diversity indexes are quite high in the different archaeostratigraphic units of Lazaret, highlighting significant biotope diversity (mosaic landscape) (Fig. 22). Nonetheless, we can point out similarities between the MIS 6 (Lazaret), the MIS 5 (Madonna dell'arma) and the MIS 4 (Manie) palaeobiotopes. Level IIIa of the Caverna delle Fate, attributed to MIS 5e, is the only assemblage with a high index of taxa richness.

The high values for the latter site can be explained by its geographical position and the region's topography, which became a survival zone during the Quaternary (Psathi, 2003). They can also be explained by the chronological period in question: during glacial periods, several species of cold fauna migrated towards the South, while the temperate taxa remained in the Mediterranean area. These transition fauna, influenced by climatic variations during the Middle and Upper Pleistocene

climate is due to the geographical position of the cave (close to the Mediterranean seashore, in a sheltered zone between the sea and the mountains which also served as a refuge zone). Concerning UA25, vertebrate and invertebrate fauna point towards a more temperate climatic oscillation during the MIS 6 glaciation (Valensi et al., 2007).

If we analyze species diversity from other sites in similar geographical settings, for example from Mousterian sites in Liguria in Italy (Caverna delle Fate, Madonna dell'Arma, Arma delle Manie, Santa Lucia Superiore, and San Francesco), we observe that the major climate changes which occurred between MIS 6 and MIS 3

Fig. 21. Frequency (%MNI or Minimal number of individuals) of the main ungulate species in Lazaret cave and Mousterian sites from Liguria: Caverna delle Fate, Madonna dell'Arma, Arma delle Manie, Santa Lucia Superiore and San Francesco. Concerning *Bos/Bison*, both taxa (*Bos primigenius* and *Bison priscus*) are present in the large archaeostratigraphic units GUA A to GUA E of Lazaret cave, Bison is also present in Santa Lucia Superiore and Aurochs is present in all the other Italian sites as well as in the UA 25 unit of Lazaret cave.
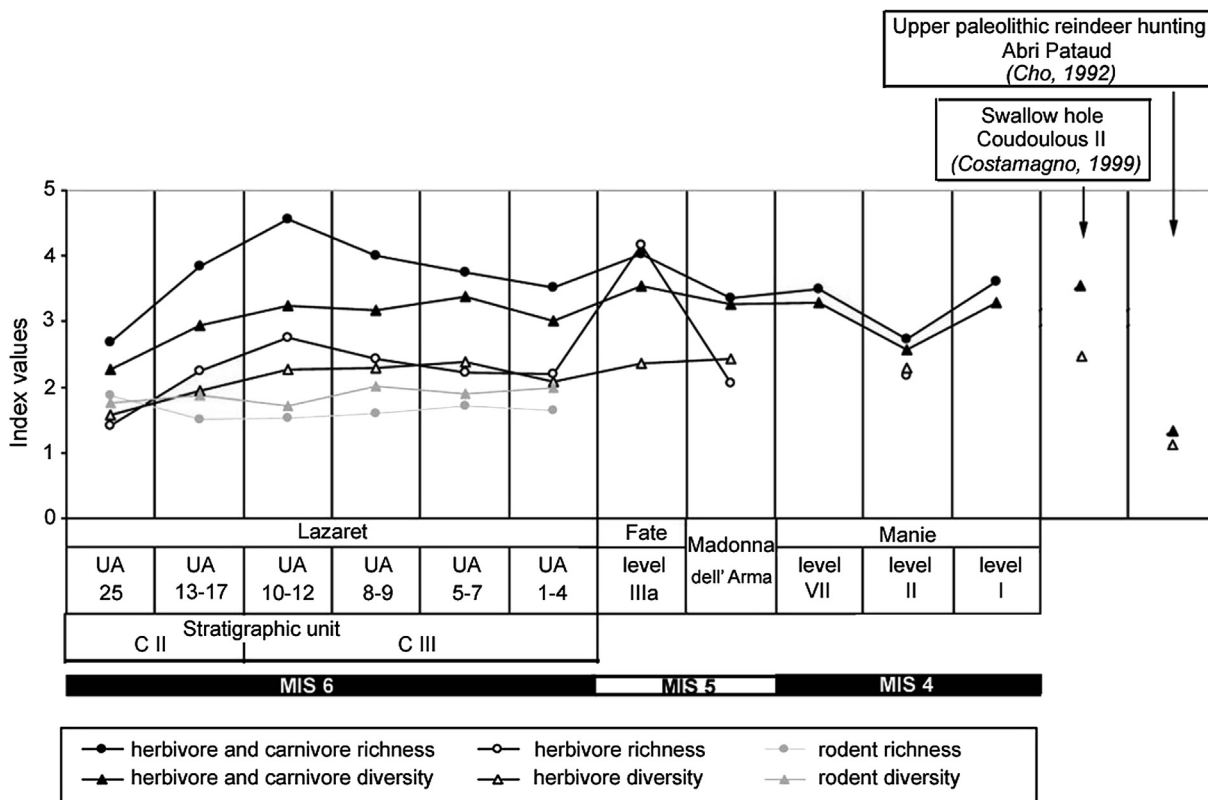
Fig. 22. Changes in the Shannon diversity index and in the taxonomic richness index in herbivores, carnivores, and rodents, recorded in the archaeostratigraphic units of Lazaret cave and from Mousterian sites in Liguria. The Shannon diversity index of a natural trap and a specialized hunting site are included for comparison.

period, play a significant role in reinforcing the richness and diversity indexes.

UA25 stands out from the other Lazaret units in that richness and diversity indexes for large mammals are lower, while those for rodents remain constant. The low diversity index may be due to selective hunting. This allows us to point out that the low values obtained for large mammals are linked to site function and closely connected to human hunting strategies: UA25 thus stands out as a short occupation camp with monospecific preferential slaughter. The red deer was deliberately selected for hunting despite faunal diversity in the immediate surroundings of the site.

5. Conclusions

The archaeostratigraphic unit 25 of Lazaret cave, excavated between 2000 and 2002, is an exceptional occupational level, rich in faunal remains and Acheulean industries (including many handaxes). Spatial analysis has allowed us to localize the main activity areas: for example, zones of bone breakage, bone waste and the hearth. One of the specific aspects of level UA25 is the presence of a bone heap in the center of the cavern containing over 600 butchery waste remains.

Lower Palaeolithic habitat sites with well-defined spatial organization are rare in Europe. In Lower and Middle Palaeolithic open-air sites, spatial organization is often easier to decipher than in cave contexts. This is the case, for example, for northern France, at sites such as Cagny-l'Epinette (Somme) and Biache-Saint-Vaast (Auguste, 1995; Tuffreau et al., 1995). In Nice, Terra Amata is another well-known Acheulean site, located just several hundred meters away from Lazaret Cave. The site contains records of recurrent occupations by groups of *H. heidelbergensis*, during the course of temperate MIS 11. The excavations and the spatial analysis

of remains brought to light evidence of the presence of huts implanted in a small creek, at the mouth of the Paillon River, close to swamps. Well-defined activity areas were identified and the analysis of refits and the density of archaeological objects indicated that links existed between these different areas (El Guennouni, 2001; Valensi and El Guennouni, 2004; Valensi et al., 2011).

In cave contexts, the interpretation and understanding of the distribution of remains is more difficult (Bietti, 1993; Meignen, 1994). In France, several sites with more or less diffuse activity areas have been identified on certain occupation floors: la Caune de l'Arago in Tautavel (Pyrénées-Orientales) (Lumley et al., 2004b), layer VIII from Vaufrey Cave (Dordogne) (Rigaud and Geneste, 1988; Simek, 1988) and in more recent levels (MIS 4) at the Canalettes Neanderthal rock shelter (Meignen, 1993).

In caves, it is not uncommon to come across accumulations of food waste along the cave walls. On the other hand, an area of circular waste, as described in the center of unit UA25 from Lazaret, is exceptional for this period. The most similar case, to our knowledge, is the Middle Palaeolithic cave of Kebara, in the Near East, which has yielded a Neanderthal occupation floor dating to MIS 4, with several anthropic structures, including three densely packed oval to circular concentrations of bones. The excavation of one of these bone accumulations revealed a circular shape with a diameter of 1 m, corresponding to a pit about 60–70 cm deep. One viable possibility is that these structures are the remains of trash-filled pits (Bar Yosef et al., 1992; Meignen, 1994; Speth et al., 2012).

The study of large mammals at Lazaret Cave, from a zooarchaeological perspective (quantification, population structure, anatomical representation, taphonomy and spatial distribution) has led to a better comprehension of prehistoric human behavior. Red deer is the most abundant species in the assemblage, followed by ibex and aurochs. Whereas entire carcasses of small and

medium-sized animals were transported to the site, only the most nutritious parts of the aurochs were brought back. The red deer population is represented mainly by adults, of which 67% are hinds (sex ratio established using upper canines). The structure of the red deer population in UA25 reflects in many ways an autumn herd comprised of stags, followed by several females with one and two-year-old fawns. Although the occupants of UA25 preferentially hunted red deer, they did not focus on any particular sex group, but they did however target mostly adult animals. Data from UA25 designate this archaeostratigraphic unit as a short autumnal occupation camp, the main activity of which was butchering and possibly food storage before winter.

This massive slaughtering of 23 red deer in a relatively short lapse of time (between one and two months?) could be explained by the amassing of meat stocks (by smoking), before the lean season. This type of anticipatory behavior to avert shortages has already been evoked for European Neantherthals (Patou-Mathis, 1996).

The selective hunting of large mammals emerged in Europe during the course of the Middle Pleistocene. Although hunting is still opportunistic at Terra Amata (MIS 11), it becomes selective in the south-east of France at Orgnac 3 (Ardèche) approximately 300,000 years ago (MIS 9) (Michel et al., 2011; Moncel et al., 2012). At Lazaret, the palaeoecological analysis revealed that red deer were the preferred large game, independently of the diversity of prey available in the surrounding biotope. The selective red deer hunting which appears towards 200,000 years at Lazaret is also observed in most Middle or Upper Palaeolithic sites in the region (Alpes-Maritimes and Liguria) (Valensi and Psathi, 2004; Negrino and Tozzi, 2008; Valensi, 2009; Tagliacozzo et al., 2012). The selective hunting of red deer can be explained in terms of the pursuit of the best energy return, but also because of the constant presence of these populations in the region, regardless of climatic conditions.

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