C. R. Palevol 9 (2010) 171–184

Contents lists available at ScienceDirect

Comptes Rendus Palevol

www.sciencedirect.com

Human palaeontology and prehistory

Several different strategies for obtaining animal resources in the late Middle Pleistocene: The case of level XII at Bolomor Cave (Valencia, Spain)

Plusieurs stratégies différentes pour l'obtention de la nourriture à la fin du Pléistocène moyen : le cas du niveau XII de la Grotte du Bolomor (Valencia, Espagne)

Ruth Blasco [a,*], Josep Fernández Peris [b], Jordi Rosell [a]

[a] *Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Universitat Rovira i Virgili, (URV), Campus Catalunya, Avinguda de Catalunya, 35, 43002, 43005 Tarragona, Spain*
[b] *Servei d'Investigació Prehistòrica (SIP), Museo de Prehistoria, Diputación de Valencia, C/Corona, 36, 46003 Valencia, Spain*

ARTICLE INFO

Article history:
Received 25 January 2010
Accepted after revision 5 May 2010

Presented by Philippe Taquet

Keywords:
Middle Pleistocene
Bolomor Cave
Subsistence strategies
Hunting
Multiple predation
Scavenging
Small prey
Spain

Mots clés :
Pléistocène moyen
Grotte du Bolomor
Stratégies de subsistance

ABSTRACT

Bolomor Cave, located in Tavernes de la Valldigna (Valencia, Spain), contains a sedimentary deposit composed of seventeen stratigraphic levels ranging from MIS 9 to MIS 5e. This extensive sequence allows us to ask different questions about how the human groups of this chronological period related to their environment. We report several different strategies by which animal resources were obtained from level XII faunal assemblage (MIS 6). These practices range from scavenging to the complex hunting techniques, such as multiple predation. This practice is inferred in the case of horses (*Equus ferus*) on the basis of: (1) the proportional representation of skeletal elements (elements with high marrow content, such as stylopodials and zeugopodials); (2) age at death of these animals (from infantile to advanced adult); (3) the position and function of cutmarks and toothmarks (mainly oblique and longitudinal incisions on limb bones diaphyses); (4) archaeostratigraphic distribution of their remains in the assemblage; and (5) presence of refits among the bones located at this archaeostratigraphical line. Evidence of anthropogenic processing of small prey (*Oryctolagus cuniculus* and *Cygnus olor*) is also identified at level XII. These discoveries imply the development of techniques different from those used to capture large and medium ungulates. From this perspective, a variety of strategies to obtain animal food can be documented at Bolomor Cave. This phenomenon can be related to the highly adaptive subsistence strategies of these hominids, who could take advantage of the benefits offered by a diverse and rich environment. In general, the aim of this study is to provide data about the subsistence strategies of human groups from Bolomor Cave and contribute to knowledge about the human groups' way of life of in the late Middle Pleistocene.

RÉSUMÉ

La Grotte du Bolomor, située à Tavernes de la Valldigna (Valence, Espagne), contient un dépôt sédimentaire composé de dix-sept niveaux stratigraphiques qui vont du MIS 9 au MIS 5e. Cette séquence permet d'aborder différentes questions liées aux groupes humains de cette période chronologique et leurs relations avec l'environnement. Précisément, à

* Corresponding author.
E-mail address: rblasco@iphes.cat (R. Blasco).

1631-0683/$ – see front matter © 2010 Académie des sciences. Published by Elsevier Masson SAS. All rights reserved.
doi:10.1016/j.crpv.2010.05.004

Chasse
Prédation multiple
Charognage
Petites proies
Espagne

partir de l'assemblage faunique du niveau XII (MIS 6), différentes stratégies pour obtenir les ressources animales ont été identifiées. Ces pratiques vont du charognage aux techniques de chasse les plus complexes, comme la prédation multiple. Cette dernière pratique est documentée sur les chevaux (*Equus ferus*) à partir de : (1) la représentation squelettique des individus identifiés (éléments anatomiques avec un contenu élevé de moelle, comme par exemple les stylopodes et les zigopodes) ; (2) l'âge au moment du décès de l'animal (des infantiles aux séniles) ; (3) la situation et le but des traces de boucherie et des marques de carnivores (principalement des incisions obliques et longitudinales sur les diaphyses des os) ; (4) distribution archéostratigraphique des restes des chevaux dans l'ensemble (ces restes montrent une ligne clairement visible au niveau vertical sur les sections NS et EO) ; et (5) présence de remontages osseux entre les ossements localisés dans cette ligne. De plus, des preuves de la consommation humaine de petites proies (*Oryctolagus cuniculus* et *Cygnus olor*) sont également observées dans le niveau XII. Cela implique le développement de techniques différentes de celles utilisées pour la capture des grands et moyens ongulés. Dans cette perspective, une diversité de stratégies d'obtention des ressources fauniques est documentée à la Grotte du Bolomor. Ce phénomène peut être lié au développement d'une haute capacité d'adaptation des stratégies de subsistance de ces groupes humains, qui seraient favorisées par un environnement riche et diversifié. Ce phénomène montre l'importante capacité des groupes humains, non seulement pour l'improvisation (charognage), mais aussi pour l'organisation (prédation multiple). En général, cette étude vise à fournir des données sur les stratégies de subsistance des hominidés de la Grotte du Bolomor et à contribuer aux connaissances sur les modes de vie des groupes humains à la fin du Pléistocène moyen.

1. Introduction

The study of subsistence strategies at archaeological sites is important for knowing the behaviour of human groups in the past. Subsistence strategies are defined as the activities carried out by human groups in a territory to guarantee their survival and their continuity over time (Díez and Rosell, 1998). From studies of subsistence strategies, inferences can be drawn about economic and social organisation, movements across the territory, and ecological relationships with other animals, such as large carnivores.

One of the most important aspects in defining the strategies used by human groups is how they obtained faunal resources. Apparently, hunting and scavenging are the only two approaches used by hominids. Theoretically, the distinction between these two techniques is simple. Hunting is obtaining wild animals by killing them; scavenging is merely consuming the carcass without directly causing death. However, between the simplest scavenging and the most sophisticated hunting there is a wide spectrum of possible techniques. Bunn and Ezzo (1993) propose an approach keyed to access type (primary or secondary), access time (immediate or late) and access mode (active or passive) to the animals; in other words, a *continuum* of ways to obtain faunal resources, ranging from the most passive scavenging to the most complex hunting techniques. Among these techniques, Steele and Baker (1993) distinguish among:

(1) individual hunting, a direct interaction between a single hunter and the prey;
(2) social hunting, in which an animal is obtained through the cooperation of various members of the same group;
(3) multiple predation, which aims to obtain several specimens in a single hunting foray.

The second and third options require a more complex social organization. Individual hunting and social hunting occur not only among hominids; large predators, such as hyenas, lionesses, African wild dogs, dholes, and wolves undertake this practice regularly (Kruuk, 1972). However, multiple predation, practiced in a systematic way, only seems to appear among human groups quite recently, and the mass kill being is its maximum expression (Speth, 1997). From this perspective, hominids can develop and improvise different techniques to hunt animals, whereas carnivores use default strategies depending on their morphology, physiology, and/or ethology (Kruuk, 1972; Schaller, 1972; *inter alia*). The aim of this study is to provide evidence of the variety of strategies used by human groups to obtain animals in the Middle Pleistocene from level XII of Bolomor Cave.

2. Bolomor Cave

Bolomor Cave is located on the southern slope of the Valldigna valley, approximately 2 km southeast of the town of Tavernes (Valencia, Spain) (Fig. 1). The site is a karstic rock shelter in the Monduver Mountain. The cave is situated approximately 100 m above sea level. The sedimentary sequence of Bolomor Cave consists mainly of allochthonous material of colluvial origin. In addition to these deposits, there are other autochthonous sediments of gravitational origin from the roof subsidence, due to tectonics or weathering processes. Seventeen geoarchaeological levels have been identified (Fumanal, 1995). Level XII consists of a clayey sediment with subangular limestone clasts. The sedimentary characteristics display a marked brecciation to the east due to the constant precipitation that produces the drip line of the cave. The karstic deposit of Bolomor Cave has been dated by Amino Acid Racemization (AR) and Thermoluminescence (TL) to between MIS 9 and MIS

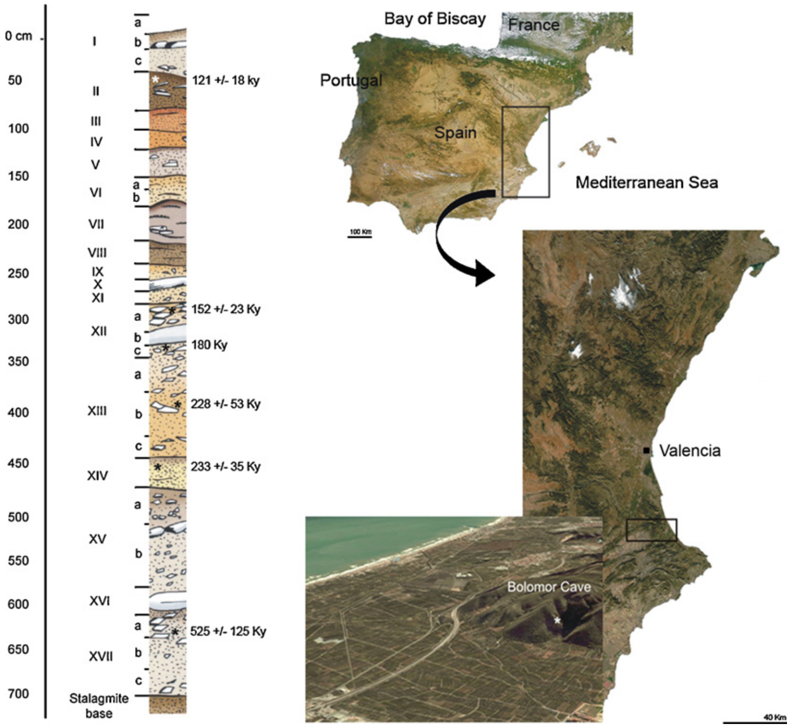

Fig. 1. General stratigraphy and dating of the levels of Bolomor Cave (left) and the location of the site (right).

Fig. 1. Stratigraphie générale avec les datations de la Grotte du Bolomor (gauche) et la localisation du site (droite).

5e (Fernández Peris, 2007). Levels are numbered from the top of the deposit. Several TL dates have been obtained: 121 ± 18 Ky for Level II, 225 ± 34 Ky for Level XIII and 233 ± 35 Ky for Level XIV. AR dates have also been made: 228 ± 53 Ky for Level XIII and 525 ± 125 Ky for Level XVII. Specifically, an AR date has been obtained for Level XII of approximately 180 Ky (Fig. 1).

The lithic industry recovered from Bolomor Cave is classified as a Middle Palaeolithic techno-complex. The raw materials used consist of flint, limestone and quartzite, which come from marine, colluvial and fluvial stones from the immediate area around the site and from areas further afield up to 15 km from the site (Fernández Peris, 2007). The Level XII industry consists almost exclusively of limestone flakes and sporadic flakes of flint.

The fauna from Bolomor Cave includes 20 species of macromammals. The biostratigraphic sequence is mainly characterized by the presence of *Hemitragus cedrensis*, *Hemitragus bonali*, *Equus ferus*, *Cervus elaphus* and *Dama* sp. and by more specific records at certain times of other species such as *Megaloceros giganteus*, *Sus scrofa*, *Macaca sylvana*, *Equus hydruntinus*, *Bos primigenius*, *Stephanorhinus hemitoechus*, *Paleoloxodon antiquus*, *Hippopotamus amphibius* and *Castor fiber*. The presence of carnivores in the cave is sporadic, but fossil remains of *Ursus arctos*, *Ursus tibetanus*, *Canis lupus*, *Panthera leo*, *Lynx pardina*, *Vulpes vulpes* and *Meles meles* have been recovered (Blasco, 2008; Blasco and Fernández Peris, 2009; Martínez Valle, 2001; Sarrión and Fernández Peris, 2006). It is important to note also the presence of small prey such as lagomorphs, tortoises and birds throughout the entire sedimentary sequence (Blasco, 2008; Blasco and Fernández Peris, 2009; Sanchís Serra and Fernández Peris, 2008).

Investigations carried out to date at the site have yielded remains of combustion structures at Levels II, IV, XI and XIII (Fernández Peris, 2007). For this last level, there is an AR dating on malacofaunal remains from the area close to the hearths of 228 ± 53 ky. Therefore, Bolomor Cave provides the earliest evidence for the controlled use of fire on the Iberian Peninsula.

To date, seven human bones and dental fragments have been recovered from Bolomor Cave. According to Arsuaga et al. (2001), the morphology of the human remains from Bolomor Cave is compatible with that of the European human fossils of the Middle Pleistocene.

3. Methodology

All the archaeological remains recovered during the excavation of level XII at Bolomor Cave were three-dimensionally recovered and mapped. This allows spatial reconstructions both on horizontal and vertical axes.

The faunal analysis of level XII of the Bolomor Cave site was carried out following standard archaeozoological methods (Lyman, 1994; Reitz and Wing, 1999) and includes all fossil material recovered until the 2005 season. Anatomical, taxonomic and modification details were recorded.

To assess completeness of the sample, Number of Identified Specimens (NISP), Minimum Number of Elements (MNE), Minimum Number of Individuals (MNI) and skeletal survival rate (Brain, 1981; Lyman, 1994) were calculated. Skeletal survival rate estimates the proportion between the

Table 1
NR, NISP, MNE and MNI by ages from level XII of Bolomor Cave.
Tableau 1
NR, NISP, NME et NMI par âges, du niveau XII de la Grotte du Bolomor.

Taxa	NR	NISP	MNE	MNI	MNI Age			
					inf	juv	ad	sen
Macaca sylvana	2	2	2	2	–	1	1	–
Lynx sp.	1	1	1	1	–	–	1	–
Castor fiber	2	2	1	1	–	–	1	–
Paleoloxodon antiquus	1	1	1	1	1	–	–	–
Stephanorhinus hemitoechus	6	6	5	2	–	1	1	–
Equus ferus	165	165	80	9	1	2	5	1
Megaloceros giganteus	5	5	4	2	–	–	1	1
Dama sp.	17	17	12	2	1	–	1	–
Cervus elaphus	325	325	119	11	–	1	9	1
Bos primigenius	35	35	19	4	–	1	3	–
Hemitragus bonali	4	4	3	2	–	1	1	–
Oryctolagus cuniculus	135	135	102	10	2	1	7	–
Cygnus olor	1	1	1	1	–	1	–	–
Large size	365	–	67	–	–	–	–	–
Medium size	808	–	73	–	–	–	–	–
Small size	155	–	33	–	–	–	–	–
Very small size	12	–	5	–	–	–	–	–
Unidentified	20	–	–	–	–	–	–	–
Total	2059	699	528	48	5	9	31	3

elements recovered and those expected (Brain, 1969). To determine the age at death of the animals, the best indicator in this study has been tooth replacement and dental wear (Azorit et al., 2002; Bökonyi, 1972; Mariezkurrena and Altuna, 1983; Silver, 1969). Nevertheless, the degree of development and fusion of the epiphyses of the limb bones has also been used in some cases (Silver, 1969), as well as the type of cortical tissue (compact in adults or more porous in young animals).

Fractures and breaks on bones were analyzed and classified according to Villa and Mahieu (1991). The outline (transverse, curved/V-shaped, longitudinal), fracture angle (oblique, right, mixed) and fracture edge (smooth, jagged) were recorded. The high proportion of broken and partial bones can make specific identifications difficult. Bone fragments were included in size categories related to the estimated body weight of individuals identified in the assemblage, following the criteria established by Díez et al. (1999): large, medium, small and very small-sized animals.

Alterations observed on bone surfaces were treated at both macroscopic and microscopic level. For the microscopic study an Olympus SZ11 stereoscopic (magnification up to 110) and ESEM (FEI QUANTA 600) were used. Damage observed on the faunal remains included cutmarks, intentional bone breakage and carnivore toothmarks.

Incisions, scrapes and chopmarks have been identified at level XII (Binford, 1981; Bromage and Boyde, 1984; Potts and Shipman, 1981; Shipman and Rose, 1983). The analysis of cutmarks took into account the number of striations, location on the anatomical element, distribution over the surface (isolated, clustered, crossed), orientation with respect to longitudinal axis of the bone (oblique, longitudinal, transverse) and delineation (straight or curved).

Surface damage caused during the bone breakage was also analyzed and the diagnostic elements of anthropic breakage were documented on faunal remains from the level XII sample: percussion pits or percussion marks (Pickering and Egeland, 2006), percussion notches, impact flakes (Capaldo and Blumenschine, 1994; Pickering and Egeland, 2006), adhering flakes (Díez et al., 1999; Fernández-Jalvo et al., 1999) and peeling (White, 1992).

The carnivore toothmarks identified on bone remains at level XII were mainly pits, punctures and scores (Binford, 1981; Blumenschine, 1995; Haynes, 1980, 1983; Stiner, 1994, *inter alia*). The analysis of toothmarks also took into account the number, the location and the distribution on the anatomical element.

4. Data presentation

The level XII faunal assemblage includes all fossil remains from the excavation seasons 2000-2004 and from the soundings made in 1989 and 1996. Level XII provided 2059 faunal remains (Table 1). From these, 699 have been identified to taxonomic level. The MNE is 528, mostly represented by tibiae (43), mandibles (40) and humeri (39), while basipodials and acropodials are represented by few elements (Table 2). The greatest representation of skeletal elements is due to red deer, rabbit and horse. The MNI is 48, established from the most common skeletal element according to species and age at death. *Cervus elaphus* is the predominant species (11), followed by *Oryctolagus cuniculus* (10), *Equus ferus* (9) and *Bos primigenius* (4). These animals represent 72% of the total MNI of the assemblage. All the other species are nominal in representation, and do not exceed 2 specimens in any cases.

Regarding age at death of the animals, one group is clearly predominant over the rest. Adults represent 65% of the specimens. We stress that only in *Equus ferus* are all age groups represented, with the exception of neonates (absent in the assemblage). The skeletal survival rate assesses the proportion between the recovered elements and those expected from the MNI. In this way, the anatomical representation obtained is valid in order to observe the elements

Table 2
MNE from level XII faunal assemblage.
Tableau 2
MNE de l'assemblage faunique du niveau XII.

	P. antiquus	*S. hemitoechus*	*Bos primigenius*	*Hemitragus* sp.	*Cervus elaphus*	*Dama* sp.	*M. giganteus*	*Equus ferus*	*Macaca sylvana*	*Lynx* sp.	*Castor fiber*	*O. cuniculus*	*Cygnus olor*	Large size	Medium size	Small size	Very small size	Total MNE
Skull	–	–	–	–	3	–	–	–	–	–	–	2	–	2	5	2	–	14
Maxilla	–	1	1	1	6	–	2	12	2	–	–	1	–	1	3	–	–	30
Mandible	–	1	1	2	16	–	–	9	–	–	1	5	-	3	2	–	–	40
Ribs	–	–	–	–	–	–	–	–	–	–	–	3	–	7	8	5	–	23
Vertebrae	–	–	–	–	–	1	–	–	–	–	–	13	–	9	8	4	2	37
Pelvis	–	–	–	–	1	–	–	–	–	–	–	12	–	–	–	1	–	14
Scapula	–	–	–	–	5	–	–	4	–	–	–	5	–	1	2	–	–	17
Humerus	–	–	2	–	10	3	–	7	–	–	–	9	1	5	2	–	–	39
Radius	–	1	1	–	6	2	–	8	–	–	–	4	–	2	1	1	–	26
Ulna	–	–	2	–	5	–	–	10	–	–	–	3	-	1	1	–	–	22
Femur	–	–	4	–	9	2	–	9	–	–	–	6	-	4	1	2	–	37
Tibia	1	2	2	–	13	1	–	5	–	–	–	10	–	5	3	1	–	43
Carpals	–	–	–	–	5	–	–	3	–	–	–	–	–	1	–	–	–	9
Tarsals	–	–	–	–	6	–	–	3	–	–	–	3	–	1	1	–	1	15
Metacarpals	–	–	1	–	6	1	1	3	–	1	–	5	–	1	3	1	–	23
Metatarsals	–	–	1	–	7	2	1	3	–	–	–	15	–	2	3	2	–	36
Phalax 1	–	–	1	–	3	–	–	2	–	–	–	4	–	–	–	–	–	10
Phalax 2	–	–	1	–	6	–	–	1	–	–	–	2	–	–	–	–	–	10
Phalax 3	–	–	-	–	10	–	–	–	–	–	–	–	–	–	–	–	–	10
Sesamoideus	–	–	2	–	2	–	–	1	–	–	–	-	–	–	–	–	–	5
Long bones	–	–	–	–	–	–	–	–	–	–	–	–	–	10	15	6	2	33
Flat bones	–	–	–	–	–	–	–	–	–	–	–	–	–	12	15	8	0	35
Total MNE	1	5	19	3	119	12	4	80	2	1	1	102	1	67	73	33	5	528

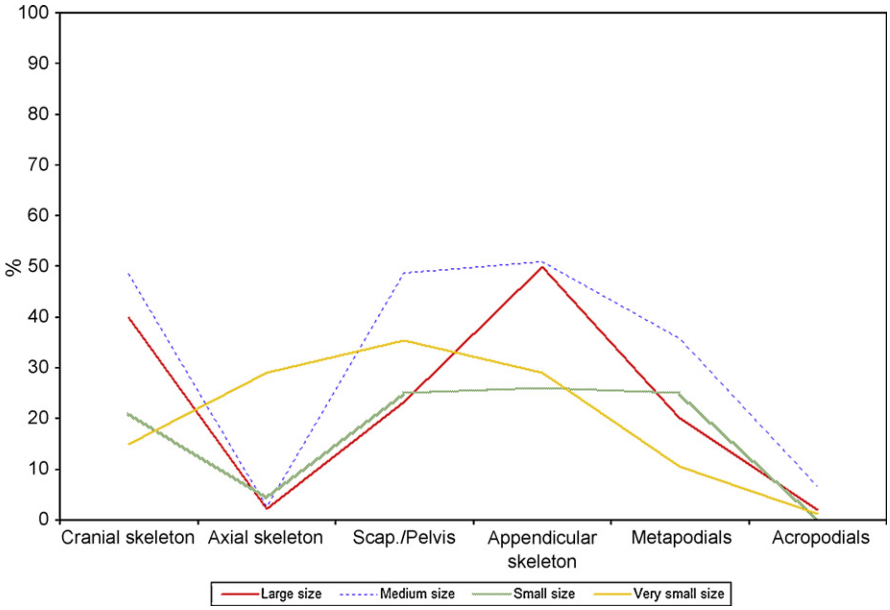

Fig. 2. Graphical representation of skeletal survival rate according to size categories of identified individuals at the level XII faunal assemblage.

Fig. 2. Représentation graphique de l'index de survivance en relation avec les catégories de poids des individus identifiés au niveau XII.

absent in the assemblage (Brain, 1969). This rate indicates a biased skeletal representation in all the taxa in the assemblage. This selection of elements is essentially characterized by cranial elements (mainly mandibles and maxillaries) and by stylopodials and zeugopodials. On the other hand, the low proportions of autopodials and the almost total absence of the axial skeleton and phalanges are characteristic for most of the species documented at this level (Fig. 2). The elements of the greatest representation are those with the greatest nutritional and medullary value (Binford, 1981; Emerson, 1993). As for very small-sized animals (mainly represented by *O. cuniculus*), the standard representation varies significantly. The axial skeleton (vertebrae and ribs) shows a greater representation than in any other size class of superior weight.

Analysis of bone breakage shows that curved/V-shaped fractures predominate (55.1%), along with oblique angles (44.9.8%), and smooth edges (75.5%). This degree of bone breakage at level XII indicates fresh bone breakage, according to Villa and Mahieu (1991). Surface damage caused during breakage of the bones has also been analyzed and diagnostic evidence has been documented: percussion pits, percussion notches, impact flakes, adhering flakes and peeling (Fig. 3) (Table 3).

Cutmarks, which are found on 12.3% of the bone remains at level XII, establish an association between hominids and other animals at the site. These were identified mainly on the long bones of medium and large-sized animals with a predominance of the incisions on the shaft and the sawing marks on the metaphysis. The action performed (viscera removal, defleshing, disarticulation and periosteum removal) was recorded according to morphology, emplacement and distribution of striations (Table 4). The consumption of small prey, specifically of *Oryctolagus cuniculus* and *Cygnus olor* has also been documented from cutmarks and anthropogenic bone breakage (Fig. 4).

However, hominids are not the only agents that play a part in the faunal assemblage. Carnivore toothmarks have been identified mainly on the proximal appendicular skeleton of medium and large-sized animals (which are the most abundant in the record). However, the incidence of activity of these carnivores is low (3% of the analyzed remains). The dimensions of the predominant toothmarks suggest small and medium-sized carnivores, such as canids (Andrews and Fernández Jalvo, 1997; Domínguez-Rodrigo and Piqueras, 2003; Selvaggio and Wilder, 2001).

On the other hand, 29 bone remains show evidence of both human and carnivore activity on the cortical surface. From these, 6 faunal fragments allow us to establish the access sequence of both kinds of predators to animal nutrients (overlapped marks): 4 bone remains show carnivore toothmarks on cutmarks (primary human access) and 2 bone fragments describe the opposite phenomenon (secondary human access) (Blasco and Rosell, 2009).

5. Discussion

Several types of evidence provide information about the methods used to obtain animal nutrients. Some researchers suggest that the main factor to be considered is the skeletal representation of the different taxa identified in the assemblage (Binford, 1981; Brain, 1981; Lyman, 1994; Stiner, 1994 *inter alia*). This must be considered in conjunction with the age at death of the animals (Gaudzinski and Roebroeks, 2000) and the location of processing marks on the carcasses: location and purpose of the cutmarks, presence of carnivore toothmarks, overlapping marks and fractures of both

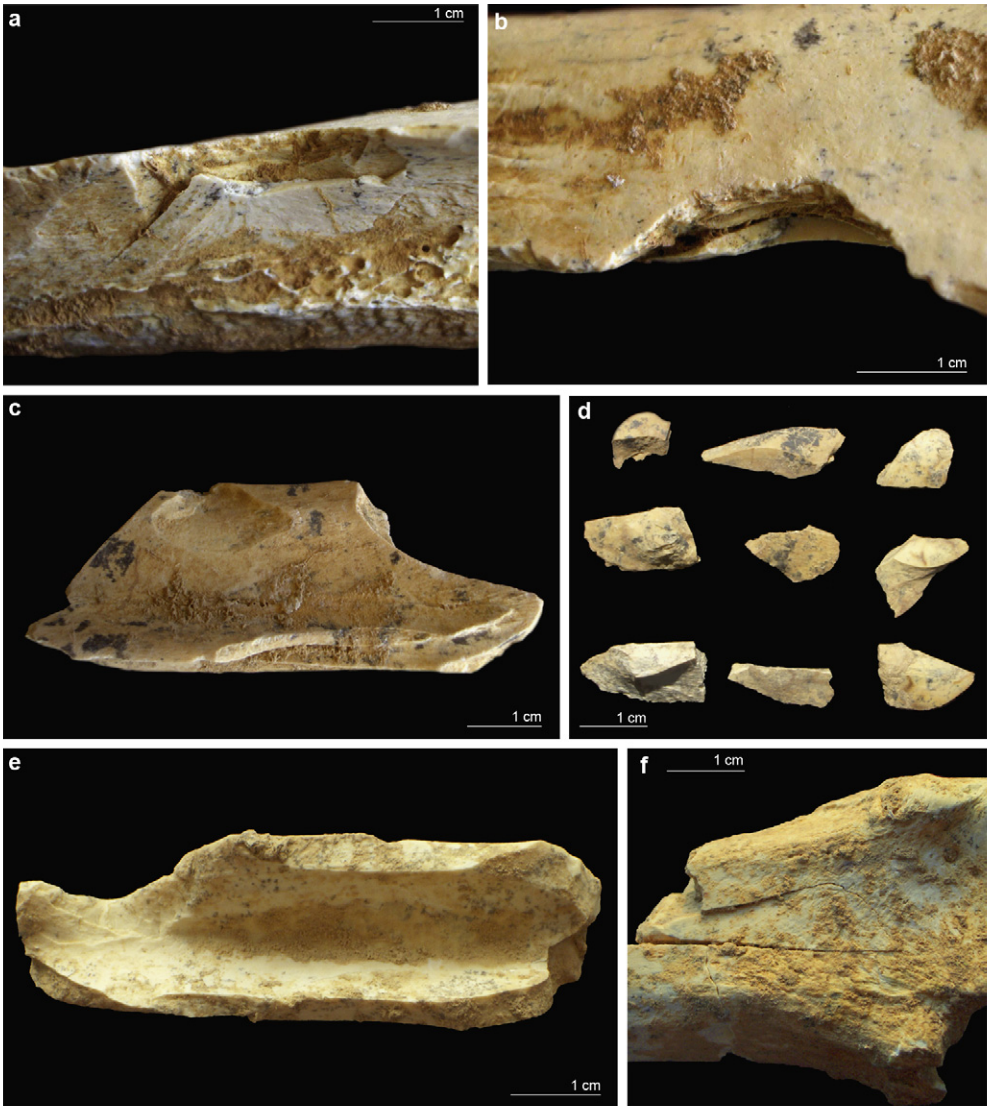

Fig. 3. Diagnostic elements of anthropic breakage on faunal remains identified at level XII of Bolomor Cave: (**a**), (**b**) adhering flake on long bone fragment of large-sized animal and detail; (**c**) negative flake scar; (**d**) impact flakes on long bone fragments of medium and large-sized animals; (**e**) percussion notch on Cervidae tibia; (**f**) opposite side of the percussion impact on Cervidae tibia (counterblow).

Fig. 3. Éléments diagnostiques de la fracturation anthropique sur les restes fauniques identifiés au niveau XII de la Grotte du Bolomor : (**a**), (**b**) éclat adhérant à un fragment d'os long d'un animal de grande taille et détail ; (**c**) négatif d'un éclat médullaire ; (**d**) éclats de percussion sur des fragments d'os longs d'animaux de taille moyenne et grande ; (**e**) encoche de percussion sur le tibia d'un cervidé ; (**f**) côté opposé à l'impact de percussion du tibia du cervidé (contrecoup).

anthropogenic and animal origin (Binford, 1981; Blasco and Rosell, 2009, Bunn, 1981; Domínguez-Rodrigo and Pickering, 2003; Domínguez-Rodrigo and Barba, 2006; Marean and Kim, 1998; Shipman and Rose, 1983; *inter alia*).

The level XII faunal assemblage shows a systematic proportion of skeletal elements with high nutritional value, a predominance of adult animals, cutmarks related to the viscera removal and oblique and longitudinal incisions on the diaphysis of the limb bones, which is associated with defleshing large muscle masses. All these elements suggest that the access of hominids to these animals was mainly primary and immediate. The pattern of these lines of evidence suggests the development of hunting techniques among the level XII hominids.

As already mentioned, for Gaudzinski and Roebroeks (2000) the age at death of prey animals can help determine the anthropogenic strategies for obtaining these faunal resources. According to them, adult individuals are generally healthy and strong animals and therefore could have been the main objective in hunting by human groups. At level XII, adult specimens predominate; however, in the case of the horses 44.5% are non-adult (infantile, juvenile and of advanced age). Nevertheless, the skeletal representation of these ungulates and the location and types of cutmarks suggest primary and immediate access.

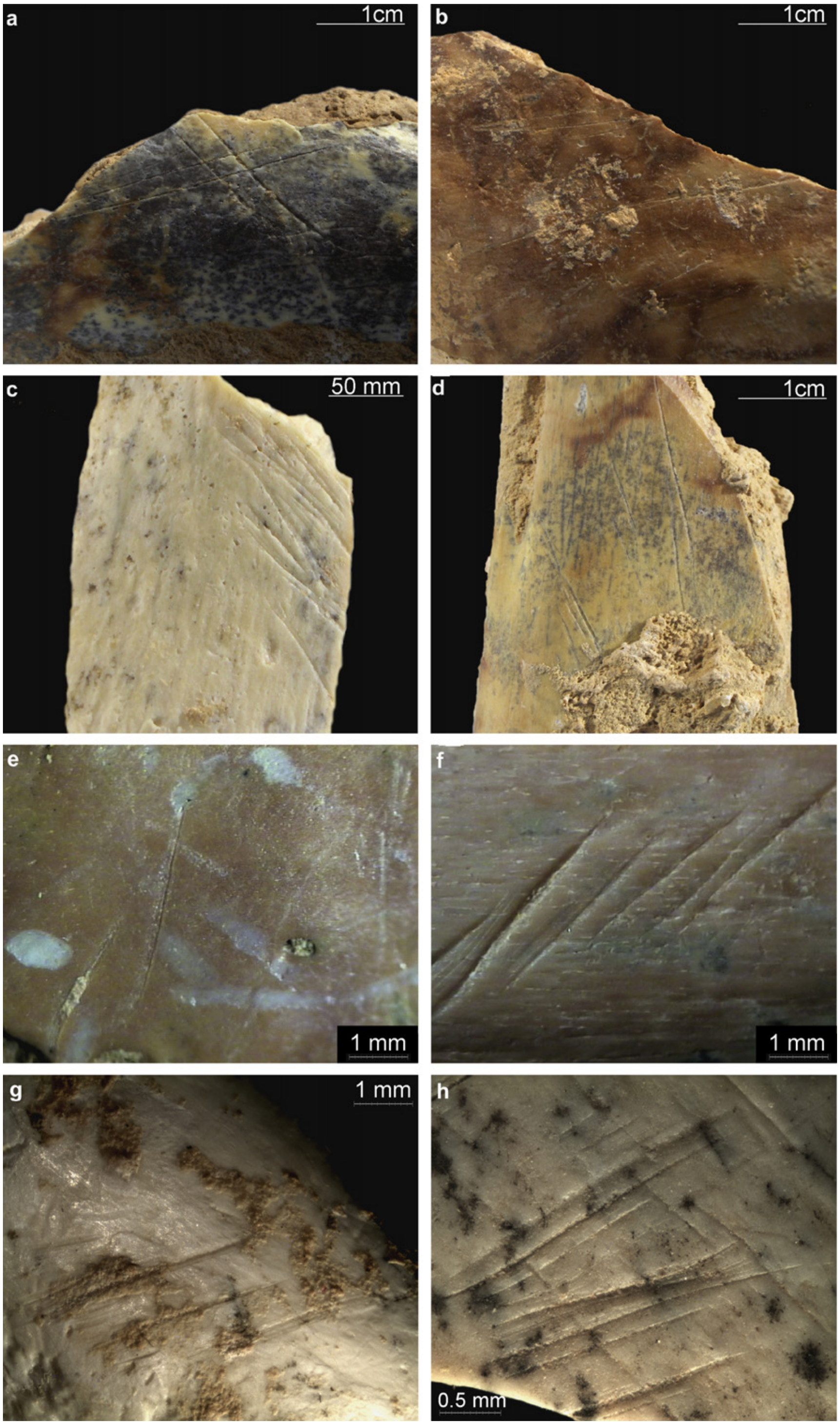

Fig. 4. Cutmarks on faunal remains identified at level XII of Bolomor Cave: (**a**) incisions on diaphysis of Equidae humerus; (**b**) incisions on diaphysis of Cervidae tibia; (**c**) cutmarks on diaphysis of long bone fragment of medium-sized animal; (**d**) incisions on diaphysis of Cervidae tibia; (**e**) incisions on *Oryctolagus cuniculus* mandible; (**f**) incisions on Cervidae metapodium; (**g**) incisions on distal metaphysis of *Cygnus olor* humerus and cutmarks detail; (**h**) incisions on proximal metaphysis of *Oryctolagus cuniculus* tibia. * obl, oblique; long, longitudinal and tr, transverse.

Fig. 4. Incisions et stries de découpe sur des restes fauniques, identifiées au niveau XII de la Grotte du Bolomor: (**a**) incisions sur la diaphyse d'un humérus de cheval ; (**b**) incisions sur la diaphyse d'un tibia de cervidé ; (**c**) incisions sur la diaphyse d'un os long d'un animal de taille moyenne ; (**d**) incisions sur la diaphyse d'un tibia de cervidé; incisions sur une mandibule d'*Oryctolagus cuniculus* ; (**f**) incisions sur un mégapode de cervidé ; (**g**) incisions sur la métaphyse distale d'un humérus de *Cygnus olor* et détail des traces de boucherie ; (**h**) incisions sur la métaphyse d'un tibia d'*Oryctolagus cuniculus*. *obl, oblique ; long, longitudinale et tr, transversale.

Table 3
Number of bone fragments with diagnostic elements of anthropogenic breakage according to specimens and skeletal elements from level XII faunal record.
Tableau 3
Nombre d'os du niveau XII avec des éléments diagnostiques de la fracturation anthropique, en fonction des spécimens et des éléments du squelette.

		Percussion notches	Percussion pits	Impact flakes	Adhering flakes	Peeling	Total
B. primigenius	Humerus	1					1
	Femur	1					1
	Tibia	1					1
C. elaphus	Mandible	3					3
	Humerus	3	1				4
	Radius	2					2
	Femur	5					5
	Tibia	10	2				12
	Metatarsus	6	1				7
	Metapodium	1					1
Dama sp.	Humerus	1					1
E. ferus	Humerus	2					2
	Radius		1				1
	Femur	1					1
	Tibia	3	1				4
	Metapodium	1					1
Large size	Humerus	1	1				2
	Long bones	4	2	13	1		20
Medium size	Rib					5	5
	Long bones	9	2	33	2		46
Small size	Long bones	1		9			10
Total		56	11	55	3	5	130

On the other hand, the archaeostratigraphic distribution of the horse fossils describes a continuous vertical horizon in both north-south and east-west sections of the excavation (Fig. 5). This particular distribution is not a consequence of the slope layer or of the intervention of post-depositional agents in the assemblage:

(1) preferential inclines or orientations of the faunal remains are not observed;
(2) drag striae caused by the moving of remains in the sediment are not identified;
(3) a selection of bone remains by size is not documented. To evaluate the possible synchrony of the remains contained in this line, faunal refits have been carried out.

According to Todd and Stanford (1992b) and Todd and Frison (1992a), a faunal refit is the reassembly of a skeletal element from several fragments recovered in the same archaeological site. For Waguespack (2002), refitting skeletal elements of the same animal and/or fragments of individual skeletal elements provides a direct method of linking skeletal segments or fragmentary elements to individual carcasses or anatomical units across an archaeological site. From this perspective, a minimum of 10 bone refits belonging to this species has been documented: 4 maxillae, 2 mandibles and 4 ulnae. This fact in addition to the single line observed in the vertical projection, indicates a certain synchrony in the deposition of horse remains. Therefore, we can distinguish at least one single event related to horses. Only in this case, and based on general characteristics of the fossils belonging to this species, we could propose the possibility of a different hunting strategy. Within the wide diversity of game techniques, perhaps the most appropriate to explain this phenomenon is those based on multiple predation. According to Steele and Baker (1993), multiple predation consists of the capture of various individuals of a herd (regardless of their age) in a single hunting event. Theoretically, this type of hunting would be reflected, at the archaeological sites that were used as a place of habitat, in: (i) a high diversity of age at death of the species captured by this technique (if these animals were hunted in different events, they would show the same age pattern as a consequence of anthropogenic selection of the individuals of the herd: adults only); (ii) a predominance of anatomic elements with high nutritional content; (iii) incisions located mainly on the shafts of the limb bones; (iv) at a given archaeostratigraphic level, a single line of fossils belonging to the same species; (v) presence of refits among the faunal remains at this archaeostratigraphic line. From this perspective, all the characteristics documented from the horse remains at level XII could correspond to a hunting strategy based on multiple predation. An important fact to consider is the behaviour of wild horses and the location of the site itself. We must bear in mind that horses are grouped in large herds, which have a gregarious and seasonal character (Nowak, 1991). Their behaviour, in addition to the high view above the plain offered by Bolomor Cave, made locating herds easier and could have favoured the development of these practices. Few archaeological examples of multiple predation are documented in early chronologies. Nevertheless, cooperative hunting is suggested at the Lower Palaeolithic site of Qesem Cave in Israel (Stiner et al., 2001). Another example of social implication in hunting could be the human use of natural traps to capture animals. At the Coudoulous I site (MIS 8-6) some researchers raise the hypothesis of a possible human intervention in the ungulates' fall into natural traps, specifically bison (*Bison priscus*) (Brugal and Jaubert, 1991; Brugal et al., 2006). For these authors, this fact probably provides the basis to use these karstic sinkholes for the development of communal hunting strategies. Nevertheless, these cases are more frequent later in human history. Some examples

Table 4
Number of faunal remains with cutmarks according to skeletal element and taxa from level XII bone assemblage.
Tableau 4
Nombre d'os, avec traces de découpe selon l'élément du squelette et les taxons au niveau XII.

		Groups	N° striations by group	Type of cutmarks	Location	Orient*	(mm)	Action performed
Skull	*C. elaphus*	1	1	incisions	nasal	tr	12.3	skinning
Maxilla	*E. ferus*	1	1	incisions	M1	obl	24.8	defleshing
Mandible	*C. elaphus*	5	1–9	incisions	M1-M2 mental foramen	obl	3–10.2	defleshing skinning
	E. ferus	6	2–6	incisions	D2	obl	25–50.2	defleshing
	O. cuniculus	1	2	incisions	masseteric fossa	obl	4.2	defleshing
	Large size	1	5	incisions	–	obl	3–8.1	defleshing
Ribs	Large size	5	2–3	incisions	diaphysis: dorsal face diaphysis: ventral face	obl	2.3–11.7 5–22.3	defleshing viscera removal
	Medium size	6	3–5	incisions	diaphysis: dorsal face diaphysis: ventral face	obl	5.6–10.1 5.3–9.8	defleshing viscera removal
	Small size	1	1	incisions	dorsal face	obl	4.4	defleshing
Vertebrae	Medium size	1	8	incisions	spinous process	obl	2.5–12.3	defleshing
Pelvis	*O. cuniculus*	2	2 2	incisions	acetabular fossa ischial tuberosity	tr obl	1.2–1.9 1.3–2.7	dismembering defleshing
Scapula	*C. elaphus*	1	14	incisions	axillary border	obl-tr	2.1–3;2.2	defleshing
Humerus	*M. giganteus*	1	6	incisions	diaph.-metaph.	long	10–31.2	defleshing
	B. primigenius	1	5	incisions	diaph.-metaph.	obl	14–32.1	defleshing
	C. elaphus	2	1-5	incisions scrape	diaph.-metaph. diaphysis	obl long	2.9 22.3–36.1	defleshing periosteum removal
	Cygnus olor	2	2–7	incisions	distal metaphysis	obl-tr	1.5–7.2	defleshing
	Dama sp.	1	14	incisions	diaphysis	obl	2.5–7.2	defleshing
	E. ferus	6	1–4	incisions	diaphysis	obl	2–26.8	defleshing
	Large size	5	1–4	incisions	distal metaphysis	long-obl	3–10.2; 2.7	defleshing
	Large size	1	5	scrape	diaphysis	long	14.2–21.2	periosteum removal
	Medium size	1	1	incisions	diaphysis	obl	4.6	defleshing
Radius	*C. elaphus*	5	2–7	incisions	diaphysis insertion	obl obl	8–31.1	defleshing
	E. ferus	2	4–5	incisions	diaphysis	obl(tr)	2–11.5	defleshing
	Small size	1	3	incisions	diaphysis	obl	2–4.6	defleshing
Ulna	*B. primigenius*	1	3	incisions	diaphysis	long(obl)	9–28.3	defleshing
	C. elaphus	3	1–3	incisions	olecranon process diaphysis	obl	3–11.2	disarticulation defleshing
Metacarpus	*C. elaphus*	2	1–4	incisions	diaphysis	obl-tr	1.9–3.8; 5.9	skinning
Femur	*M. giganteus*	1	2	incisions	proximal metaphysis	tr	3.4	defleshing
	B. primigenius	2	2	incisions	insertion	obl	16–22.1	defleshing
	C. elaphus	12	1–8	incisions scrape	prox. epiphysis diaphysis diaphysis	obl(long) obl(long) long	7.8 6.7–33.5 13.1	dismembering defleshing periosteum removal
	Dama sp.	2	5–8	incisions	diaphysis	obl(long)	2–28.1	defleshing
	E. ferus	5	1–6	incisions	diaph. prox. metaph.	obl-tr	8–12; 4–5.1	defleshing
	Medium size	2	4–5	incisions	diaphysis	obl	6.7–15	defleshing
Tibia	*B. primigenius*	3	2	incisions	–	obl(long)	4.4–16	defleshing
	C. elaphus	18	1–12	incisions chopmarks scrape	diaph.-metah. metahysis diaphysis	obl-tr tr long	7–35.2 2–8.5 17.6–42.3	periosteum removal
	E. ferus	5	3–8	incisions	diaphysis	–	2.7–18.6	defleshing
	O. cuniculus	3	1–4	incisions	diaph.-prox. metah.	obl-tr	1.3–18	defleshing

Table 4
Number of faunal remains with cutmarks according to skeletal element and taxa from level XII bone assemblage.
Tableau 4
Nombre d'os, avec traces de découpe selon l'élément du squelette et les taxons au niveau XII.

		Groups	N° striations by group	Type of cutmarks	Location	Orient*	(mm)	Action performed
	Large size	5	1–5	incisions	diaph.-prox. metah.	obl-tr	4–25.3	defleshing
	Medium size	1	2	incisions	diaphysis	long	4.3–9.2	defleshing
Metatarsus	*C. elaphus*	2	2–5	incisions	diaphysis	obl-tr	9.8–12.5; 19–22.3	skinning
Metapodium	*C. elaphus*	6	1–6	incisions	diaphysis	obl-tr	2.4–5.2; 13–25.2	skinning
	E. ferus	2	1–7	incisions	diaph.-prox. metah.	obl-tr	12.1–17.5	skinning
	Dama sp.	3	6–8	incisions	diaphysis	obl-tr	2.1–5.8	skinning
	Large size	1	4	incisions	prox. metaphysis	obl(tr)	4.9–5.7	skinning
Phalanges	*C. elaphus*	2	3–5	incisions	metaphysic diaphysis	obl	2.3–4.4	skinning
	E. ferus	1	2	incisions	diaphysis	obl	5.6–8.4	skinning
Long bones	Large size	31	1–12	incisions scrape	diaphysis	obl-long	5.7–69.8	defleshing? periosteum removal
	Medium size	48	1–11	incisions scrape	diaph.-metaph. diaphysis	obl-tr long	2–27.4; 2–9 7.7–11.4	defleshing? periosteum removal
	Small size	6	1–10	incisions scrape	diaph.-metaph. diaphysis	obl-tr long	3.9–14.3 7.3–8.3	defleshing ? periosteum removal
Flat bones	Large size	5	1–3	incisions	diaphysis	obl-long	7–18.5	defleshing
	Medium size	20	2–6	incisions	diaphysis	obl-obl	5–30.2	defleshing

* obl, oblique; long, longitudinal and tr, transverse.
*obl, oblique ; long, longitudinale et tr, transversale.

are recorded at the South African site of Namaqualand in the Later Stone Age (Dewar et al., 2006) and at the Neolithic site of Tell Abu Hureyra in Syria (Legge and Rowley-Conwy, 1987). Nevertheless, we have to take into account that in the case of Bolomor, multiple predation may not have been used on all the individuals of this species; the possibility that some adult horses were hunted individually cannot be excluded.

Despite this predominance of primary and immediate access at the level XII assemblage, secondary access has also been documented. There are anatomical elements that characterize the skeletal parts left by carnivores or other hominids after primary and immediate access (Binford, 1981; Brain, 1981; Lyman, 1994; Stiner, 1994; *inter alia*): vertebrae, ribs and pelves of large and medium-sized animals have also been identified. Although these elements are not abundant, they are present in the fossil record. Occasionally, cutmarks on the dorsal surfaces of ribs in the form of prominent sawing and deep incisions are also observed. This evidence is recorded on large and medium-sized animals and represents 2% of the total analyzed remains. In addition, overlapped marks made by carnivores and hominids are also documented. Specifically, two of these overlapping marks coincide with those described at an experimental level in the cases of cutmarks on carnivore toothmarks (Blasco and Rosell, 2009):

(1) variations in the delineation, thickness and depth of incisions in the area closest to the puncture;
(2) signs of cutmarks on toothmark edges as a result of the lithic tool intersecting the puncture edge (in one case, a notch was generated).

Furthermore, the cortical tissue located on the puncture base is not altered by carnivore action in the case shown in Fig. 6a. If the incisions preceded the toothmarks, these would have been conserved on the puncture base. Therefore, these overlapping marks suggest a sporadic secondary access to the carcasses by hominids. Nevertheless, the main type of access used by the hominids to obtain animal resources was mainly primary and immediate, although, occasionally, scavenging might be another option to obtain nutrients.

On the other hand, the human consumption of small prey is also documented at level XII in the form of cutmarks and anthropogenic bone breakage of birds (*Cygnus olor*) and lagomorphs (*Oryctolagus cuniculus*). The use of small prey for food is common throughout the entire stratigraphic sequence of Bolomor Cave (Blasco, 2008; Blasco and Fernández Peris, 2009; Sanchís Serra and Fernández Peris, 2008). Stiner (2001) distinguishes among slow-moving, easily collected types (mostly tortoises and shellfish), fast-running mammals (mostly lagomorphs), and quick-flying animals (birds). The hunting of fast-running and quick-flying small prey involves complex trapping methods and a sophisticated technology. On the other hand, slow-moving small animals can essentially be captured with limited technology. Isaac and Crader (1981) consider that acquiring

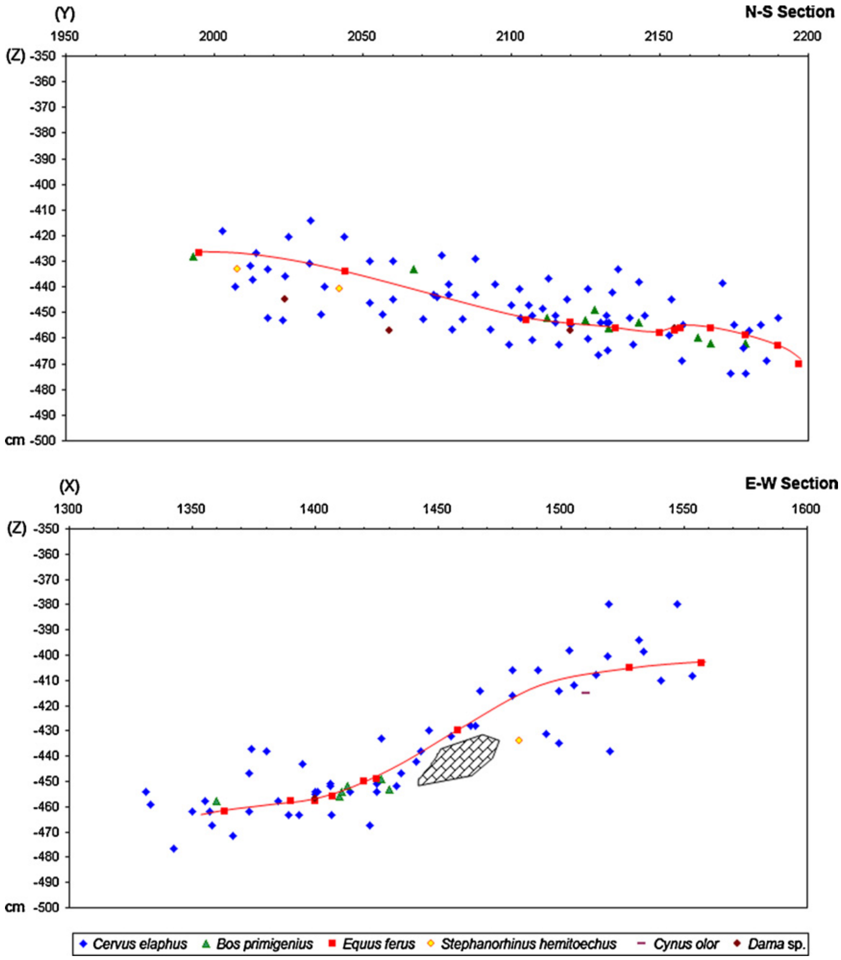

Fig. 5. **(a)** Stratigraphic distribution of the faunal remains from level XII of Bolomor Cave along the north-south section ($X=1400$–1424); **(b)** stratigraphic distribution of the faunal remains from level XII along the east-west section ($Y=2126$–2150). To avoid problems derived from the layer slope, only the faunal remains contained in a band of 24 cm wide have been projected at the vertical level.

Fig. 5. **(a)** Distribution stratigraphique des restes fauniques du niveau XII de la Grotte du Bolomor selon une coupe nord-sud ($X=1400$–1424) ; **(b)** distribution stratigraphique des restes fauniques du niveau XII selon une coupe est-ouest ($Y=2126$–2150). Pour éviter les problèmes dus à de la pente de la couche, seulement les restes fauniques contenus dans une bande de 24 cm de largeur ont été projetés au niveau vertical.

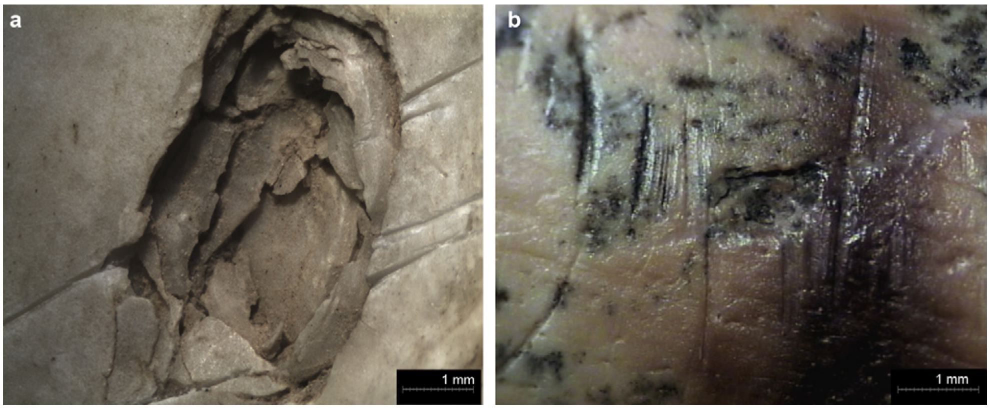

Fig. 6. Stereoscopic view (SZ11) from level XII bone assemblage: (**a**) scapula of large-sized animal with cutmarks over carnivore toothmark (puncture); (**b**) long bone fragment of middle-sized animal with carnivore toothmarks (pit) over cutmarks.

Fig. 6. Vue stéréoscopique (SZ11) de quelques os du niveau XII : (**a**) scapule d'un animal de grande taille, avec traces de boucherie sur la morsure d'un carnivore (perforation) ; (**b**) fragment d'os longs d'animaux de taille moyenne, avec morsures de carnivore sur les traces de boucherie.

small prey is closer to gathering than hunting. In any case, it is evident that their capture requires techniques different from those used for large and medium ungulates.

From this perspective, several strategies to obtain animal resources are documented at level XII of Bolomor Cave. This diversity is common in current hunter-gatherer groups, such as Hadza (Bunn et al., 1988; O'Connell et al., 1988a, 1988b), Kua (Bartram and Marean, 1999) or Efe pygmies of the Ituri Forest (Coon, 1971). These groups are able to practice strategies of social hunting and to take advantage of carcasses left by large carnivores in early stages of consumption. From this perspective, it is not rare that the complex hunting suggested at Bolomor Cave, the cooperative hunting identified in Qesem Cave (Stiner et al., 2009) and the specialized hunting documented at several European Middle Palaeolithic sites, such as Mauran in France (Farizy et al., 1994), Biache-Saint-Vaast in Belgium (Auguste, 1995), Salzgitter Lebenstedt in Germany (Gaudzinski and Roebroeks, 2000) or Chokurcha, Buran Kaya, Starocelié and Kabazi II in Crimea (Patou-Mathis, 2006) coexist with episodes of opportunistic scavenging or with small game. In general, this diversity can be related to the highly adaptive subsistence strategies of these hominids, who could take advantage of the benefits offered by a diverse and rich environment, which might allow the development of diverse strategies to obtain food resources.

6. Conclusions

The zooarchaeological study of level XII of Bolomor Cave has allowed us to identify the coexistence of different anthropogenic strategies to obtain faunal resources in the late Middle Pleistocene, specifically during MIS 6. In the case of horse remains, the combination of the skeletal representation, their ages at death, the location and purpose of cutmarks, the archaeostratigraphic distribution of their fossils within the assemblage and bone refits might suggest the practice of complex techniques of hunting such as multiple predation. In this sense, the location of the cave at a high point above the plain and the gregarious character of horses could favour the development of this type of strategy.

On the other hand, individual hunting seems to have been the principal technique to obtain the other ungulates identified in the assemblage, mainly red deer. In this case, the same age pattern (mainly adults) is documented as a result of an anthropogenic selection of the individuals. Also, the human consumption of small prey, specifically *Oryctolagus cuniculus* and *Cygnus olor*, is identified in the assemblage. The capture of these animals implies the development of other techniques different from those used to acquire large and medium ungulates.

From this perspective, these different practices of hunting coexist at level XII with sporadic events of secondary access to the carcasses (scavenging). Although not abundant, some anatomical elements that characterize the skeletal parts left by carnivores after primary and immediate access, cutmarks on the dorsal surfaces of ribs in the form of prominent sawing and deep incisions and overlapping of cutmarks on carnivore toothmarks are documented.

In general, a variety of strategies to obtain faunal resources is documented at the Bolomor Cave site. For us, this fact might suggest an important human capability not only for improvisation (sporadic scavenging), but also for organization (complex hunting) during the late Middle Pleistocene. The development of all these techniques at the same site might show a sophisticated human knowledge of animal behaviour and the features of the territory during the MIS 6.

Acknowledgments

Thanks to the Prehistory Museum of Valencia, to the SIP (Prehistoric Investigation Service) and to the Conselleria de Cultura de la Generalitat Valenciana for their economic contributions to the excavation. Thanks to the fieldwork team and special thanks to Helle Kettner for English corrections and Florent Rivals for the French translation. This research was supported by Generalitat de Catalunya Grant 2009 SGR 188. Ruth Blasco is the beneficiary of a predoctoral research fellowship (FI) from the Generalitat de Catalunya and is financed by the European Social Fund.

References

Andrews, P., Fernández Jalvo, Y., 1997. Surface modifications of the Sima de los Huesos fossil humans. J. Human Evol. 33, 191–216.
Arsuaga, J.L., Martínez, I., Villaverde, V., Lorenzo, C., Quam, R., Carretero, J.M., Gracia, A., 2001. Fósiles humanos del País Valenciano. In: Villaverde, V. (Ed.), De Neandertales a Cromañones. El Inicio del Poblamiento Humano en las Tierras Valencianas. Universidad de Valencia, Valencia, pp. 265–322.
Auguste, P., 1995. Chasse et charognage au Paléolithique moyen : l'apport du gisement de Biache-Saint-Vaast (Pas-de-Calais). Bull. Soc. Prehist. Fr. 92, 155–167.
Azorit, M., Analla, M., Carrasco, R., Calvo, J.A., Muñoz-Cobo, J., 2002. Teeth eruption pattern in red deer (*Cervus elaphus hispanicus*) in southern Spain. Ann. Biol. 24, 107–114.
Bartram, L.E.J., Marean, C.W., 1999. Explaining the "Klasies pattern": Kua ethnoarchaeology, the Die Kelders Middle Stone Age archaeofauna, long bone fragmentation and carnivore ravaging. J. Archaeol. Sci. 26, 9–29.
Binford, L.R., 1981. Bones: ancient Men and Modern Myths. Academic Press, New York, 440 p.
Blasco, R., 2008. Human consumption of tortoises at Level IV of Bolomor Cave (Valencia Spain). J. Archaeol. Sci. 35, 2839–2848.
Blasco, R., Fernández Peris, J., 2009. Middle Pleistocene bird consumption al level XI of Bolomor Cave (Valencia Spain). J. Archaeol. Sci. 36, 2213–2223.
Blasco, R., Rosell, J., 2009. Who was the first? An experimental application of carnivore and hominid overlapping marks at the Pleistocene archaeological sites. C. R. Palevol 8, 579–592.
Blumenschine, R.J., 1995. Percussion marks, tooth marks, and experimental determinations of the timing of hominid an carnivore access to long bones at FLK *Zinjanthropus*, Olduvai Gorge, Tanzania. J. Human Evol. 29, 21–51.
Bökonyi, S., 1972. Zoological evidence for seasonal or permenent occupation of prehistoric settlements. In: Ucko, P.J., Tringham, R., Dimbleby, G.W. (Eds.), Man, Settlement and Urbanism. Duckworth, London, pp. 121–26.
Brain, C.K., 1969. The contribution of Namib desert Hottentots to an understanding of australopithecine bone accumulations. Scientific Paper Namib Desert Res. Stn. 39, 13–22.
Brain, C.K., 1981. The Hunters or the Hunted. An Introduction to African Cave Taphonomy. University of Chicago Press, Chicago, 365 p.
Bromage, T.G., Boyde, A., 1984. Microscopic criteria for the determination of directionality cutmarks on bone. Am J. Phys. Anthropol. 65, 359–366.
Brugal, J.-P., Jaubert, J., 1991. Les gisements paléontologiques pleistocènes à indices de fréquentation humaine : un nouveau type de comportament de prédation? Paleo. 3, 15–41.

Brugal, J.-P., Díez-Lomana, C., Huguet, R., Michel, P., Rosell, J., 2006. Karstic cavities, natural bone accumulations and discrete human activities in the European Palaeolithic: some case studies. In: Haws, J.A., Hockett, B.S., Brugal, J.-P. (Eds.), Paleolithic Zooarchaeology in Practice. BAR International Series, 1564, pp. 1–12.
Bunn, H.T., 1981. Archaeological evidence for meat-eating by Plio-Pleistocene hominids from Koobi Fora and Olduvai Gorge. Nature 291, 574–577.
Bunn, H.T., Ezzo, J.A., 1993. Hunting and scavenging by Plio-Pleistocene hominids: nutritional constraints, archaeological patterns, and behavioural implications. J. Archaeol. Sci. 20, 365–398.
Bunn, H.T., Bartram, L.E., Kroll, E.M., 1988. Variability in bone assemblage formation from Hadza hunting, scavenging, and carcass processing. J. Anthropol. Archaeol. 7, 412–457.
Capaldo, S.D., Blumenschine, R.J., 1994. A quantitative diagnosis of notches made by hammerstone percussion and carnivore gnawing in bovid long bones. Am. Antiquity 59, 724–748.
Coon, C., 1971. The Hunting Peoples. Little Brown, Boston, 413 p.
Dewar, G., Halkett, D., Hart, T., Orton, J., Sealy, J., 2006. Implications of a mass kill site of springbok (*Antidorcas marsupialis*) in South Africa: hunting practices, gender relations, and sharing in the Later Stone Age. J. Archaeol. Sci. 33, 1266–1275.
Díez, J.C., Rosell, J., 1998. Estrategias de subsistencia de los homínidos de la Sierra de Atapuerca. Atapuerca y la Evolución Humana. Fundación Ramón Areces, Madrid, pp. 361–90.
Díez, J.C., Fernández-Jalvo, Y., Rosell, J., Cáceres, I., 1999. Zooarchaeology and taphonomy of Aurora Stratum (Gran Dolina, Sierra de Atapuerca Spain). J. Human Evol. 37, 623–652.
Domínguez-Rodrigo, M., Pickering, T.R., 2003. Early hominid hunting and scavenging: a zooarcheological review. Evol. Anthropol. 12, 275–282.
Domínguez-Rodrigo, M., Piqueras, A., 2003. The use of tooth pits to identify carnivore taxa in tooth-marked archaeofaunas and their relevance to reconstruct hominid carcass processing behaviours. J. Archaeol. Sci. 30, 1385–1391.
Domínguez-Rodrigo, M., Barba, R., 2006. New estimates of tooth mark and percussion mark frequencies at the FLK Zinj site: the carnivore-hominid-carnivore hypothesis falsified. J. Human Evol. 50, 170–194.
Emerson, A.M., 1993. The role of body part utility in small-scale hunting under two strategies of carcass recovery. In: Hudson, J. (Ed.), From Bones to Behavior: ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains. Center for Archaeological Investigation, Occasional Paper 21, Southern Illinois, pp. 138–155.
Farizy, D., David, F., Jaubert, J., 1994. Hommes et Bisons du Paléolithique moyen à Mauran (Haute-Garonne), xxx^{e} suppl. Gallia Préhistoire, Paris, 265 p.
Fernández-Jalvo, Y., Díez, J.C., Cáceres, I., Rosell, J., 1999. Human cannibalism in the Early Pleistocene of Europe (Gran Dolina, Sierra de Atapuerca, Burgos Spain). J. Human Evol. 37, 591–622.
Fernández Peris, J., 2007. La Cova del Bolomor (Tavernes de la Valldigna, Valencia). Las industrias líticas del Pleistoceno medio en el ámbito del Mediterráneo peninsular. Serie de Trabajos Varios del SIP (Servicio de Investigación Prehistórica), 108, Valencia, 462 p.
Fumanal, M.P., 1995. Los depósitos cuaternarios en cuevas y abrigos rocosos. Implicaciones sedimentológicas. El Cuaternario del País Valenciano 4, 115–124.
Gaudzinski, S., Roebroeks, W., 2000. Adults only. Reindeer hunting at the Middle Palaeolithic site Salzgitter Lebenstedt, northern Germany. J. Human Evol. 38, 497–521.
Haynes, G., 1980. Evidence of carnivore gnawing on Pleistocene and recent mammalian bones. Paleobiology 6, 341–351.
Haynes, G., 1983. Frequencies of spiral and green-bone fractures on ungulate limb bones in modern surface assemblages. Am. Antiquity 48, 102–114.
Isaac, G.L., Crader, D.C., 1981. To what extent were early hominids carnivorous? An archaeological perspective. In: Harding, R.S.O., Teleki, G. (Eds.), Omnivorous Primates. Columbia University Press, New York, pp. 37–103.
Kruuk, H., 1972. The spotted hyaena: a study of predation and social behavior. University of Chicago Press, Chicago, 335 p.
Legge, A.J., Rowley-Conwy, P.A., 1987. Caza de gacelas en la Siria de la edad de Piedra. Rev. Invest. Ciencia 133, 72–80.
Lyman, R.L., 1994. Vertebrate Taphonomy. University Press, Cambridge, 524 p.
Marean, C.W., Kim, S.Y., 1998. Mousterian large-mammal remains from Kobeh Cave. Behavioral implications for Neanderthals and Early Modern Humans. Curr. Anthropol. 39, 79–113.
Mariezkurrena, K., Altuna, J., 1983. Contribución al conocimiento del desarrollo de la dentición y el esqueleto postcraneal de *Cervus elaphus*. Munibe 35, 149–202.
Martínez Valle, R., 2001. Los grandes mamíferos pleistocenos. Una aproximación paleoambiental y bioestratigráfca. In: Villaverde, V. (Ed.), De Neandertales a Cromañones. El Inicio del Poblamiento Humano en las Tierras Valencianas. Universidad de Valencia, Valencia, pp. 45–57.
Nowak, R.M., 1991. Walker's mammals of the world. Volume I–II. The Johns Hopins University Press, Baltimore, Maryland, EUA, 1629 p.
O'Connell, J.F., Hawkes, K., Blurton Jones, N., 1988a. Hadza scavenging: implication for Plio-Pleistocene hominid subsistence. Curr. Anthropol. 29, 356–363.
O'Connell, J.F., Hawkes, K., Blurton Jones, N., 1988b. Hadza hunting, butchering, and bone transport and their archaeological implications. J. Anthropol. Res. 44, 113–161.
Patou-Mathis, M., 2006. Comportements de subsistance des Néandertaliens d'Europe. In: Demansin, B., Otte, M. (Eds.), Neanderthals in Europe, Proceedings of the international conference held in the Gallo-Roman Museum in Tougereu (September 17-19th 2004), 117. Eraul, Liège, pp. 67–76.
Pickering, T.R., Egeland, C.P., 2006. Experimental patterns of hammerstone percussion damage on bones: implications for inferences of carcass processing by humans. J. Archaeol. Sci. 33, 459–469.
Potts, R., Shipman, P., 1981. Cutmarks made by stone tools on bones from Olduvai Gorge Tanzania. Nature 291, 577–580.
Reitz, E.J., Wing, E.S., 1999. Zooarchaeology. Cambridge University Press, New York, 455 p.
Sanchís Serra, A., Fernández Peris, J., 2008. Procesado y consumo antrópico de conejo en la Cova del Bolomor (Tavernes de la Valldigna Valencia). Complutum 19, 25–46.
Sarrión, I., Fernández Peris, J., 2006. Presencia de *Ursus thibetanus mediterraneus* (Forsyth Major 1873) en la Cova del Bolomor (Tavernes de la Valldigna, Valencia). Arch. Prehistoria Levantina 26, 25–38.
Schaller, G.B., 1972. The Serengeti lion. University of Chicago Press, Chicago, 480 p.
Selvaggio, M.M., Wilder, J., 2001. Identifying the involvement of multiple carnivore taxa with archaeological bone assemblages. J. Archaeol. Sci. 28, 465–470.
Shipman, P., Rose, J., 1983. Early hominid hunting, butchering and carcass-processing behaviors: approaches to the fossil record. J. Anthropol. Archaeol. 2, 57–98.
Silver, I.A., 1969. La determinación de la edad en los animales domésticos. In: Silver (Ed.), Ciencia en Arqueología, Mexico, pp. 229–39.
Speth, J.D., 1997. Communal bison hunting in western North America: background for the study of Paleolithic bison hunting in Europe. In: Patou-Mathis, M.E., Otte, M. (Eds.), L'alimentation des hommes du Paléolithique. Approche pluridisciplinaire, Études et Recherches Archéologiques. Université de Liège, Liège, pp. 23–57.
Steele, D.G., Baker, B.W., 1993. Multiple predation: a definitive human hunting strategy. In: Hudson, J. (Ed.), From Bones to Behavior. Ethnoarchaelogical and Experimental Contributions to the Interpretation of Faunal Remains. Center for Archaeological Investigation Occasional Paper 21, southern Illinois, pp. 9–37.
Stiner, M.C., 1994. Honor among thieves: a zooarchaeological study of Neandertal ecology. Princeton University Press, Princeton, 447 p.
Stiner, M.C., 2001. Thirty years on the "Broad Spectrum Revolution" and Paleolithic demography. P. Natl. Acad. Sci. USA 19, 6993–6996.
Stiner, M.C., Barkai, R., Gopher, A., 2009. Cooperative hunting and meat sharing 400–200 kya at Qesem Cave. Israel. P. Natl. Acad. Sci. USA 106, 13207–13212.
Todd, L.C., Frison, G.C., 1992a. Reassembly of bison skeletons from the Horner site: a study in anatomical refitting. In: Hofman, J.L., Enloe, J.G. (Eds.), Putting the pieces together: an introduction to refitting. BAR International Series, 578, pp. 63–82.
Todd, L.C., Stanford, D.J., 1992b. Application of conjoined bone data to site structural studies. In: Hofman, J.L., Enloe, J.G. (Eds.), Putting the pieces together: an introduction to refitting. BAR International Series, 578, pp. 21–35.
Villa, P., Mahieu, E., 1991. Breakage patterns of human long bones. J. Human Evol. 21, 27–48.
Waguespack, N.M., 2002. Caribou sharing and storage: refitting the Palangana site. J. Anthropol. Archaeol. 21, 396–417.
White, T.D., 1992. Prehistoric Cannibalism at Mancos 5MTURM-2346. Princeton University Press, Princeton, 462 p.