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Small and large game: Human use of diverse faunal resources at Level IV of Bolomor Cave (Valencia, Spain)

Petit et grand gibier : l'utilisation humaine de ressources fauniques diversifiées au niveau IV de la Grotte du Bolomor (Valence, Espagne)

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ABSTRACT

Within the framework of nutritional ecology, subsistence diversification is achieved by adding different species to a diet, but explanations for this diversification vary. In the Broad Spectrum Revolution approach, explanations include demographic, ecological, nutritional and technological factors, as well as the mobility of hunter-gatherer groups. The origin of small animal assemblages is a key issue underlying this debate, as these were an important food resource for several non-human predators (diurnal and nocturnal birds of prey and terrestrial carnivores). To establish the genesis of these accumulations, it is important to analyse the anatomical and age profiles of the animals, the bone breakage patterns and the bone surface modifications. With this aim, we present data from the Level IV faunal assemblage of Bolomor Cave (Valencia, Spain). Level IV, corresponding to MIS 5e, shows human use not only of small animals but also of large- and small-sized carnivores in addition to ungulates. Anthropogenic evidence includes cut-marks, intentional bone breakage, burning patterns and human tooth-marks. The utilisation of other less frequent animals could be related to a generalist human behaviour based on the exploitation of a broad range of prey, and could also be associated with an early diversification of the human diet in this locality. This study aims to provide data concerning human consumption of small prey, to establish the processing sequence both of large/medium and small animals and to contribute to the knowledge of human subsistence strategies in the European Middle Palaeolithic.

Mots clés :
Stratégies de subsistance
Grotte du Bolomor
Niveau IV
Paléolithique moyen
Péninsule ibérique

RÉSUMÉ

Dans le cadre de l'écologie nutritionnelle, la diversification de la subsistance est assurée par l'ajout d'espèces différentes à un régime alimentaire. Les explications de la diversité des aliments sont variées. Du point de vue de l'approche à la *Broad Spectrum Revolution*, ces explications incluent différents facteurs tels que les aspects démographiques, écologiques, nutritionnels et technologiques, et la mobilité des groupes de chasseurs-cueilleurs. L'origine des assemblages osseux avec petits animaux est une question clé qui sous-tend ce débat, car il s'agissait d'une ressource alimentaire importante pour plusieurs prédateurs non humains (oiseaux de proie diurnes et nocturnes et carnivores terrestres). Pour établir la

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genèse de l'accumulation, il est important d'analyser les profils anatomiques et l'âge des animaux, les patrons de fracturation des ossements et les modifications sur la surface osseuse. Avec tel objectif, nous présentons les données de l'assemblage faunique du niveau IV de la Grotte du Bolomor (Valence, Espagne). Le niveau IV, daté en MIS 5e, montre l'exploitation anthropique, non seulement des petits animaux, mais aussi des grands et petits carnivores, en plus des ongulés. Les preuves d'activité anthropique sur les os incluent des traces de découpe, des fractures intentionnelles, des traces de brûlure, et des marques de dents humaines. L'utilisation d'autres animaux moins fréquents pourrait être également liée à un comportement généraliste humain, basé sur l'exploitation d'un large éventail de proies. Ce fait pourrait également être associé à une diversification ancienne de l'alimentation humaine dans cette localité. Cette étude vise à fournir des données concernant la consommation humaine de petites proies, établir la séquence de traitement à la fois des grands, moyens et petits animaux et contribuer à la connaissance des stratégies de subsistance humaines dans le Paléolithique moyen européen.

1. Introduction

The study of the hominid diets and especially how they have evolved throughout time has been the focus of several areas of Archeology and Palaeoanthropology, but it is also becoming an important research area in other fields such as nutrition science and evolutionary medicine. Human groups use plants and animals according to their nutritional, technical and cultural needs. Within the range of faunal resources in a specific environment, obtaining prey involves making decisions. During the search for food, the forager may find many resources that are potentially exploitable; however, he must choose which resources to use. Different and often interconnected hypotheses have been proposed to explain changes in the choice of prey and the exploitation of resources. These are mainly based on the Broad Spectrum Revolution (BSR) approach, which Flannery (1969) proposed, and which was a response to the emergence of the Neolithic in western Asia. For this author, an increase in dietary breadth in foraging societies just before this period was the cause of this change. A substantial diversification in the human diet was also noted by Binford (1968) at the end of the Palaeolithic in the middle and high latitude of Europe. This subsistence diversification, mainly characterised by the inclusion of new species in the diet (such as small prey), raised the carrying capacity of an environment increasingly constrained by climate instability at the end of the Pleistocene. This proposal has been accepted by several researchers and linked to the declining supply of high ranked prey (concurrent with an increased emphasis on low ranked prey), to considerable demographic growth, to a reduction in residential mobility, to a high number of ubiquitous small mammals (such as hares and rabbits) and to important technological developments (e.g. Aura et al., 2002; Byers and Broughton, 2004; Jones, 2006; Pérez-Ripoll and Martínez-Valle, 2001; Schmitt and Lupo, 1995; Stiner, 2001; Stiner and Munro, 2002; Stiner et al., 1999, 2000; Villaverde et al., 1996). Regarding this last topic, some technological advances were based on the production of nets, traps and snares, which allowed the exploitation of small game with a higher energetic return.

The origin of small animal assemblages is a key issue underlying this debate, because these were an important food resource for several non-human predators. Before the Upper Palaeolithic, natural death, carnivores, diurnal raptors and/or owls have often been proposed as mainly responsible for leporid and bird accumulations. However, hominids could have also played an important role in the formation of the small prey assemblages in these chronologies. The faunal assemblage from Bolomor Cave presents diagnostic evidence for systematic human consumption of small prey from MIS 9 to MIS 5e (Blasco, 2008, 2011; Blasco and Fernández Peris, 2009, 2012; Blasco et al., 2010; Sanchis Serra, 2010; Sanchis Serra and Fernández Peris, 2008). At Level IV, the human diet is characterised not only by small animals but also by ungulates and small and large carnivores at times. The aim of this study is to establish the anthropic sequence of obtaining and processing of faunal resources from Level IV and to contribute to the discussion of the broad spectrum diet in Europe.

2. Bolomor Cave

The Bolomor Cave is located on the central Mediterranean coast of Spain, in the town of Tavernes in the Valencian Community. Specifically, the cave is in the Valldigna Valley, a narrow and short valley bordered by the Iberian mountain range to the north and the Prebetic mountain range to the south. Northeast of the site, the coast runs almost perpendicular to the valley, and its base runs along the Vaca River. The cave is situated approximately 100 m above sea level.

The stratigraphic sequence of Bolomor Cave has been divided by sedimentological study into 17 levels numbered from the top of the deposit and with a maximum thickness of 14 m (Fumanal, 1995). The karstic deposit of Bolomor Cave has been dated by Amino Acid Racemization (AAR) and Thermoluminescence (TL) to between MIS 9 and MIS 5e. 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. Therefore, Level IV involves an *ante quem* time of 121 ± 18 Ky from TL and Magnetic Susceptibility (Fernández Peris, 2007) (Fig. 1).

The lithic industry is elaborated mainly in flint and is characterised by the production of flakes. The majority of the retouched artefacts are scrapers and lateral

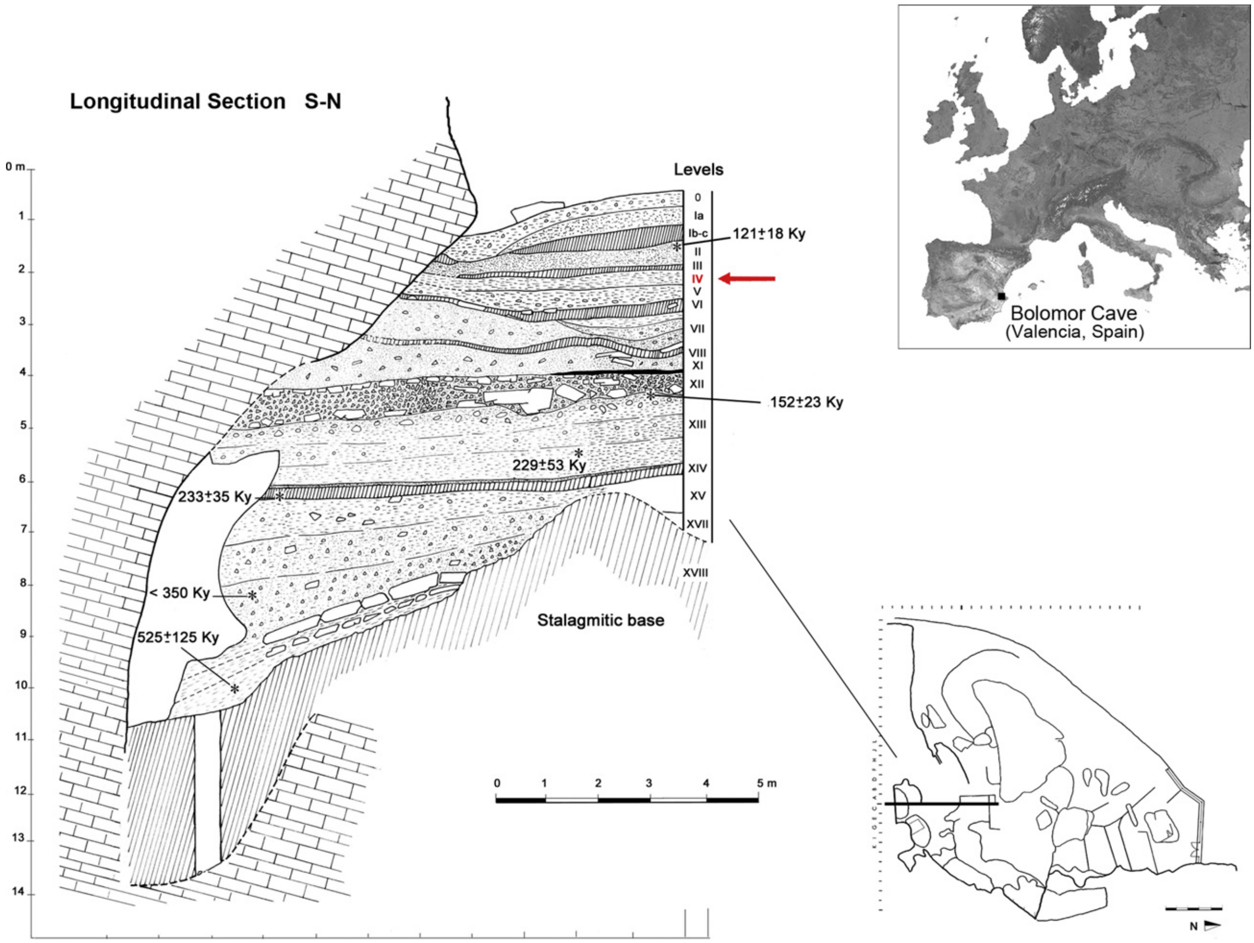

Fig. 1. Location, composite stratigraphic profile of deposits and levels dating at Bolomor Cave (Valencia, Spain) modified from Fernández Peris (2007).
Fig. 1. Localisation, profil stratigraphique composite des dépôts et datations des niveaux de la Grotte du Bolomor (Valence, Espagne) modifié d'après Fernández Peris (2007).

denticulates. The raw materials also consist of limestone and quartzite, which come from marine, colluvial and fluvial stones. The Level IV industry consists mainly of small tools, predominantly scrapers, denticulates and various retouched pieces. The tools are characterised by intensive re-use and recycling of lithics at Level IV (Cuartero, 2008). This technocomplex is older than the regional Classic Mousterian age and has its beginning at some point during the Middle Pleistocene age, under the consideration of an Ancient Middle Palaeolithic, although it is not related to the Acheulian age (Fernández Peris, 2007).

The biostratigraphic sequence is mainly characterised by *Cervus elaphus* and *Equus ferus* and at certain times, by other species such as *Hemitragus cedrensis*, *Hemitragus bonali*, *Dama* sp., *Megaloceros giganteus*, *Sus scrofa*, *Macaca sylvana*, *Equus hydruntinus*, *Bos primigenius*, *Stephanorhinus hemitoechus*, *Palaeoloxodon antiquus*, *Hippopotamus amphibius* and *Castor fiber*. Although fossil remains of *Ursus arctos*, *Ursus thibetanus*, *Canis lupus*, *Panthera leo spelaea*, *Lynx pardina*, *Vulpes vulpes* and *Meles meles* have been documented, carnivore remains are rare (Blasco et al., 2010; Blasco, 2011; Martínez Valle, 2001; Sarrión and Fernández Peris, 2006).

At present, several combustion structures have been documented at levels II, IV, XI and XIII of Bolomor Cave. The hearths are morphologically simple with plain bases and they are not superimposed. Their appearance is lenticular, with diameters between 30 to 120 cm and an average thickness of 5 to 10 cm. In general, they are primary facies hearths and contain pseudomorphs of vegetal ash at different burning stages (Fernández Peris et al., 2012).

3. Methodology

The Level IV faunal remains were classified to both specific and anatomical levels. The Number of Remains (NR) or 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. The MNE was calculated taking into account age, portion and size. The skeletal survival rate estimates the proportion between the elements recovered and those expected (Brain, 1969). The following formula was used to calculate the skeletal survival rate:

$$\%Survival_i = MNE \times 100/\text{number of element}_i \text{ in the animal skeleton} \times MNI.$$

To determine the age at death of the animals, the best indicator in this study was tooth replacement and dental wear for ungulates and carnivores (Azorit et al., 2002; Silver, 1969). Nevertheless, the degree of development and fusion of the epiphyses of the limb bones was also used in some cases (Silver, 1969), especially on leporid remains (Cochard, 2004; Jones, 2006; Sanchis Serra, 2010). The following age groups were established for rabbits: infantile (less than 2/3 months), juvenile (2/3 to 9 months) and adult (more than 9/10 months).

Bone breakage was analysed and classified according to Villa and Mahieu (1991). The outline (transverse, curved/V-shaped, longitudinal), fracture angle (oblique, right, mixed) and surface edge (smooth, jagged) were recorded. The breaks on the small animal bones were classified as either being old (at or near the time of deposition) or new (during or after excavation) (Steadman et al., 2002). The new breaks were well defined by colour changes in the section of bone. In either case, the outline and the fracture angle were also taken into account. The high proportion of broken and partial bones makes specific identifications difficult, but bone fragments were included in size categories related to the estimated body weight of individuals identified in the assemblage, following the criteria established by Bunn (1986) and modified by Díez et al. (1999): very small size or size 1 (< 20 kg); small size or size 2 (100–20 kg); medium size or size 3A and 3B (300–100 kg); large size or size 4 (1000–300 kg); very large size or size 5 (> 1000 kg).

Surface modifications were treated at both macroscopic and microscopic levels. All of the skeletal remains recovered were examined using a binocular magnifier (OPTHEC HZ, up to 120). In some cases, bone remains were also analysed with an Environmental Scanning Electron Microscope (FEI Quanta 600). Damage observed on the faunal remains included cut-marks, intentional bone breakage, burning and carnivore and human tooth-marks. The following types of cut-marks were identified at Level IV according to descriptions made by several authors (Binford, 1981; Bromage and Boyde, 1984; Noe-Nygaard, 1989; Potts and Shipman, 1981; Shipman and Rose, 1983): incisions, scrapes and chopmarks. The analysis took into account the number of striations, location on the anatomical element, distribution over the surface (isolated, clustered, crossed), orientation with respect to the longitudinal axis of the bone (oblique, longitudinal, transverse) and delineation (straight or curved).

Bone damage caused during the breakage was also analysed, and the diagnostic elements of anthropogenic breakage were documented on faunal remains. The following elements were recorded: percussion pits or percussion marks, percussion notches, impact flakes, countercoup (Capaldo and Blumenschine, 1994; Pickering and Egeland, 2006), adhering flakes (Díez et al., 1999) and peeling (White, 1992).

Thermal-modifications were also identified at Level IV (e.g. Buikstra and Swegle, 1989; Guillon, 1987; Nicholson, 1993; Shipman et al., 1984). The skeletal remains progress through different colour stages (mainly from brown, black, and grey to white) and physical alterations during exposure to fire (Correia, 1997; Mayne, 1997). The burning modifications documented are arranged in 6 degrees (from degree 0 or unburned, to degree 5 or calcined).

The carnivore tooth-marks identified on bone remains from Bolomor Cave were mainly pits, punctures and scores (e.g. Binford, 1981; Blumenschine, 1995; Haynes, 1980, 1983; Stiner, 1994). The analysis of tooth-marks also took into account the number, location and distribution on the anatomical element. To estimate the size of the carnivore involved, measurements of the pits' widths and lengths were taken using the criteria described by Selvaggio and Wilder (2001), Domínguez-Rodrigo and Piqueras (2003) and Delaney-Rivera et al. (2009). In the case of small animals, these marks were compared with human tooth-marks (Landt, 2007; Laroulandie, 2000, 2005; Pérez Ripoll, 2005; Sanchis Serra, 2010) and with non-human predator marks (e.g. Andrews, 1990; Andrews and Evans, 1983; Bochenski et al., 2009; Cochard, 2004; Hockett, 1996, 1999; Laroulandie, 2000; Lloveras et al., 2008a, 2008b, 2009; Mayhew, 1976; Sanchis Serra, 2000; Schmitt, 1995).

4. Data presentation

Level IV provided 25323 faunal remains. From these, 2864 have been attributed to 28 taxa, which include the categories of Cercopithecinae, Carnivora, Ungulata and small prey (Leporidae, Aves, Testudinidae, Amphibia and Salmonidae). The MNE is mostly represented by mandibles in carnivores, metapodials, tibiae and phalanges in ungulates; and humeri, femuri, metapodials and phalanges in the case of small prey. In general, basipodials and acropodials are represented by few elements in all of the species from the faunal assemblage. The MNI is 99 and was established from the most common skeletal element according to species and age at death. This is mostly characterised by leporids (20), tortoises (19), birds (15) and red deer (12). These species represent 66.6% of the individuals documented in the faunal assemblage, although small animals represent only 54.5% of the MNI total.

Regarding the age at death of the animals, one group, adult individuals, is clearly predominant over the rest at Level IV with a total of 83 animals (83.8%) (Table 1). The skeletal survival rate assesses the proportion between the recovered elements and those expected from the MNI. Thus, the anatomical representation obtained is valid to observe the elements absent in the assemblage. This rate indicates a biased skeletal representation in all of the taxa in the assemblage. This selection of elements is essentially characterised by cranial elements (mainly mandibles and maxillaries) and by stylopodials and zeugopodials in ungulates. For small prey, such as lagomorphs, all of the skeletal elements are represented, although hindlimbs and forelimbs show dominance over the rest of the skeletal portions, followed by pelvic girdles. Regarding birds, the

Table 1
Number of Remains (NR), Number of Identified Specimens (NISP), Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI) by ages from Level IV faunal assemblage.
Tableau 1
NR, NISP, NME et NMI par âges de l'assemblage faunique du niveau IV.

Level IV Taxa*	NR	NISP	MNE	MNI	MNI by age				
					neo.	inf.	juv.	ad.	sen.
Macaca sylvana	1	1	1	1				1	
Carnivora unident.	5	5	4						
Ursus arctos	1	1	1	1				1	
Canis lupus	2	2	2	1				1	
Vulpes vulpes	2	2	2	1				1	
Panthera leo spelaea	3	3	2	2		1		1	
Lynx pardina	2	2	2	1				1	
Palaeoloxodon antiquus	4	4	2	1		1			
Equus ferus	65	65	25	4			1	3	
Equus hydruntinus	16	16	9	1				1	
Hippopotamus amphibius	46	46	5	2		1		1	
Sus scrofa	115	115	55	5	1	1		2	1
Dama sp.	91	91	41	3		1		2	
Cervus elaphus	647	647	193	12		1	1	10	
Bos primigenius	213	213	63	4		1		3	
Hemitragus cedrensis	121	121	47	3		1		2	
Oryctolagus cuniculus	789	789	440	20		3	1	16	
Passeriformes	25	25	21	2				2	
Corvidae	20	20	13	1				1	
Pyrrhocorax sp.	6	6	6	1				1	
Galliformes	19	19	16	1				1	
Phasianidae	24	24	16	2				2	
Columba sp.	34	34	25	2				2	
Anas sp.	29	29	25	2				2	
Aythya sp.	34	34	28	3				3	
Strigidae	1	1	1	1				1	
Birds unident.	17	17	2						
Testudo hermanni	526	526	131	19				19	
Bufo sp.	4	4	2	2				2	
Salmonidae	2	2	2	1				1	
Very large size	37		6						
Large size	1975		49						
Medium size	10,274		116						
Small size	9053		275						
Very small size	304		61						
Unident.	816								
Total	25323	2864	1689	99	1	11	3	83	1

* Human remains have not been included in this study.
Les restes humains ne sont pas inclus dans cette étude.

anatomical elements with the highest survival are coracoid and tibiotarsus. By contrast, cranium, carina/sternum, ribs, and vertebrae are absent in the assemblage. In the case of tortoises, the anatomical elements with the highest survival are humeri, femuri and plastron (Blasco, 2008) (Table 2).

Following the criteria established by Villa and Mahieu (1991), the degree of bone breakage at Level IV indicates that bones were mainly fractured in the fresh state, and curved fractures (45.4%) and smooth edges (75.2%) are predominant. Diagnostic elements of anthropogenic bone breakage are documented on the majority of species with percussion pits, percussion notches, impact flakes, adhering flakes, counterblows and peeling being present. *C. elaphus* and large- and medium-sized animals are the most affected (72.4%). Bone breakage is mainly focused on the appendicular skeleton, specifically on stylopodials, zeugopodials and metapodials (96.8%). In the case of tortoises, three diagnostic elements of anthropogenic breakage are identified: percussion pits or percussion marks (3), percussion notches (2) and impact flakes (8). Two percussion pits and two percussion notches are located on the carapace (neural bone) and one percussion mark on the plastron (hypoplastron). Impact flakes of the shell are identified and situated on neural (2) and costal bones (3), and three impact flakes are also located on hypoplastron (Blasco, 2008) (Table 3) (Fig. 2). To fracture the leporid and bird bones, the human groups of Level IV probably used their teeth, as no diagnostic elements of fracturing by active or passive percussion are identified. In total, 31 bones of *Oryctolagus cuniculus* and 20 belonging to several species of birds (Galliformes, Phasianidae, Corvidae, *Columba* sp., *Anas* sp., *Aythya* sp. and *Pyrrhocorax* sp.) show human toothmarks in form of small pits associated with broken edges, longitudinal fissures and peeling. In some cases, human tooth-marks take the form of crenulated edges. Similarly, these marks are also observed on tortoise remains, specifically on 15 limb bones (humerus, femur and tibia) and 1

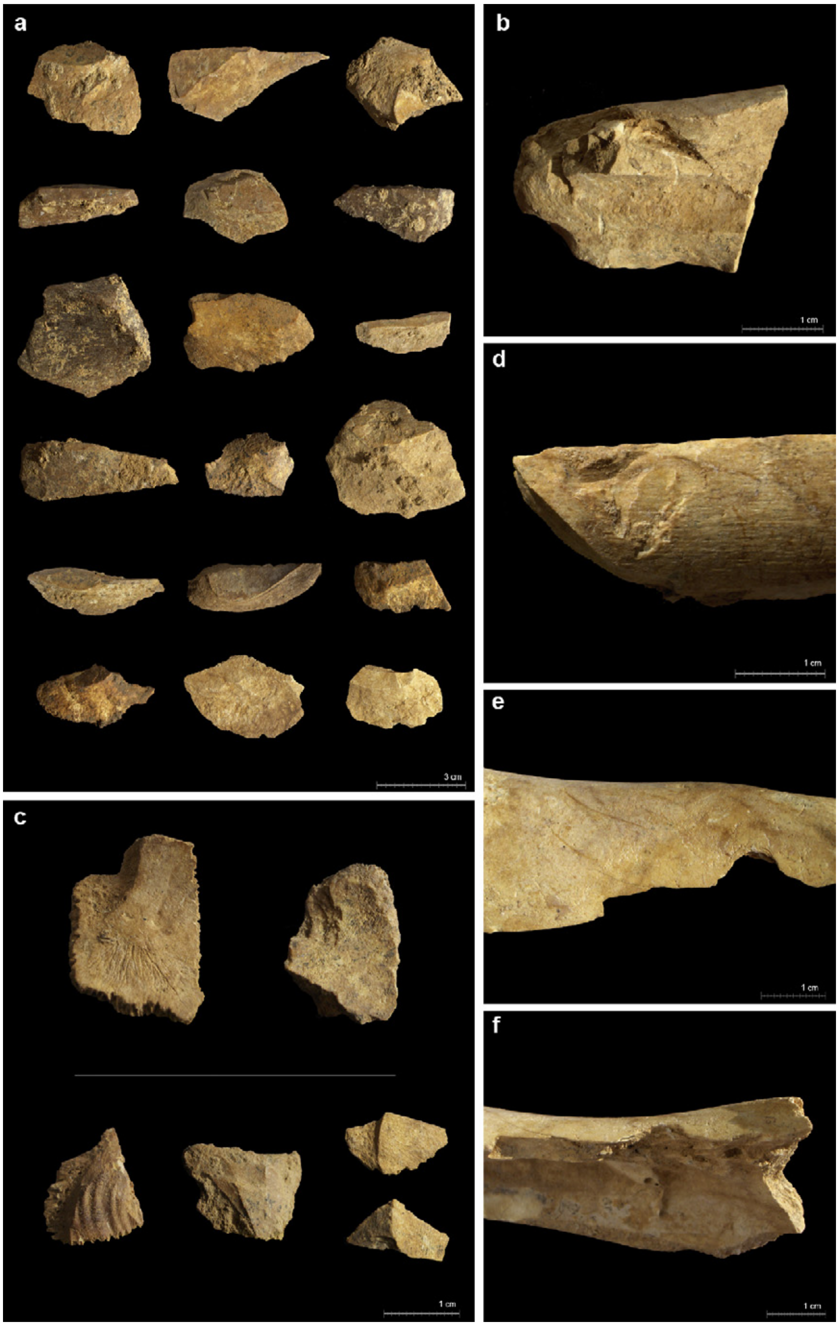

Fig. 2. Diagnostic elements of anthropogenic breakage on several taxa from Level IV faunal assemblage: a: impact flakes on large, medium and small-sized animals; b: percussion notch and adhering flake on distal metaphysis of *Bos primigenius* humerus; c: percussion notches and negative flake scars on ventral surfaces of carapace (costal bones) (top) and impact flakes on carapace and plastron (bottom) of *Testudo hermanni*; d: percussion pit on long bone attributed to medium-sized animal; e, f: percussion notches on distal metaphysis of *Cervus elaphus* humeri.

Fig. 2. Éléments diagnostiques de fracturation anthropique sur quelques taxons de l'assemblage faunique du niveau IV : a : cônes de percussion sur les animaux de grande, moyenne et petite tailles ; b : encoches et éclat adhéré sur la métaphyse distale de l'humérus d'un *Bos primigenius*, c : encoches de percussion et traces négatives des éclats sur les surfaces ventrales de la carapace (os costal) (en haut) et de cônes de percussion sur la carapace et le plastron (en bas) de *Testudo hermanni* ; d : impact de percussion sur un os attribué à un animal de taille moyenne ; e, f: des encoches de percussion sur la métaphyse distale d'un humérus de *Cervus elaphus*

Table 2
Skeleton survival rate (%Surv) according to size categories (making up those identified at specific level) from Level IV faunal assemblage.
Tableau 2
Index de survivance (Surv%) selon les catégories de taille (qui composent celles identifiées au niveau spécifique) de l'assemblage faunique du niveau IV.

	Very large size	Large size	Medium size	Small size	Very small size*		
					Birds	Rabbits	Tortoises
Cranium	100.00	50.00	18.75	46.67	–	–	–
Maxilla	–	43.75	34.38	83.33	–	–	–
Mandible	100.00	68.75	50.00	96.67	–	50.00	–
Clavicle/furcula	–	–	–	–	–	–	–
Hioides	–	–	6.25	6.67	–	–	–
Vertebrae	6.45	1.92	2.88	13.08	–	3.85	3.85
Ribs	–	2.40	2.88	13.33	–	0.96	–
Pelvis	–	31.25	21.88	40.00	10.00	42.50	15.67
Scapula	50.00	50.00	53.13	68.00	23.33	32.50	21.06
Coracoides	–	–	–	–	63.33	–	2.63
Humerus	50.00	68.75	89.31	79.00	33.33	50.00	94.73
Radius	50.00	68.75	87.50	80.33	40.00	40.00	10.53
Ulna	–	56.25	34.38	63.33	43.33	42.50	2.63
Femur	–	56.25	83.75	76.00	33.33	27.50	73.69
Tibia/Tibiotarsus	–	62.50	84.50	76.67	46.67	45.00	36.84
Fibula	–	–	6.25	–	–	–	10.53
Patella/Sesamoideus	–	4.86	6.60	4.44	–	–	–
Carpal/Tarsal	–	2.27	2.56	2.42	–	–	–
Astragalus	–	18.75	6.25	20.00	–	10.00	–
Calcaneus	–	6.25	9.38	10.00	–	75.00	–
Metacarpus/Carpometacarpus	–	37.50	34.38	33.33	40.00	31.25	–
Metatarsus/Tarsometatarsus	–	18.75	28.13	26.67	30.00	36.25	–
Metapodium	14.29	15.63	28.13	28.33	–	–	–
Lateral/Residual metapodium	–	1.56	0.78	–	–	–	–
Phalanges	3.13	10.42	9.11	10.56	12.63	13.65	–
Carapace	–	–	–	–	–	–	42.11
Plastron	–	–	–	–	–	–	68.42

* Skeletal elements belonging to Salmonidae (mandible and vertebra) and *Bufo* sp. (humerus) have not been included into this category to avoid distortion of remains.
Les éléments du squelette appartenant aux salmonidés (mandibule et vertèbres) et à Bufo sp. (humérus) ne sont pas inclus dans cette catégorie pour éviter les distorsions.

fragment belonging to the pelvic girdle. In general, human tooth-marks are related to the removal of meat and fat from the bones. In the case of lagomorphs, these marks are also associated with the marrow removal and cartilage consumption.

As a result of fracturing, patterns can be observed on different skeletal elements of small prey in form of diaphyseal cylinders and isolated ends. For example, the bone fragments belonging to the humerus, femur and tibia of lagomorphs mainly correspond to the distal and proximal part of these bones, and in the case of birds, the bone fragments belonging to tibiotarsus mainly correspond to the distal part of this bone. Bone breakage near ends or joint areas leads to diaphyseal cylinders of the humerus, femur and tibia and the presence of longitudinal bone fragments. Sanchis Serra (2010) observed similar breakage patterns on leporid remains from a Level IV sample to those presented here.

Cut-marks are also identified on 7.2% of the bone remains and are present on all identified species in the assemblage including carnivores, ungulates and small prey (Table 4). At Level IV, incisions are the principal type of modification, although scrapes and sawing marks are also documented. These striae are located on different anatomical portions depending on their type. For example, oblique and longitudinal incisions are mainly situated on limb bone diaphysis, and transversal sawing marks are mainly located on limb bone metaphyses. These marks are predominant on medium- and large-sized taxa. In small animals, these marks are observed on 111 remains of *O. cuniculus*, 32 bones of birds and 49 bones of tortoises. In lagomorphs, incisions are predominant on the diaphysis of metapodials and the first phalanx. These incisions are related to skinning. Cut-marks are also located on the metaphysis and diaphysis of both forelimbs and hindlimbs, and sporadic incisions are observed on several flat bones (mandible, scapula and pelvis). In the case of tortoises, cut-marks are mainly identified on the carapace with a predominance of the incisions and scrapes on the ventral surface of the costal shield. In birds, cut-marks are mainly documented on the coracoid and tibiotarsus with a predominance of incisions on the diaphysis (Fig. 3). Burning is identified on 61.5% of the faunal remains at Level IV (Table 5). This modification is observed on all of the skeletal elements with definite predominance on long bones of medium- and small-sized animals. *O. cuniculus* and *Testudo hermanni* are the most affected small prey. The remains of 481 lagomorphs and 333 bones attributed to tortoises show evidence of burning. In the case of lagomorphs and birds, the highest grades of burning on bones with double colouration coincide with the areas of the skeleton with less muscle (mainly joints of limb bones). For example, in the case of birds, the highest grade of burning is observed on the head of the proximal joint of the humerus, on the distal extremity of the

Table 3
Number of diagnostic elements of anthropogenic breakage according to taxa and size categories from Level IV faunal assemblage. Note that some remains contain several diagnostic characteristics of human fracturing.
Tableau 3
Nombre d'éléments diagnostiques de la fracturation anthropique selon les catégories taxonomiques et la taille des animaux identifiés au niveau IV. Notez que certains contiennent plusieurs caractéristiques diagnostiques.

	Percussion notches	Percussion pits	Impact flakes	Adhering flakes	Cortical negative	Countercoup	Peeling	Total
Sus scrofa								
Phalanx 1	1							1
Equus ferus								
Humerus	1							1
Tibia	4			1				5
Dama sp.								
Humerus	2				1			3
Radius					1			1
Tibia					1			1
Cervus elaphus								
Pelvis		1						1
Scapula	1							1
Humerus	13	2	1		2	1		19
Radius	1				1	1		3
Femur	2	1						3
Tibia	9				1			10
Metacarpus	3		1		1			5
Metatarsus	5	1		1				7
Metapodium	1				2			3
Phalanx	1							1
B. primigenius								
Mandible	1							1
Scapula	1							1
Humerus	2			1				3
Radius	1							1
Femur	1							1
Tibia	2				2			4
Metacarpus	2		1		2			5
Metatarsus			1		1			2
Metapodium	1							1
H. cedrensis								
Humerus	1				1			2
Radius					1			1
Tibia	1							1
Metacarpus			1					1
T. hermanni								
Carapace	2	2	5					9
Plastron		1	3					4
Very large size								
Humerus	1							1
Long bones			9					9
Large size								
Ribs							2	2
Humerus	1				1			2
Metapodium	1	1			1			3
Long bones	13	4	151		14			182
Medium size								
Ribs							4	4
Long bones	29	4	334	1	13	1		382
Small size								
Ribs							1	1
Femur	1							1
Metapodium	1							1
Long bones	6	1	81	1	2			91
Flat bones		1						1
Unident.								
Long bones			83					83
Total	112	19	671	5	48	3	7	865

Table 4
Number of Remains (NR) with cut-marks from Level IV faunal assemblage according to taxa and size categories.
Tableau 4
NR avec traces de découpe du niveau IV selon les catégories des taxons et la taille des animaux identifiés.

	Vulpes vulpes	*P. leo spelaea*	*Lynx pardina*	Carnivora unident.	*Equus ferus*	*E. hydruntinus*	*H. amphibius*	*Sus scrofa*	*Dama* sp.	*C. elaphus*	*B . primigenius*	*H. cedrensis*	*O. cuniculus*	Passeriformes	Corvidae	Galliformes	Phasianidae	*Columba* sp.	*Anas* sp.	*Aythya* sp.	Birds unident.	*T. hermanni*	V. large size	Large size	Medium size	Small size	V. small size	Unident.	NR Total
Cranium																								1	1	2			4
Mandible					1		1		2	2	3		9											1					19
Vertebrae																								4	5	5			14
Ribs																								9	11	13			33
Pelvis								1		2	1		5									2			2				13
Furcula															2														2
Scapula								2		5	3		4		1				1	1				1	2				20
Coracoides																		2	1	4									7
Humerus					2				3	25	4	2	2					2				6				1			47
Radius					1			1		7	2	1	6					2	2										22
Ulna						1		1		3	1		2				1												9
Femur					3				2	9	1	2	2			1				1		2		1		1			25
Tibia/Tbt					4				3	14	4	2	9		1	1				2		1		1		1			43
Fibula	1	2		1										1															5
Astragalus											1																		1
Calcaneus													2																2
Metacarpus/Cmc					1			2	2	11	4	2	8				1	1	1										33
Metatarsus/Tmt								1	2	19	5	2	15																44
Metapodium					1		1		1	12	2		3											5	1	1			27
Phalanx 1			1			1		1	1	7	1		24																36
Phalanx 2							1			1			1																3
Carapace																						28							28
Plastron																						10							10
Long bones													19								3		1	178	722	327	7	5	1262
Flat bones																							1	20	63	24			108
NR Total	1	2	1	1	13	2	3	9	16	117	32	11	111	1	4	2	2	7	5	8	3	49	2	221	807	375	7	5	1817

Tbt: Tibiotarsus; Cmc: carpometacarpus; Tmt: Tarsometatarsus.

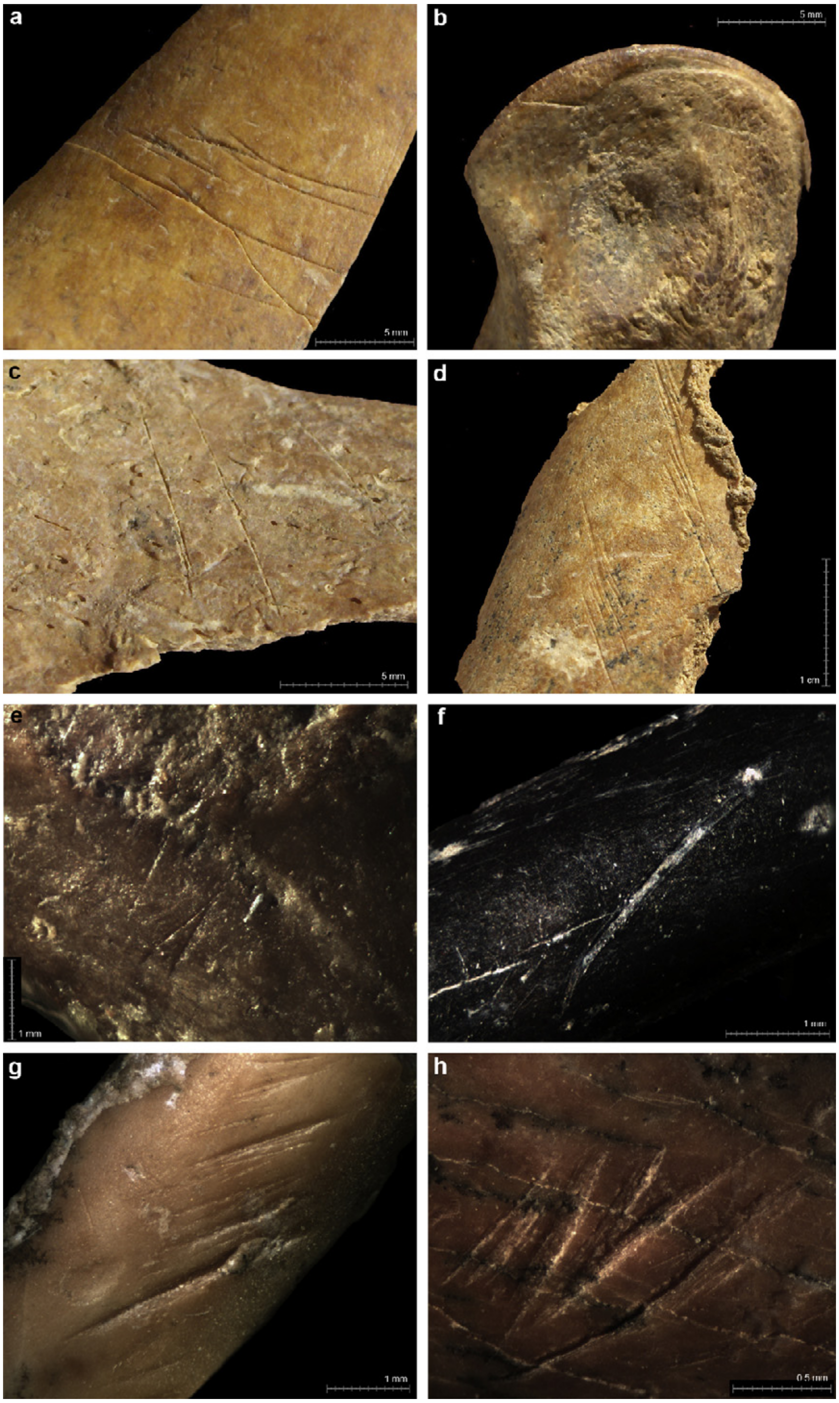

Fig. 3. Examples of cut-marks on several taxa from Level IV faunal assemblage: a: long bone metaphysis attributed to small-sized animal; b: distal epiphysis of *Cervus elaphus* first phalanx; c: flat bone of medium-sized animal; d: long bone diaphysis of small-sized animals; e: distal end of *Aythya* sp. humerus; f: diaphysis of tortoise femur; g: diaphysis of tortoise humerus: h: diaphysis of *Oryctolagus cuniculus* tibia.

Fig. 3. Exemples de traces de découpe sur quelques taxons de l'assemblage faunique du niveau IV : a : métaphyse d'os longs attribuée à un animal de petite taille ; b : épiphyse distale d'une première phalange de *Cervus elaphus* ; c : os plat d'un animal de taille moyenne ; d : diaphyse d'os long d'un animal de petite taille ; e : extrémité distale d'humérus d'*Aythya* sp. ; f : diaphyse de fémur de tortue ; g : diaphyse d'humérus de tortue ; h : diaphyse de tibia d'*Oryctolagus cuniculus*.

Table 5
Number of burned remains according to colour degrees from Level IV faunal assemblage.
Tableau 5
Nombre de restes brûlés en fonction des degrés de couleur dans l'assemblage faunique du niveau IV.

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Double colouration*		Number of Remains (NR) Total	NR %
						SCort	DCort		
Carnivora unident.		2						2	40.0
Vulpes vulpes	1							1	50.0
Palaeoloxodon antiquus				1				1	25.0
Equus ferus	2	20	6		1	8	2	39	60.0
Equus hydruntinus		5	2			1	2	10	62.5
Hippopotamus amphibius	2	5	2	2		1		12	26.1
Sus scrofa	8	17	3	1	1	5		35	30.4
Dama sp.	3	21	8	2	1	11	3	49	53.8
Cervus elaphus	61	112	46	8	2	74	20	323	49.9
Bos primigenius	18	33	17	2		8	1	79	37.1
Hemitragus cedrensis	9	23	22			8	1	63	52.1
Oryctolagus cuniculus	25	334	80	8	1	33		481	60.9
Passeriforme		7	2			2		11	44.0
Corvidae	1	8	3					12	60.0
Galliforme	1	4	2	1				8	42.1
Phasianidae	1	11	1			1		14	58.3
Columba sp.	2	10	1	1		3		17	50.0
Anas sp.	1	15	1			1		18	62.1
Aythya sp.	1	20	3	1				25	73.5
Birds unident.	1	9	2					12	70.6
Testudo hermanni	30	210	50	1	2		40	333	63.3
Very large size	3	5	4			3	2	17	45.9
Large size	66	398	277	20	7	192	83	1043	52.8
Medium size	127	3197	2105	136	56	784	194	6599	64.2
Small size	60	2529	2383	105	110	448	66	5701	62.9
Very small size	4	111	47	5	4	15	1	187	61.5
Unident.	6	155	243	18	12	57	2	493	60.4
NR Total	433	7261	5310	312	197	1655	417	15,585	61.5

* Double colourations are related to the presence of at least two colour grades on the same cortical surface (SCort) or on different cortical surfaces (DCort).
Les doubles colorations sont liées à la présence d'au moins deux degrés de couleur sur la même surface corticale (SCort) ou sur différentes surfaces corticales (DCort).

tibiotarsus and on the distal part of the ventral (palmar) surface of the ulna and the radius. In tortoises, the carapace is the most affected element, and degree 2 is the most abundant modification type. By contrast, degree 4 is the least represented modification type. Double colouration is also observed on 12.1% of the burned tortoise remains. This is mainly documented on the carapace (70.1%). Double colourations identified on faunal remains from Level IV do not coincide with those described by Bennett (1999) for bones burned after burial.

Finally, the incidence of carnivore damage on the faunal assemblage from Level IV is very low. Only 0.5% of bone remains show alterations generated by these non-human predators. Specifically, carnivore damage is identified on 142 fragments: Carnivora indet. (1), *P. leo spelaea* (1), *Equus ferus* (3), *S. scrofa* (2), *Dama* sp. (1), *C. elaphus* (12), *B. primigenius* (8), *Hemitragus cedrensis* (4), *O. cuniculus* (10), very large (2), large (31), medium (55) and small-sized animals (12).

Pits and scores are the most abundant alteration types. Nevertheless, two lagomorph bones show low degrees of digestion. The metric study based on tooth pit sizes according to the bone type (cancellous and dense cortical) suggests the presence of small and medium-sized carnivores during the Level IV formation, although four large puncture marks may be related to the sporadic presence of large carnivores, such as bears or wolves.

5. Discussion

A high specific diversity is observed in the faunal assemblage from Level IV. Evidence of anthropogenic processing is observed not only on ungulates but also on small prey (rabbits, birds and tortoises) and, to a lesser extent, on carnivores. These modifications have enabled us to reconstruct the human consumption sequence of recovered animals.

In the case of large- and medium-size animals, several elements provide information about the methods used to obtain them. These elements include the skeletal representation of the animals identified in the assemblage (e.g. Binford, 1981; Brain, 1981; Lyman, 1994; Stiner, 1994), the age at death of the animals (Gaudzinski and Roebroeks, 2000) and the location of processing marks on the carcasses, including the location and purpose of the cut-marks, presence of carnivore tooth-marks and overlapped marks (e.g. Binford, 1981; Blasco and Rosell, 2009; Bunn, 1981; Domínguez-Rodrigo and Barba, 2006; Domínguez-Rodrigo and Pickering, 2003; Marean and Kim, 1998; Shipman and Rose, 1983). From this perspective, the Level IV faunal record is characterised by a systematic proportion of skeletal elements with a high medullar value, a predominance of adult animals, cut-marks related to viscera removal and oblique and longitudinal incisions on the diaphyses of the limb bones associated with defleshing of large muscle masses, and low carnivore damage. All of these elements suggest that the anthropogenic access to these animals was mainly primary and immediate. In spite of this, occasional events of secondary access have also been documented from overlapped marks (Blasco, 2011; Blasco and Rosell, 2009).

The skeletal representation and bone alterations of lagomorphs and birds do not coincide entirely with those described in several studies on raptor and carnivore accumulations (e.g. Andrews, 1990; Andrews and Evans, 1983; Bochenski and Tomek, 1997; Bochenski and Tornberg, 2003; Bochenski et al., 2009; Bramwell et al., 1987; Cochard, 2004; Hockett, 1996, 1999; Hockett and Haws, 2002; Laroulandie, 2000; Lloveras et al., 2008a, 2008b, 2009; Mayhew, 1976; Mourer-Chauviré, 1983; Sanchis Serra, 2000, 2010; Schmitt, 1995; Trapani et al., 2006). On the other hand, the skeletal survival rate of tortoise remains does coincide with the rate described by Sampson (2000) for anthropogenic accumulations generated by Bushmen in the semi-arid Karoo of South Africa. All of these characteristics, in addition to the presence of anthropogenic evidence in form of cut-marks, burning on the ends of appendicular elements (areas of the skeleton with less meat) and human tooth-marks, show sufficient evidence to attribute the presence of small prey to human activity at Level IV.

However, ascertaining the method of obtaining small prey is a difficult subject. Recognising snares and traps in the archaeological record is difficult because they are generally made from materials that do not preserve well. Nevertheless, Wadley (2010) aims to tackle this matter through ethnographic observations and their corresponding archaeological applications. For this author, a high frequency of small prey, an extensive taxonomic diversity of animals susceptible to being captured by these systems, and a wide range of ages at death and the presence of small carnivores with evidence of human processing constitute sufficient diagnostic elements to prove the presence of trapping systems in the archaeological assemblages. Still, there are significant limitations. For Wadley (2010), the type of prey conditions the possibility of identifying its method of capture. For instance, a wide variety of bird species with different ages at death could correspond not only to the use of traps but also to occasional natural phenomena such as storms or strong winds (Avery and Underhill, 1986; De France, 2005). Therefore, it is not possible to determinate from the present evidence whether these birds were trapped or simply gathered as the occasional victims of these weather processes. However, some gregarious animals, such as European lagomorphs, which are abundant, prolific reproducers and live in easily detectable, densely packed warrens, may be susceptible to mass collection (Hockett and Bicho, 2000; Jones, 2006; Lupo and Schmitt, 2002).

Regarding the age at death, Jones (2006) states that individual trapping of lagomorphs by any method is reflected in an age profile dominated by adults, while the age profile in a leporid assemblage trapped or mass collected from warrens is dominated by immature individuals. In the case of Level IV, the adult lagomorphs are the most abundant. Nevertheless, four immature individuals with anthropogenic modifications are also identified among the estimated 20. This fact, combined with the presence of small carnivores with evidence of human processing (*Vulpes vulpes*, *Lynx pardina* and infantile *P. leo spelaea*), the high percentage of small prey and the high taxonomic diversity could suggest the occasional presence of some kind of trap-based leporid capturing system. However, this technique would not be the most commonly used at Bolomor Cave. The predominant presence of adult individuals could also suggest the existence of techniques related to the individual capture of animals. In spite of this, we must take into consideration that the normal condition of palimpsest identified not only at Bolomor Cave but also at most sites of the Middle and Upper Pleistocene could disguise the occasional use of traps (or mass collecting) during the assemblage formation. From this reasoning, we cannot rule out the possibility that these methods were occasionally used among the human groups of Level IV and that, because they were sporadic, they were practically imperceptible within an assemblage mainly composed of several events.

In any case, the different types of small prey identified at Bolomor Cave may suggest several degrees of difficulty in their individual capture (Stiner, 2001). Slow-moving animals, such as tortoises, would represent the simplest category to catch, while fast-moving animals, such as leporids and birds, would be hardest to capture. Therefore, the collection of this variety of small prey at Level IV requires the development of different strategies to obtain them, which should also be different from those used for the capture of larger animals.

From the location of cut-marks, percussion impacts and burning grades on portions and specific anatomical elements, the human sequence of processing and consumption has been reconstructed. The carcasses are usually skinned from the skull to the metapodial and, in some cases, to the first or second phalanx. Only one *H. amphibious* remain has documented evidence of this activity on a third phalanx. After skinning, the viscera are extracted. This activity seems to be under-represented due to the low representation of the axial skeleton in the faunal assemblage and to the frequent use of hands in this process. However, occasionally, human groups did carry axial elements that enable us to identify this activity. To access the viscera of tortoises, the carapace or plastron must be fractured. At Level IV, percussion marks and notches and impact flakes have been identified on the neural and costal bones of the carapace and on the hypoplastron. Similarly, and although the use of hands could cause this activity to be under-represented, the presence of scrapes on the ventral surface of the shells indicates the use of stone tools to remove the tissue adhered to the plates (Blasco, 2008). Cut-marks related to the removal of the viscera were also identified at the Oldowan site of FwJJ20 in the East Turkana Basin of northern Kenya (Braun et al., 2010), at the Early Pleistocene site of Sima del Elefante in Spain (Blasco et al., 2011), in subsequent periods at Pinnacle Point Cave 13B in the western Cape of South Africa (Thompson, 2010) and at a modern camp (Site 20) located on the eastern shore of Lake Turkana (Rybczynski et al., 1996).

Burning alterations identified on the faunal remains may suggest the presence of several processes, such as the

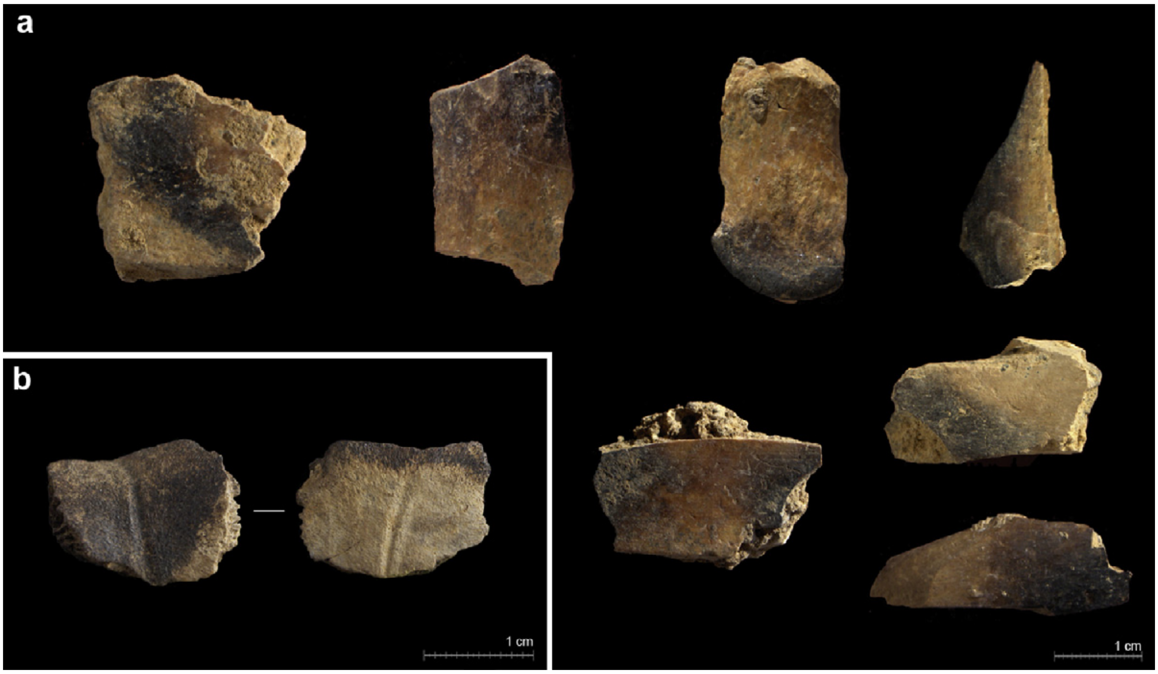

Fig. 4. Examples of thermo-altered bones from Level IV faunal assemblage: a: double colourations on the same bone surface: b: double coloration on ventral and dorsal surface of tortoise peripheral bone.

Fig. 4. Traces de thermoaltération sur quelques os de l'assemblage faunique du niveau IV : a : doubles colorations sur la même surface d'un os ; b : double coloration sur les faces ventrale et dorsale de l'os périphérique d'une tortue.

existence of thermal treatment of the meat, the development of possible cleaning activities or the preparation of bones to facilitate their breakage. Double colouration on the same bone surface has been recorded, which suggests a differential preservation of the meat at the moment it is exposed to fire. The least affected areas are those that present a greater quantity of muscle and a lower degree of cremation, while the most affected are those that hardly have any tissue attached and therefore reach the highest degrees of colouration. This phenomenon allows us to infer that the meat was roasted prior to the removal of the bone (Fig. 4). The presence of uniform double colouration on the same cortical surface rules out a priori the thermal alteration of the bones after they were buried (Bennett, 1999). This fact is reinforced by the absence of thermally altered remains underneath the hearths. The presence of differential thermal alterations on the ends of lagomorph and bird bones also suggests the fact that the meat was cooked before its removal. This phenomenon is also observed by Sanchis Serra (2010) during the analysis of a sample of lagomorph remains at the same level. The phenomenon is also described by several researchers at both experimental and archaeological levels at sites of the Upper Palaeolithic of Western Europe (Cassoli and Tagliacozzo, 1997; Laroulandie, 2000, 2005; Vigne and Balasse, 2004).

Despite this, double colouration on different sides of the bone is also documented. Although these colourations are registered in a low percentage (1.6%), their presence allows us to infer the existence of other processes, which may not be related to the cooking of the meat (cleaning activities or simply unintended actions that lead to the burning of the bones once they have been broken). However, the identified remains with the highest proportion of these modifications are the shells of *T. hermanni*.

Although there is a certain degree of variability, these alterations seem to describe a pattern based on differential burning of the bone surface (with a greater degree of burning on the dorsal surface than on the ventral surface). This phenomenon has been interpreted as a result of cooking these animals before consumption. The characteristics of double colouration indicate that the tortoise could have been placed into the fire upside down (Blasco, 2008). This pattern has been described ethnographically by Werner (1990) for the preparation of tortoises by the Kayapó of Central Brazil. For several authors, this fact represents a diagnostic element to identify the human consumption of tortoises (Flannery and Wheeler, 1986; Sampson, 1998; Speth and Tchernov, 2002; Stahl and Oyuela-Caycedo, 2007).

Defleshing and disarticulation are activities that are often developed simultaneously (Binford, 1981; Potts and Shipman, 1981; Shipman and Rose, 1983; Shipman et al., 1984). The meat removal on proximal appendicular elements is performed following a certain grade of systematisation. Cut-marks can be divided into two groups based on their type and location. These might correspond to two phases in the defleshing process: extraction of large muscle masses that generates oblique and longitudinal incisions on the shaft; removal of the soft tissues attached to bone after the removal of large meat segments that involves transverse and oblique sawing marks on the metaphyses.

Table 6
Number of Remains (NR) with percussion notches according to skeletal elements, taxa and size categories from Level IV faunal assemblage.
Tableau 6
NR avec encoches de percussion en fonction des éléments du squelette, des catégories de taxons et de la taille des animaux identifiés au niveau IV.

	NR	No. impacts (blows)	Distribution	Anatomical area/region	Side
Mandible					
Bos primigenius	1	1	Isolated	Body (P_3 area)	Vestibular
Scapula					
Cervus elaphus	1	1	Isolated	Infra-spinatus fossa	Posterior
Bos primigenius	1	1	Isolated	Axillary border	Posterior
Humerus					
Equus ferus	1	1	Isolated	Distal metaphysis	Posterior
Dama sp.	2	1	Isolated	Distal metaphysis	Posterior
Cervus elaphus	13	1–3	Isolated, correlative	Distal metaphysis, diaphysis	Posterior, lateral
Bos primigenius	2	3	Consecutive	Distal metaphysis	Posterior
Hemitragus cedrensis	1	1	Isolated	Distal metaphysis	Posterior
Very large size	1	1	Isolated	Diaphysis	Lateral
Large size	1	1	Isolated	Distal metaphysis	Posterior
Radius					
Bos primigenius	1	1	Isolated	Diaphysis	Lateral
Cervus elaphus	1	1	Isolated	Diaphysis	Lateral
Femur					
Cervus elaphus	2	1–3	Isolated, consecutive	Diaphysis	Anterior, medial
Bos primigenius	1	1	Isolated	Diaphysis	Anterior
Small size	1	1	Isolated	Diaphysis	Anterior
Tibia					
Equus ferus	4	1	Isolated	Distal metaphysis (diaphysis)	Posterior
Cervus elaphus	9	1–3	Isolated, correlative, consecutive	Distal metaphysis	Posterior, posterior (medial)
Bos primigenius	2	3	Consecutive	Distal metaphysis	Posterior
H. cedrensis	1	1	Isolated	Diaphysis	Posterior
Metacarpus					
Cervus elaphus	2	1	Isolated	Diaphysis	Lateral
Bos primigenius	2	1	Isolated	Diaphysis	Lateral/medial, anterior
Metatarsus					
Cervus elaphus	4	1	Isolated	Diaphysis	Lateral/medial
Metapodium					
Cervs elaphus	1	1	Isolated	Diaphysis	Lateral/medial
Bos primigenius	1	1	Isolated	Diaphysis	Lateral/medial
Large size	2	3	Consecutive	Diaphysis	Lateral/medial
Phalanx 1					
Sus scrofa	1	1	Isolated	Distal metaphysis	Dorsal
Cervus elaphus	1	1	Isolated	Distal metaphysis	Palmar
Long bones					
Large size	10	1–3	Isolated, overlapped	Diaphysis metaphysis	–
Medium size	24	1–2	Isolated, correlative, consecutive	Diaphysis metaphysis	–
Small size	5	1	Isolated	Diaphysis	–

Nevertheless, the physiological characteristics of the animals and the morphology of the bones themselves could condition the location and repetition of cut-marks on certain areas of the bone. It has not been possible to establish an action sequence for flat bones. The presence of several cut-mark types and a high variability of areas where these striae are located hamper the identification of different phases in the defleshing.

However, the meat is not only extracted through the use of lithic tools. Humans also use their teeth to deflesh animals or consume marrow, fat and cartilage of leporids, birds and tortoises. This method often generates high fragmentation, which conforms to well-established morphotypes. In the case of the lagomorphs, the bone breakage (to access the marrow) consists of separating the epiphysis from the diaphyses of the stylopodials and zeugopodials. For this reason, documentation of fragmented shafts or diaphyseal cylinders is common, with the tibia being the skeletal element that illustrates this process best. This standardisation process is also recorded in the lagomorph sample studied by Sanchis Serra (2010) at the same level and at different sites of the European Upper Palaeolithic (e.g. Allué et al., 2010; Aura et al., 2002, 2009; Bicho et al., 2000, 2006; Davis et al., 2007; Haws, 2003; Hockett, 2006; Hockett and Haws, 2002; Pérez Ripoll, 2004, 2005; Pérez-Ripoll and Martínez-Valle, 2001) and even among some groups of hunter-gatherers such as the Aché of eastern Paraguay (Jones, 1983). In the breakage of bird remains, the articular portions also tend to separate from the middle-shaft, although, depending on the skeletal element, the fracture may be located on either the proximal or distal diaphysis. This variation could be the result of either a disarticulation or the consumption of marrow and/or cartilage (Laroulandie, 2000; Lefèvre and Pasquet, 1994). Because of the limited marrow content, it is possible that the breakage of coracoid, scapula and perhaps the proximal end of humerus may correspond to the disarticulation processes of the forelimb. In contrast, the bone breakage patterns are well systematised on femuri and tibiotarsi and could indicate marrow removal. These skeletal elements have the highest marrow content, particularly during the breeding period in females (Driver, 1982; Neer et al., 2002).

In ungulates, thermal treatment of the bones can facilitate their breakage (Bonfield and Li, 1966; Brain, 1981; Bunn and Blumenschine, 1987; Cáceres et al., 2002; Noe-Nygaard, 1977). This fact would produce very low grades of burning (mainly grade 1) and a certain variation in both their fracture morphologies and angles (Cáceres et al., 2002). The bones exposed to high temperatures accelerate the drying process such that the outermost bone tissue loses its fresh state, while the innermost tissue keeps it intact. The result is a relative increase of the mixed angles similar to those observed at Level IV (50.1%). This fact, together with the presence of a low grade of burning, could suggest the use of heat to facilitate the fracturing of bones. However, the removal of the periosteum can also be performed to facilitate bone breakage (Binford, 1981, 1984; Potts and Shipman, 1981; Shipman and Rose, 1983). At Level IV, two cases have been documented in which the scrape marks are located on the same side and portion of the percussion notch and pit. Therefore, it is possible that, at times, periosteum removal was performed with this aim, although this would not be a common process at Bolomor Cave. The fact that many of the bones are heat treated to facilitate the breakage implies the disappearance of this membrane. Therefore, the extraction of the periosteum would not be necessary.

Considering the available elements, two fracturing techniques can be suggested: active or thrown percussion and passive or direct percussion (Giusberti and Peretto, 1991; Anconetani, 1999). Active or thrown percussion is produced when the skeletal element is hit directly against an object such as a stone, and passive or direct percussion is caused when the anatomical element is held on the ground or on an object that acts as an anvil and is hit with an instrument generally made of stone.

Because of the low representation of the axial skeleton in the faunal assemblage, peeling is not frequently documented. Data from the location of percussion impacts on specific portions and surfaces allow us to infer a standardised manner of fracturing ungulate skeletal elements. The majority of impacts is often located on the same portion and surface of the bones according to the appendicular skeletal element in question. Although some variability is to be expected, the humerus is generally fractured by the caudal side of the distal metaphysis, the radius by the lateral side of the diaphysis, the femur by the cranial side of the diaphysis, and the metapodium by the lateral and medial side of the diaphysis. The tibia registers higher variability according to the species. *C. elaphus* and *B. primigenius* show percussion impacts on the caudal side of the distal metaphysis and *Equus ferus* on the caudal side of the proximal metaphysis and diaphysis (Table 6). This systematic bone breakage could suggest the existence of certain social components, in which intergroup transmission and learning seem to be important elements.

Once the resources were used, fragmented bones were left and the smell given off by the remains could attract other predators that acted as scavengers in search of potentially consumable resources. The number and dimensions of the tooth-marks identified on bone remains may be due to the activity of small scavengers, probably small canids. However, at certain times, tooth-marks of larger dimensions have also been observed, which could be related to large predators such as bears and wolves. Further evidence that corroborates the marauding activity of carnivores at Level IV is the presence of overlapping marks on some ungulate remains. These marks represent carnivore tooth-marks situated over cut-marks.

6. Conclusions

Anthropogenic evidence on a high diversity of species has been identified at Level IV of Bolomor Cave. The spectrum of animals includes ungulates, lagomorphs, birds, tortoises and, occasionally, carnivores. Large and small carnivore consumption could be considered isolated cases in the faunal assemblage and obtaining them could be understood as a rare event rather than a systematic activity of the human groups at Level IV. In the case of herbivores, mainly represented by red deer, the systematic proportion of skeletal elements with high medullar value, a predominance of adult animals, cut-marks related to the viscera removal and oblique and longitudinal incisions on the diaphysis of the limb bones and low carnivore damage suggest that the anthropogenic access to animals was mainly primary and immediate. Nevertheless, sporadic events of secondary access could also occur. Regarding small prey, slow-moving animals and fast-running (mostly lagomorphs) and quick-flying small prey, were frequently captured at Level IV. Capturing these types of prey requires methods different from those used for large- and medium-sized animals. Although individual capture was the most probable technique used by human groups at Bolomor Cave, it is possible that certain trapping systems or mass collections could be used sporadically in the case of rabbits. At Level IV, the animals were often cooked before defleshing. Proof of this process is the presence of different burning grades on the same bone surface (double colouration), which are located on bone ends (areas of the skeleton with less meat) in the case of birds and lagomorphs. Regarding tortoises, a greater degree of burning on the dorsal surface than on the ventral surface is documented. This fact suggests that tortoises were placed into the fire upside down and roasted in their shell. Once the animals were cooked, the meat was extracted. Lithics were not the only tools used to extract the meat; human teeth were also used in the defleshing and consumption of cartilage, fat and marrow of small prey bones. This use led to bone breakage morphologies mainly represented by isolated epiphyses and diaphyseal cylinders. Although a certain grade of variability is to be expected, bone breakage shows a precise pattern on ungulates. From this perspective, human groups that occupied Bolomor cave during the Level IV formation show well-established processing patterns. The high diversity of species with anthropogenic alterations, and the intensive use of small animals suggest generalist behaviour based on a broad diet.

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