

The application of actualistic studies to assess the taphonomic origin of Musterian rabbit accumulations from Arbreda Cave (North-East Iberia)

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ABSTRACT: Distinguishing leporid bones accumulated by humans and other kind of predators becomes imperative to accurately understand human subsistence activities in the past, specially in the Iberian Peninsula and the Mediterranean region where these taxa are very abundant. Over the last years we have conducted several actualistic studies with modern leporid remains with the aim of identifying differences in the taphonomic signatures produced by competing predators (*i.e.*, humans, nocturnal or diurnal raptors and mammalian terrestrial carnivores). The patterns observed for each of these predators are now applied to the analysis of archaeological leporid remains from Mousterian layers of the Arbreda Cave site (North-East Iberia). The results obtained not only provide new data on Middle Palaeolithic small prey accumulations but also enable us to assess the methodological approach previously followed with modern samples.

KEYWORDS: EUROPEAN RABBIT, *Oryctolagus cuniculus*, MOUSTERIAN, TAPHONOMY, IBERIAN PENINSULA, SMALL PREY, ACTUALISTIC STUDIES

RESUMEN: Distinguir los restos arqueológicos de lepóridos que son consecuencia del consumo antrópico de aquellos acumulados por otros depredadores es esencial para la correcta comprensión de las actividades de subsistencia de nuestros antepasados, especialmente en la Península Ibérica y la región mediterránea, donde estos taxones son muy abundantes. En los últimos años hemos llevado a cabo diversos trabajos actualísticos con restos de lepóridos con la finalidad de identificar diferencias entre los patrones tafonómicos característicos de los distintos tipos de depredadores (humanos, rapaces diurnas y nocturnas, y carnívoros terrestres). En este trabajo los patrones observados para cada uno de estos depredadores se aplican al análisis de los restos arqueológicos de lepóridos del nivel musteriense I de la cueva de la Arbreda (Noreste de la Península Ibérica). Los resultados obtenidos no solo aportan nuevos datos sobre acumulaciones de pequeñas presas en el Paleolítico Medio sino que al mismo tiempo nos permiten evaluar la perspectiva metodológica desarrollada en el análisis de muestras actuales.

PALABRAS CLAVE: CONEJO, *Oryctolagus cuniculus*, MUSTERIENSE, TAFONOMÍA, PENÍNSULA IBÉRICA, PEQUEÑAS PRESAS, ESTUDIOS ACTUALÍSTICOS

INTRODUCTION

European rabbit (*Oryctolagus cuniculus*) remains are most abundant in many Middle and Upper Palaeolithic and Epipalaeolithic archaeological sites from the Iberian Peninsula and other places from the western Mediterranean region. Rabbits have been shown to yield important information about subsistence practices, mobility patterns and demographic trends (Villaverde *et al.*, 1997; Stiner *et al.*, 1999, 2000; Hockett & Ferreira-Bicho, 2000; Hockett & Haws, 2002). Specifically, in the transition from the Pleistocene to the Holocene, human diet seems to have undergone a radical transformation to smaller prey and in particular to the European rabbit (Jones, 2004, 2006). This trend has been shown by the presence of cut marks and other anthropic evidences in rabbit assemblages from this geographical area (Pérez Ripoll, 1992, 1993, 2001, 2004, 2006; Villaverde *et al.*, 1997; Aura *et al.*, 2002; Hockett & Haws, 2002; Cochard & Brugal, 2004; Manne & Bicho, 2009). Notwithstanding, the acquisition and consumption of rabbits in European pre-Upper Palaeolithic times is still under much discussion.

Several researchers state that the systematic use of resources offered by very small-sized animals is limited to the Upper Palaeolithic (Villaverde *et al.*, 1997; Martínez Valle, 2001; Pérez Ripoll, 2001; Aura *et al.*, 2002; Hockett & Haws, 2002; Lupo & Schmitt, 2002; Cochard & Brugal, 2004). They argue that such a subsistence strategy is exclusively linked to anatomically modern Humans. However, there are some Middle Palaeolithic sites in which anthropic consumption of rabbits has been documented. For example, in Iberia, early leporid hunting has been reported in a number of Spanish sites, *i.e.*, Gabasa I (Blasco Sancho, 1995), Cova Negra (Martínez Valle, 1996), Cova Beneito (Martínez Valle, 1996), Vanguard Cave South (Fernández-Jalvo & Andrews, 2000) and Bolomor Cave (Blasco, 2008; Sanchís Serra & Fernández Peris, 2008). Evidence for consistent consumption of small prey has also been observed at Crouzade (Gerber, 1973 cited by Costamagno & Laroulandie, 2004), Les Canalettes (Cochard, 2004a), Pié Lombard, Salpêtre de Pompignan and Combe Grenal (Chase, 1986) in France. Further, it should be kept in mind that archaeological rabbit accumulations may have other origins other than anthropogenic. Thus, in order to understand human subsistence activities in the past it is essen-

tial to discriminate between leporid bones accumulated by humans and other kind of predators.

With such an aim we have been carrying out over the last years systematic actualistic studies on modern leporid remains produced by mammalian terrestrial carnivores, nocturnal and diurnal raptors and humans (Lloveras *et al.*, 2008a, 2008b, 2008c, 2009), which are beginning to allow us to recognize diagnostic taphonomic characters for competing predators.

In this paper the patterns observed in those studies are applied to the taphonomical analysis of an archaeological sample of rabbit and hare remains from a late Mousterian layer (level I) of the Arbreda Cave located in the North-East of the Iberian Peninsula. Preliminary faunal analysis showed that this level is dominated by rabbits (Maroto *et al.*, 1996) and it was assumed that the role played by humans in their accumulation was minor. The approach followed here provides an opportunity for not only evaluate how the observed actualistic models work on an archaeological sample but also to add new data to the ongoing research on Middle Palaeolithic small prey accumulations.

ARCHAEOLOGICAL CONTEXT

Arbreda Cave is one of the sites of the Reclau cave system (Serinyà, Catalonia, Spain), a clustered formation perched on a small talus of a somewhat karstic cascading travertine, above the Serinyadell Stream (Figure 1). These shelters face towards the west at a height of about 200 m a.s.l. The archaeological site preserves one of the longest continuous stratigraphic and cultural sequences in the area (Figure 2). Currently, it provides the most accurate information about the changes that occurred between late Middle and early Upper Palaeolithic in the Eastern Pyrenees (Maroto *et al.*, 1996).

Level I has not been completely excavated yet presents a minimum average thickness of 60 cm. ¹⁴C AMS dating shows an average value of 39.9 ± 0.6 ky BP (see Figure 2). This Mousterian level of the Arbreda sequence is rich in lithic industry (N=638), cut essentially in quartz (75.9%). Tools were classified by categories as scrapers (144, 55.6%), denticulates (87, 33.6%) and Upper Palaeolithic type tools such as Chatelperronian points (28, 10.8%). A very large number of tiny blow remains indicates that tool making took place in

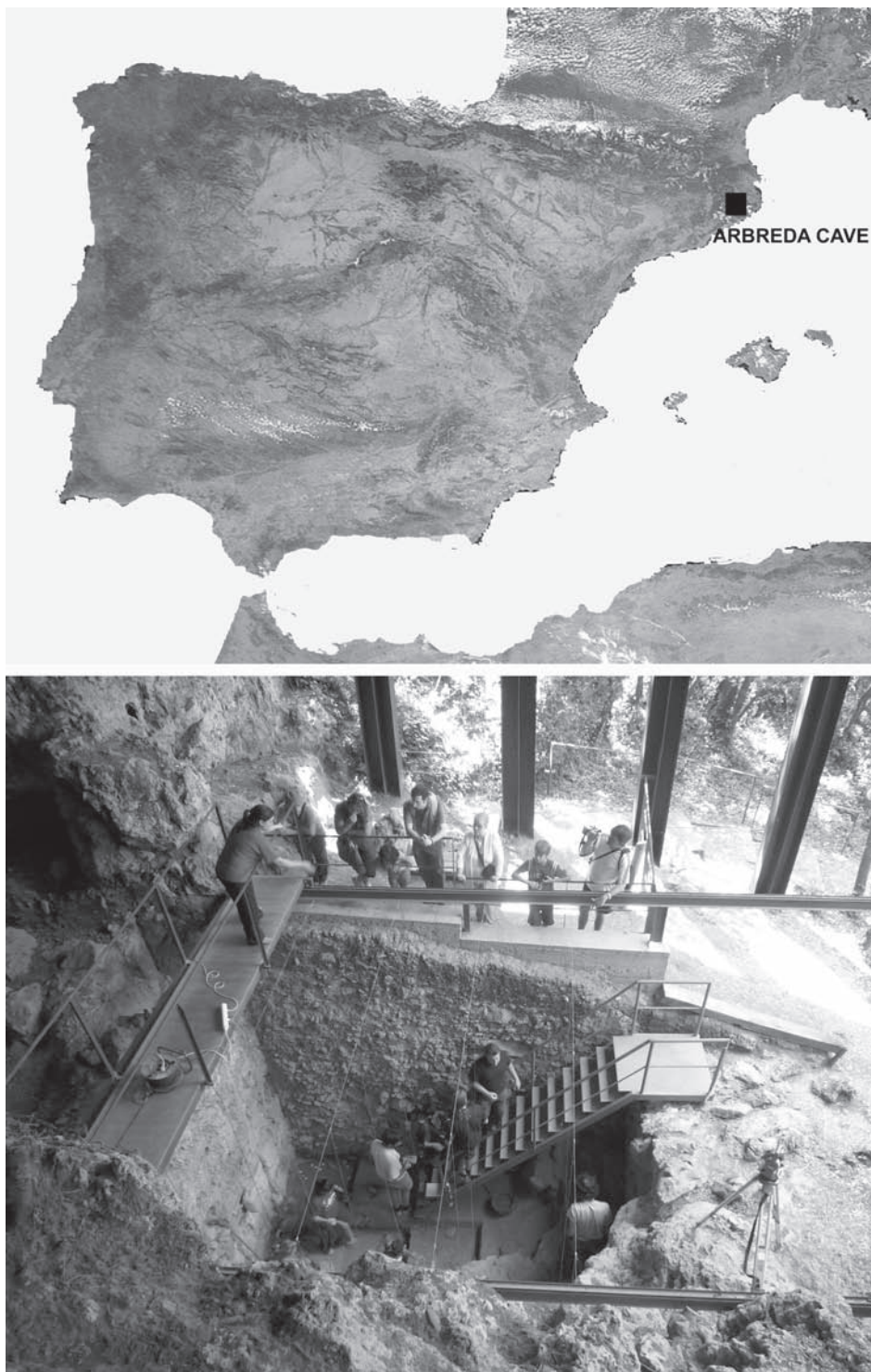


FIGURE 1

Map of the Iberian Peninsula with the location of Arbreda Cave and a photograph of the Arbreda Cave site.

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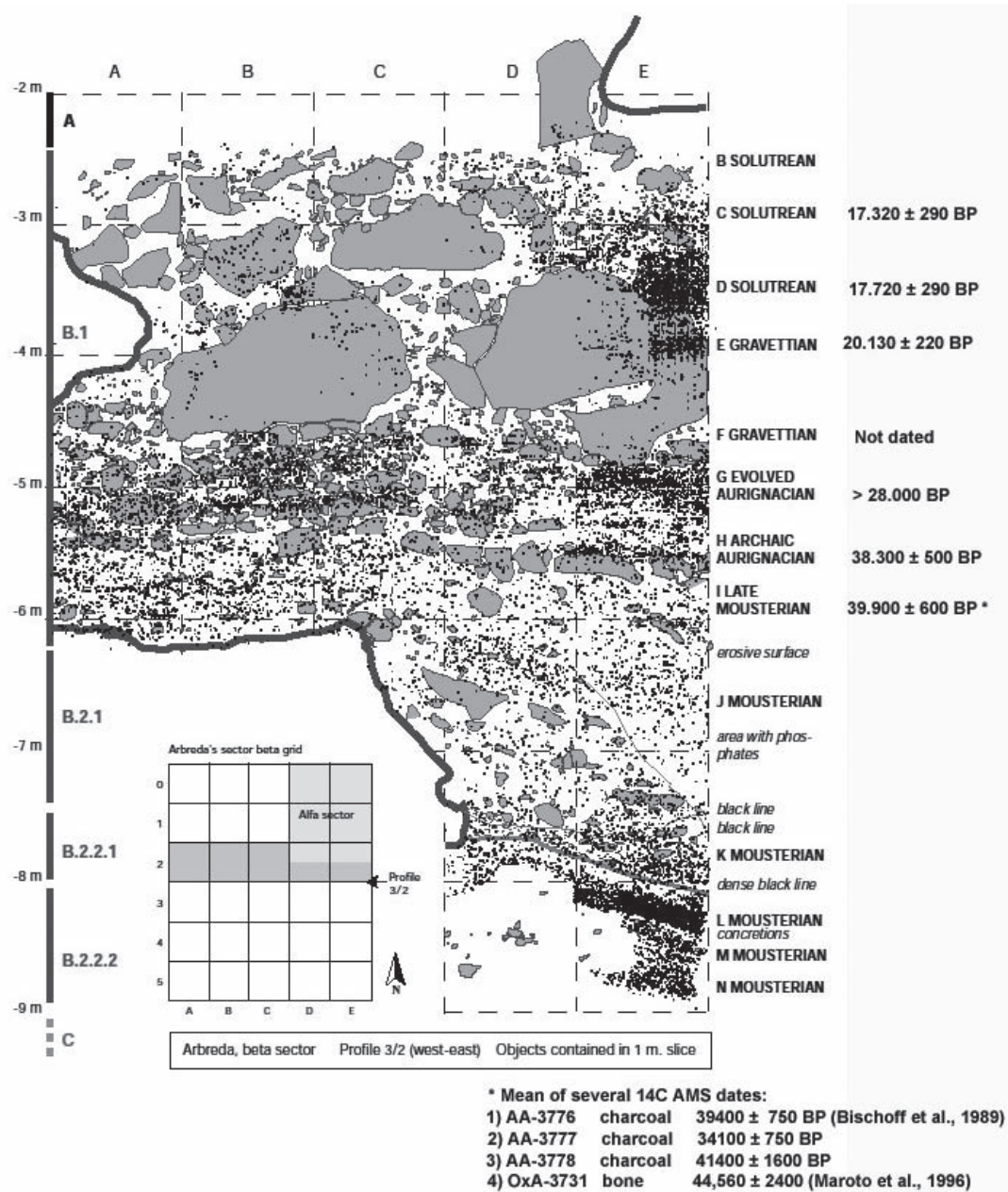


FIGURE 2
Archaeological levels and ^{14}C AMS dates from Arbreda Cave.

the cave. Retouched tools make up 37.4% of all findings over 1 cm - quite a high percentage (Maroto *et al.*, 1996). Also, faunal remains analysed from this level show that rabbits are the most abundant taxon. They constitute 87% of the NISP

of the large to medium sized mammals (Table 1). Cave bear, mostly represented by newborns and cubs, and small carnivores like the red fox, lynx and wild cat are also recorded. They most probably reflect natural deaths (Maroto *et al.*, 1996).

SPECIES	NISP	%NISP	MNI
<i>Equus caballus</i>	57	7.8	4
<i>Equus hydruntinus</i>	10	1.4	1
<i>Equus caballus-hydruntinus</i>	10	1.4	
<i>Bos-Bison</i>	68	9.3	3
<i>Cervus elaphus</i>	127	17.4	5
<i>Capreolus capreolus</i>	4	0.5	1
<i>Cervus-Capreolus</i>	4	0.5	
<i>Lepus europaeus</i>	39	5.3	7
<i>Erinaceus europaeus</i>	8	1.1	1
<i>Canis lupus</i>	6	0.8	1
<i>Vulpes vulpes</i>	6	0.8	1
<i>Ursus spelaeus</i>	377	51.6	21
<i>Crocota spelaea</i>	1	0.1	1
<i>Lynx cf. spelaeus</i>	7	1.0	1
<i>Felis sylvestris</i>	5	0.7	2
<i>Felis pardus</i>	2	0.3	1
TOTAL	731	100.0	50
<i>Oryctolagus cuniculus</i> *	4900	87	

TABLE 1

Numbers, percentages and minimum number of individuals (MNI) of large and medium sized mammals (excluding rabbit) in Level I of Arbreda Cave (taken from Maroto *et al.*, 1996). *Approximate number of remains from rabbits estimated by Maroto *et al.* (1996).

Among the ungulate remains, red deer constitutes the most frequent species.

ACTUALISTIC STUDIES ON LEPORID REMAINS

The number of taphonomical studies that attempt to distinguish leporid bones modified by humans from those modified by terrestrial carnivores (Schmitt & Juell, 1994; Sanchís Serra, 2000; Cochard, 2004a), and diurnal and nocturnal raptors (Hockett, 1989, 1991, 1995, 1996; Schmitt, 1995; Cruz-Urbe & Klein, 1998; Sanchís Serra, 2000; Cochard, 2004a) has considerably increased during the last decades. They have provided an important and useful set of data. However, they have also brought to light the complexity that surrounds the recognition of taphonomic signatures for different predators due to the great variability observed within a single species (Hockett, 1995; Cochard, 2004a, 2008; Lloveras *et al.*,

2008c). In addition, a review of all these works shows that the available data are frequently difficult or impossible to compare because the methodological approaches followed vary greatly. Sometimes the samples analysed are too small, in other occasions they are of mixed or unknown origin and in general, the number of variables considered is scarce. Qualitative more than quantitative data are usually presented.

In order to overcome some of these problems, in 2005 the senior author of this paper set up a project focused on the analysis of leporid assemblages accumulated by their most important Iberian predators - Iberian lynx, red fox, Spanish Imperial Eagle and Eagle Owl (Lloveras *et al.*, 2008a, 2008b, 2008c). The material analyzed in those studies came from scats, non ingested remains, pellets, nests and carnivore dens. Thus, assemblages from different origins could be clearly characterized. A set of variables relating to anatomical representation, breakage, degree of digestion and the occurrence of teeth, beak and talons marks on

the surface of the bones has been systematically considered in order to be able to compare taphonomical patterns confidently. Table 2 summarizes the results obtained so far.

In this way, it seems evident that Eagle Owl's nesting sites are characterised by high values in the relative abundance of posterior skeletal elements, more hindlimb than forelimb bones and more postcranial than cranial elements. These are features are partially shared by diurnal raptors and terrestrial carnivores so they cannot be considered as truly diagnostic of Eagle Owls. In fact, it appears that breakage and the degree of digestive corrosion may be better diagnostic features to distinguish among the various leporid predators. Diurnal raptors and terrestrial carnivores tend to more intensively fracture the bones of their prey than Eagle Owls. For such reason, the average maximum length of bone splinters in the later spe-

cies (15 mm) contrasts with the lower values obtained for the Spanish Imperial Eagle (8.36 mm), the Iberian Lynx (7.1 mm) and the red fox (9.2 mm). Such differences are more evident if the degrees of digestion corrosion are considered. Whereas over 40% of digested remains in Eagle Owls nest assemblages were classified as lightly corroded, *Aquila adalberti* pellets showed the same proportion of leporid remains moderately digested and Iberian lynx and red fox scats registered that percentage as heavily corroded (Figures 3 and 4). Beak and tooth marks can be considered diagnostic traces as well (Figure 5).

To assess the taphonomic signature derived from anthropic activities on rabbit bones an experimental study was conducted using lithic tools (Lloveras *et al.*, 2009). Cut marks resulting from skinning, disarticulation and defleshing as well as cooking damage and tooth marks caused by

COMPARATIVE CRITERIA	NOCTURNAL RAPTORS		DIURNAL RAPTORS	TERRESTRIAL CARNIVORES		
	Eagle Owl <i>Bubo bubo</i>		Spanish Imperial Eagle <i>Aquila adalberti</i>	Iberian Lynx <i>Lynx pardinus</i>	Fox <i>Vulpes vulpes</i>	
	Lloveras <i>et al.</i> (2008c)		Lloveras <i>et al.</i> (2008a)	Lloveras <i>et al.</i> (2008b)	Unpublished personal data	
Origin	nest	nest	pellet	scat	scat	not ingested
N	1808	1932	824	1522	113	611
RA > values	pat-cal-inn-fem	cal-inn-tib-mts	phal 3- u mol- tib	man-teeth-cra	long bones- sc	mts-cal-ast-tib
RA < values	mtc-c/t	rad-c/t-mtc	rib-fem-rad-ver	c/t-ver-ribs	mtc-inn-ast-pat	cra-sc-rib-inn
PCRLB/CR	+ postcranial	+ postcranial	+cranial	+ postcranial	+postcranial	+postcranial
P/D	+ proximal	+ proximal	+ distal	+proximal	+proximal	+ distal
AN / PO	+ hindlimb	+ hindlimb	+ hindlimb	+forelimb	=	+hindlimb
Complete elements %						
Mean value long bones	14.6	10.8	0	2.5	0	5.9
Mean value total	53.9	45.9	27	43	8	92.3
Length (in mm.)						
maximum	86.3	90.0	36.1	30.1	22.6	-
minimum	2.3	2.5	1.8	1.1	2.6	-
average	14.07	14.78	8.36	7.1	9.13	-
% < 10 mm	49	40	73	80	63	-
Digestion						
% Digested remains	68.8	65.6	98	97.2	100	-
% Digested long bones	88.9	83.9	100	100	100	-
Intensity						
null	31.2 X	34.4 X	2.0	2.8	0	-
light	40.2 X	40.2 X	18.2	12.0	1	-
moderate	19.8	19.8	46.8X	22.0X	26.7X	-
heavy	8.0	5.3	27.4X	43.8X	43.5X	-
extreme	0.7	0.15	5.6	19.3X	28.7X	-
Beak/teeth marks %	2.0	1.34	0.5	0.26	1.7	9.5

TABLE 2

Anatomical representation, breakage, digestion and beak/teeth mark comparisons on rabbit remains accumulated by the Eagle Owl, diurnal raptors and terrestrial carnivores. *Teeth, vertebrae, ribs, carpal/tarsal and phalanges not included. X: Digestion categories where authors place most of the rabbit remains analysed.

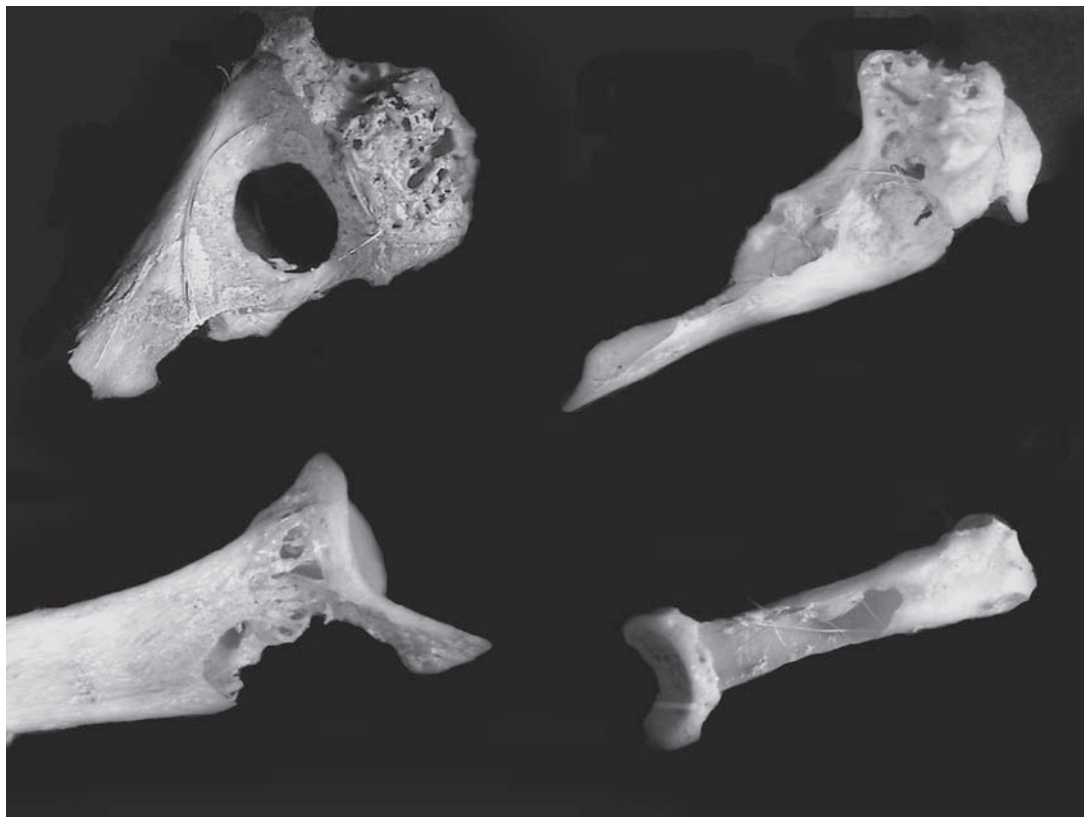


FIGURE 3

Heavy digestion damage on rabbit remains consumed by the Iberian lynx.

human consumption were analyzed and evaluated. Results showed that butchery marks could not only be relatively abundant but also their location, intensity and orientation could differ according to the activity that caused them. Cooking damage was evidenced by specific burnt areas on the extremities of the bones. Tooth marks were scarce and often difficult to detect although they tended to occur on long bones.

It is hoped that the application of the patterns observed in these studies to the leporid remains recovered from the Mousterian levels at Arbreda Cave will help with the identification of the agent(s) responsible for those accumulations.

MATERIAL AND METHODS

The sample of leporid remains analysed here was retrieved from squares A4, B3, C3 and D3, *Archaeofauna* 19 (2010): 99-119

corresponding to the Mousterian level (level I) of Arbreda Cave (Figure 6).

For the sake of clarity the variables considered in each of the analytical parameters studied are presented below (1 to 5). Also, it is important to note that the age of the individuals was estimated taking into account the epiphyseal fusion state of long bones (humerus, femur and tibia), metapodials, scapula, calcaneum and innominate (Hale, 1949; Taylor, 1959).

1. Anatomical representation

Numbers of identified skeletal elements (N) were counted and relative abundance was also calculated (Dodson & Wexlar, 1979; Andrews, 1990). In addition, proportions of skeletal elements were evaluated using several indexes (Lloveras *et al.*, 2008a).



FIGURE 4

Heavy digestion damage on rabbit remains accumulated by the Eagle Owl «exhibiting different digestion intensities».

2. Breakage

Breakage patterns were described by the maximum length of the identified skeletal elements. Percentages of complete elements, isolated teeth and articulated elements were also calculated. For immature individuals, diaphyses of long bones with unfused epiphyses were considered as complete elements. Unfused proximal or distal epiphyses were classified as fragments of long bones. Different breakage categories were used depending on bone type:

- Patellae, carpals, tarsals and ribs were classified as complete (C) or fragmented (F).
- Phalanges were recorded as complete (C), proximal (P) or distal (D) fragments. When distinction between proximal and distal was not possible, they were recorded just as fragment (F).
- Vertebrae were registered as complete (C), vertebral body (VB), vertebral epiphysis (VE) or neural process (SP).
- Breakage of teeth was calculated separately for isolated and *in situ* elements (Fernández-

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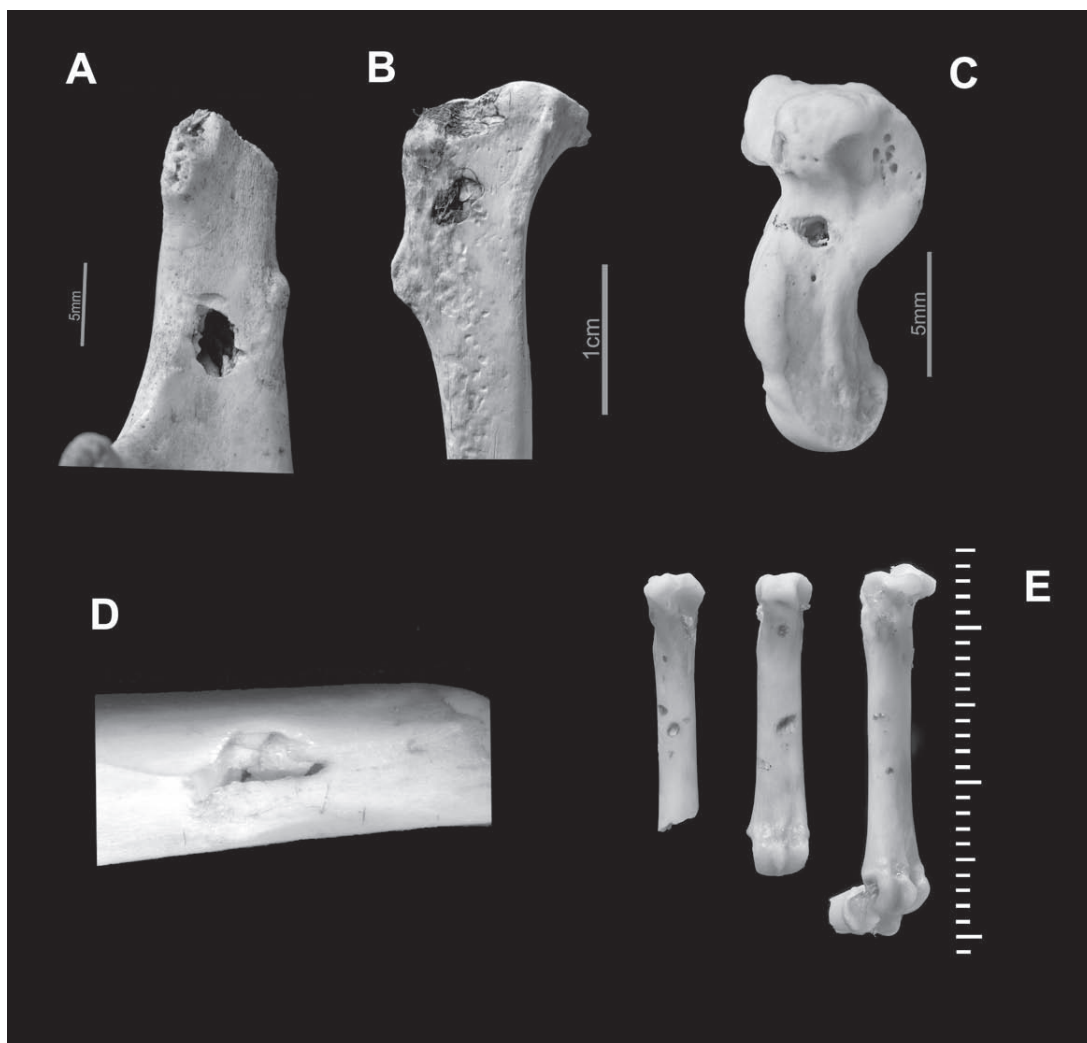


FIGURE 5

Bone surface damage. A and B: Beak marks caused by the Eagle Owl. C and E: Tooth marks caused by the Red fox. D: Tooth mark caused by the Iberian Lynx.

Jalvo & Andrews, 1992). Teeth were classified as complete (C) or fragmented (F).

Breakage categories used for long bones, metapodials, mandibles, cranium, scapula and innominate are fully described and illustrated in Lloveras *et al.* (2008a).

Long bone fragments were also analysed while attempting to distinguish old from modern (i.e., recent) fractures. Old fractures were classified as Archaeofauna 19 (2010): 99-119

green and dry (Villa & Mahieu, 1991). Long bone cylinders were also counted and registered.

3. Digestion

Damage to bone surface was observed with a light microscope (x10 to x40). Based on the methodology used for micromammals by Andrews (1990) and Fernández-Jalvo & Andrews (2000), different categories of digestion damage were

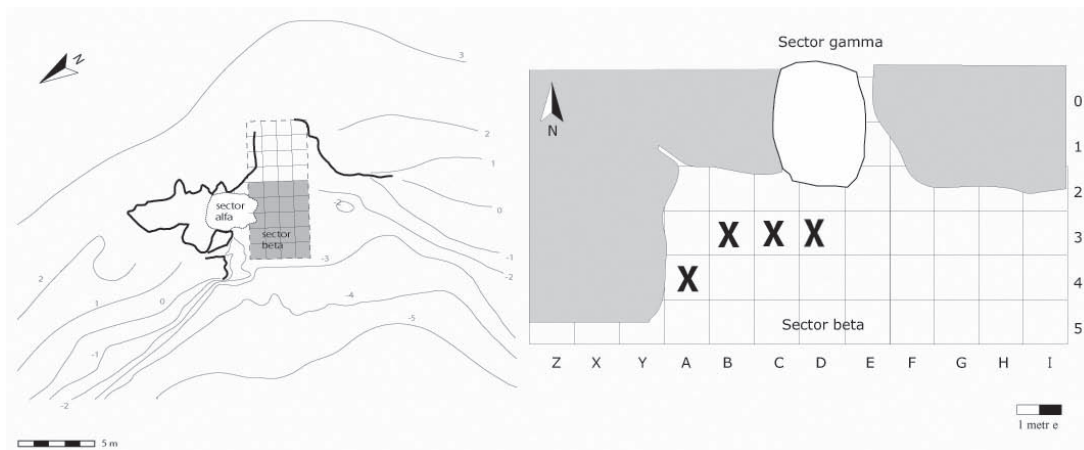


FIGURE 6

Groundplan of Arbreda Cave. «X» indicates those squares analysed in the present study.

applied to leporid bones and teeth. Five degrees of digestion were distinguished: null (0), light (1), moderate (2), heavy (3) and extreme (4). These were recorded separately for bones and dental remains.

4. Tooth marks, beak and talons marks

Tooth marks and damage to bone surface caused by the beak or talon of the predator were identified using a light microscope (x10-x40), then noted and counted. Following the methodology developed by Elkin & Mondini (2001) and Landt (2007), tooth marks were classified as scoring, notches, tooth punctures/tooth pits and crenulated edges/fractured edges.

5. Cut marks and burnt bones

Cut marks were classified following the same methodology used in Lloveras *et al.* (2009). Finally, burnt bones were identified by visual examination; colour of burning damage was recorded (Shipman *et al.*, 1984; Stiner *et al.*, 1995) and described as light (yellow-light brown), moderate (brown) or strong (black). Burnt areas were recorded on each skeletal element, according to portion (e.g., distal, proximal) and side.

RESULTS

1. Anatomical representation

The number of leporid bones and teeth identified to skeletal element was 2407. Most leporid remains identified were rabbits (99.3%), as only 17 remains were identified as hare (*Lepus* sp.). Taking into account the fusion stage of long bones and metapodial epiphyses, scapula, calcaneum and innominate, the percentage of adult individuals was 71.9%. Based on humerus counts, the minimum number of individuals (MNI) was 33.

Table 3 shows the anatomical composition of the identified remains. The entire skeleton was represented. Whereas phalanges, teeth, metatarsals and vertebrae, ribs, tibia/femur were the most frequent elements (N%), patella, ribs and scapula were the most scarce. Relative abundance of skeletal elements (RA%) is also shown in Table 3 and Figure 7. The mean value (42%) indicates an important loss of bones in the assemblage.

The best represented elements were the humerus and calcaneum followed by upper molars and incisors. Cranium, astragalus, innominate, metatarsals and the rest of the long bones (specially those of the hindlimb) also showed high percentages (Figure 7). Ribs, carpal/tarsal bones and vertebrae were poorly represented.

SKELETAL ELEMENT	N	N%	MNE	RA%
mandible	59	2.5	27	40.9
cranium	94	3.9	15	45.5
incisors	150	6.2	119	60.1
upper molars	288	12	263	66.4
lower molars	148	6.1	132	40
humerus	94	3.9	65	98.5
radius	48	2	20	30.3
ulna	57	2.4	28	42.4
femur	98	4.1	37	56.1
tibia	72	3	38	57.6
patellae	16	0.7	16	24.2
scapula	27	1.1	20	30.3
innominate	49	2	29	43.9
metacarpus	92	3.8	72	21.8
metatarsus	179	7.4	112	42.4
phalanges 1/2	387	16.1	352	31.7
phalanges 3	222	9.2	222	37.4
calcaneum	58	2.4	52	78.8
astragalus	36	1.5	36	54.5
carpal/tarsal	49	2	49	6.2
vertebrae	156	6.5	117	13.1
ribs	23	1	18	2.3
TOTAL	2402+5 = 2407*	100%	1269	–

TABLE 3

Skeletal elements of rabbit remains identified from Arbreda Cave, level I. N: number of skeletal elements. N%: skeletal elements in percentage. MNE: minimum number of elements. RA: relative abundance. *Number of skeletal elements was 2402 plus 5 fragments of unspecified metapodials.

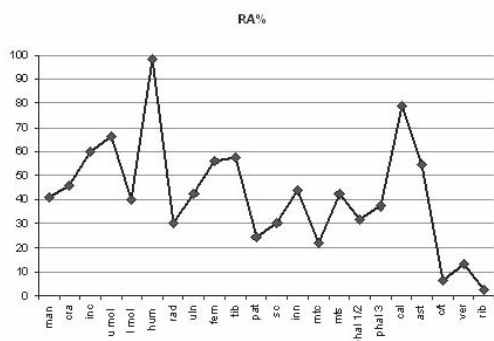


FIGURE 7

The leporid sample from Arbreda Cave. Relative abundance of different parts of the skeleton. Abbreviations; man: mandible, cra: cranium, inc: incisors, u mol: upper molars, l mol: lower molars, hum: humerus, rad: radius, uln: ulna, fem: femur, tib: tibia, pat: patella, sc: scapula, inn: innominate, mtc: metacarpals, mts: metatarsals, phal 1/2: phalanges 1/2, phal 3: phalanges 3, cal: calcaneum, ast: astragalus, c/t: carpal/tarsal, ver: vertebrae, rib: rib.

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Relative proportions of skeletal elements are shown in Table 4. Results show that:

- Index that compare postcranial to cranial elements (PCRT/CR; PCRAP/CR) point to a deficiency in the numbers of postcrania (43.6 and 56.4; that means aprox. 1.5 times more cranial than postcranial remains).
- When cranial elements are compared to long bones (PCRLB/CR) the sample shows a deficiency of crania (159.8), indicating a good representation of long bones.
- Comparisons of lower to upper limb elements (AUT/ZE and Z/E) shows a larger loss of the former.
- The AN/PO index reveals better survival of the posterior limb elements than of the anterior limb bones.

INDEX	VALUE
PCRT / CR	43.6
PCRAP / CR	56.4
PCRLB / CR	159.8
AUT/ZE	32.5
Z / E	61.5
AN / PO	62.5

TABLE 4

Proportions of different parts of the skeleton. PCRT/CR – total numbers of postcranial (limb elements, vertebrae and ribs) compared with total numbers of cranial elements (mandibles, maxillae and teeth); PCRAP/CR – limb elements (long bones, scapulae, innominate, patellae, metapodials, carpals, tarsals and phalanges) compared with cranial elements (mandibles, maxillae and teeth); PCRLB/CR – postcranial long bones (humerus, radius, ulna, femur and tibia) compared with cranial elements (mandibles and maxillae); AUT/ZE – autopodium elements (metapodials, carpals, tarsals and phalanges) compared with zigopodium and stylopodium (tibia, radius, ulna, humerus, femur and patellae); Z/E – zigopodium elements (tibia, radius and ulna) compared with stylopodium (femur and humerus); AN/PO – humerus, radius, ulna and metacarpals compared with femur, tibia and metatarsals.

2. Breakage

The size of the ranging remains varied with values of maximum length between 1.8 and 109 mm. Average maximum length was 12.5 mm and more than 50% of the rabbit remains had length values under 10 mm.

The average percentage of complete elements was 43.4%. Values varied according to bone size,

and the highest percentages were obtained for the small carpals/tarsals, patella, astragali and phalanges (Table 5; Figure 8). Only 2.4% of the long bones were complete.

Breakage categories show that (Table 5):

- skulls never appeared complete and incorporated parts of the neurocranium (NC), zygomatic arch (ZA), maxilla (M) and incisive bone (IB);
- mandibles were mostly represented by body fragments (MB), body fragments including the portion with the incisors (MBI), and condylar process (PC); in a few cases the oral portion (IP) was also recovered;
- isolated teeth were complete in 40.6% of cases and teeth placed *in situ* in 93.8%;
- vertebrae were complete in 16% of cases; vertebral fragments were represented mainly by vertebral body (VB) and vertebral epiphyses (VE); ribs were almost always fragmented;
- fragments containing the acetabulum (AISIL, AIS, A) were the most common for the innominates; ilium fragments (IL) were also common and only in one case the innominate bone was recovered complete;
- scapulae were never complete and most fragments comprised the glenoid cavity;
- all breakage categories were represented for limb bones; however, radius and ulna were never recovered complete. Both were especially represented by fragments of proximal epiphysis attached to the shaft. Most fragments of the humerus were distal epiphyses; the femur was mostly represented by fragments of proximal epiphyses whereas tibiae were mostly represented by shafts;
- metapodials were the best preserved; metacarpals were complete in 57.6% and metatarsals in 24% of cases;
- astragali were almost always complete (86.1%) and calcanea only in 48.3% of cases;
- on the whole, 79.8% of phalanges appeared complete.

The study of long bone fragments revealed a higher presence of green (78.7%) than of dry fractures (21.3%). The number of cylinders was very scarce, only 12 for the whole sample. Two of them were associated to different kinds of tooth marks. However, it should be taken into account that

modern fractures were also abundant, and that some cylinders may have disappeared as a consequence of recent breakage. Finally, the percentage of isolated teeth (79.4%) was high and articulated elements were not found.

3. Digestion

Different degrees of damage due to digestion were observed on the surface of 32.4% of the bones and teeth (Figure 9). Specifically, 28% of the bones were altered by digestion. Most bone remains presented a moderate degree of digestion (Figure 10 and Table 6). Different bones are altered in similar proportions although the calcaneum, femur, ulna and patellae remains appear to be slightly more damaged. Phalanges, metapodials, carpals/tarsals and crania, were the best preserved. Normally, the surface of the bones was partially affected by digestive corrosion, being the articulation ends the most altered areas. Teeth showed a slight bias towards stronger degrees of digestive corrosion; 46% of dental remains were altered (Figure 10; Table 7).

4. Tooth marks, beak and talons marks

Tooth marks were observed in 46 bones (2.53%). Most of them occurred on innominates (7), metatarsals (6), humerus (6) and femur (5), although their location appears to be irregular with no particular part being favoured. One exception is the medial face of the innominate under the acetabulum, which displayed the largest number of punctures. The most abundant marks were tooth pits (40%) and punctures (27.3%) but scoring (18.2%) and crenulated edges (14.5%) were also recorded. Frequently, all kinds of tooth damage were present in the same bone (Figure 11).

In the sample under study traces caused by beaks or talons of raptors were not registered.

5. Cut marks and burnt bones

Bones displaying cut marks were not found. Only 0.5% of the studied remains exhibit damage due to burning. It was not located on any particular part of the skeletal elements and it affected different kind of bones. The intensity of burning damage was both strong (60%) and moderate (40%).

Long bones and metapodial	C		PE		PES		S		SDE		DE	
	N	%	N	%	N	%	N	%	N	%	N	%
humerus	4	4.3	11	11.7	5	5.3	11	11.7	34	36.2	29	30.9
radius	0	0	2	4.2	18	37.5	18	37.5	9	18.8	1	2.1
ulna	0	0	5	8.8	26	45.6	14	24.6	8	14	4	7
femur	2	2	32	32.7	17	17.3	24	24.5	6	6.1	17	17.3
tibia	3	4.2	9	12.5	7	9.7	30	41.7	14	19.4	9	12.5
metacarpus	53	57.6	0	0	19	20.7	0	0	17	18.5	3	3.3
metatarsus	43	24	0	0	67	37.4	2	1.1	51	28.5	16	8.9

Mandible	N	%	Cranium	N	%	Innominate	N	%	Scapula	N	%
C	0	0	C	0	0	C	1	2	C	0	0
IP	6	10.2	IB	14	14.9	A	2	4.1	GC	6	22.2
MBI	9	15.3	IBM	14	14.9	AIS	18	36.7	GCN	12	44.4
MB	31	52.5	M	21	22.3	AISIL	5	10.2	NF	4	14.8
MBB	1	1.7	ZA	22	23.4	AIL	6	12.2	F	3	11.1
PC	12	20.3	NC	23	24.5	IS	5	10.2	GCNF	2	7.4
						IL	12	24.5			

Vertebrae	N	%	Phalanges 1/2	N	%	Phalanges 3	N	%
C	25	16	C	278	71.8	C	208	93.7
VB	100	64.1	P	35	9	P	14	6.3
VE	25	16	D	74	19.1	D	0	0
SP	6	3.8						

Patella	N	%	Car/tar	N	%	Cal	N	%	Ast	N	%	Ribs	N	%
C	16	100	C	49	100	C	28	48.3	C	31	86.1	C	1	4.3
F	0	0	F	0	0	F	30	51.7	F	5	13.9	F	22	95.7

Teeth	"in situ"						isolated					
	incisors		upper molars		lower molars		incisors		upper molars		lower molars	
	N	%	N	%	N	%	N	%	N	%	N	%
C	16	76.2	42	100	18	100	10	7.8	129	52.4	50	55.6
F	5	23.8	0	0	0	0	119	92.2	117	47.6	40	44.4

TABLE 5

Numbers and percentages of parts of the skeleton included in each breakage category. **Long bones, metacarpal and metatarsal** bones were classified as: complete (C), proximal epiphysis (PE), proximal epiphysis + shaft (PES), shaft (S), shaft + distal epiphysis (SDE) and distal epiphysis (DE). **Mandible** as: complete (C), incisive part (IP), mandible body + incisive part (MBI), mandible body (MB), mandible body + branch (MBB) and condylar process (CP). **Cranium** as: complete (C), premaxilar (IB), premaxilar + maxilla (IBM), maxilla (M), zygomatic arch (ZA) and neurocranium (NC). **Innominate** as: complete (C), acetabulum (A), acetabulum + ischium (AIS), acetabulum + ischium + ilium (AISIL), acetabulum + ilium (AIL), ischium (IS) and ilium (IL). **Scapula** as: complete (C), glenoid cavity (GC), glenoid cavity + neck (GCN), neck + fossa (NF) and fossa (F). **Vertebrae** as: complete (C), vertebral body (VB), vertebral epiphysis (VE) and spinous process (SP). **Phalanges** as: complete (C), proximal fragment, (P), distal fragment (D) and fragment (F). **Patella, carpal/tarsal, calcaneum, astragalus, ribs and teeth** as: complete (C) and fragment (F).

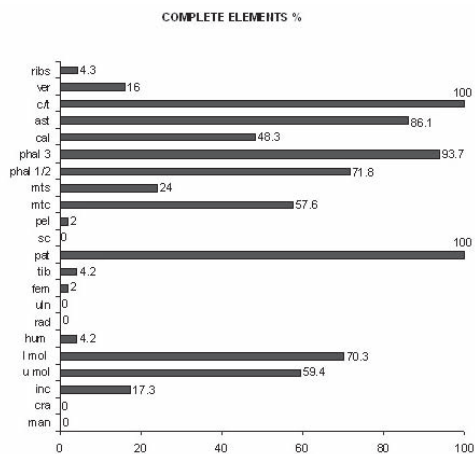


FIGURE 8

The leporid sample from Arbreda Cave. Percentage of complete rabbit remains. For abbreviations see caption of Figure 7.

DISCUSSION

Results from work carried out on archaeological assemblages from different geographical areas and spanning through time often suggest that a high percentage of adult leporid remains is associated with human procurement of rabbits and hares. It is assumed that anthropic accumulations are characterized by the occurrence of more than 85% of adult individuals (Hockett, 1991; Hockett & Ferreira-Bicho, 2000; Guennouni, 2001; Cochard, 2004a; Brugal, 2006), although lower percentages (around 60%) have also been recorded (Martínez-Valle,

1996; Sanchís Serra & Fernández Peris, 2008). The frequency of adult individuals from level I of Arbreda Cave (71.9%) is placed within that range. Further, comparisons with predators other than humans show that the frequency of adult individuals in Arbreda is higher than that recorded in any of the modern samples, with the exception of one of the red fox scats' accumulations (Table 8). At any rate, it should be borne in mind that large variability has been observed in leporid age profiles of most predators. Factors like the availability of prey or the seasonality of the hunt may greatly influence this variable. In addition, rabbit accumulations may also be a palimpsest in which the expected age profile for a specific predator can be concealed. Consequently, the age profile for the sample under study is compatible both with data obtained for terrestrial carnivores like the Red Fox and for anthropogenic assemblages.

Data on the anatomical representation hint at the presence of complete skeletons. No differential transport of any part of the rabbit carcasses is evident. Relative abundances show humeri, calcanea and cranial remains as the best represented elements. This is definitely not coincident with the expected anatomical profile for anthropic accumulations, which in spite of the large variability they register, often have mandibles, long bones, scapulae and innominates as the best represented elements (Hockett, 1991; Guennouni, 2001; Hockett & Haws, 2002; Cochard, 2004a; Brugal, 2006). Comparing our data with that from non human predators (Table 2), the closest anatomical representation appears to be that observed for terrestrial

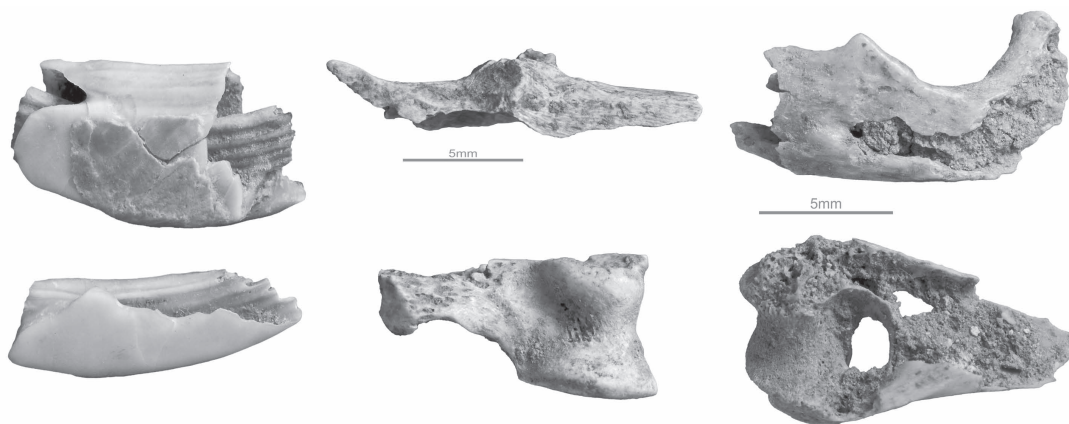


FIGURE 9

Effects of digestion on a sample of rabbit remains recovered from level I of Arbreda Cave. «From left to right and from top to bottom the specimens depicted exhibit light, moderate, moderate, null, heavy and extreme damage».

Digestion in Bone Remains	Null		Light		Moderate		Heavy		Extreme	
	N	%	N	%	N	%	N	%	N	%
mandible	38	66.7	6	10.5	11	19.3	2	3.5	0	0
cranium	73	79.3	6	6.5	12	13	1	1.1	0	0
humerus	59	64.1	6	6.5	19	20.7	8	8.7	0	0
radius	31	66	9	19.1	6	12.8	1	2.1	0	0
ulna	27	48.2	9	16.1	9	16.1	11	19.6	0	0
femur	52	55.9	7	7.5	23	24.7	9	9.7	2	2.2
tibia	51	76.1	5	7.5	7	10.4	4	6	0	0
patellae	4	25	2	12.5	6	37.5	4	25	0	0
scapula	13	48.1	2	7.4	6	22.2	6	22.2	0	0
innominate	30	68.2	1	2.3	9	20.5	3	6.8	1	2.3
metacarpus	71	78	6	6.6	9	9.9	4	4.4	1	1.1
metatarsus	149	83.7	15	8.4	10	5.6	4	2.2	0	0
phalanges 1/2	306	79.5	22	5.7	43	11.2	14	3.6	0	0
phalanges 3	177	80.8	15	6.8	20	9.1	7	3.2	0	0
calcaneum	19	32.8	4	6.9	12	20.7	21	36.2	2	3.4
astragalus	23	63.9	6	16.7	3	8.3	4	11.1	0	0
carpal/tarsal	37	75.5	9	18.4	3	6.1	0	0	0	0
vertebrae	103	68.2	8	5.3	21	13.9	16	10.6	3	2
ribs	19	82.6	3	13	1	4.3	0	0	0	0

TABLE 6

Number and percentages of rabbit bones included in each digestion category.

carnivores, in this case the Iberian lynx. Assemblages produced by this cat are characterized by abundant cranial elements followed by long bones (Lloveras *et al.*, 2008b). This is the opposite pattern to that shown by diurnal and nocturnal raptors which usually bears out deficiencies in cranial remains. Indeed, the relative proportions of skeletal

elements in the Arbreda sample reveal more cranial than postcranial elements, a loss of lower limb bones and a higher survival of hindlimb versus forelimb elements. Again, these results are comparable to the patterns observed with terrestrial carnivores (Table 2; Lloveras *et al.*, 2008a, 2008b, 2008c).

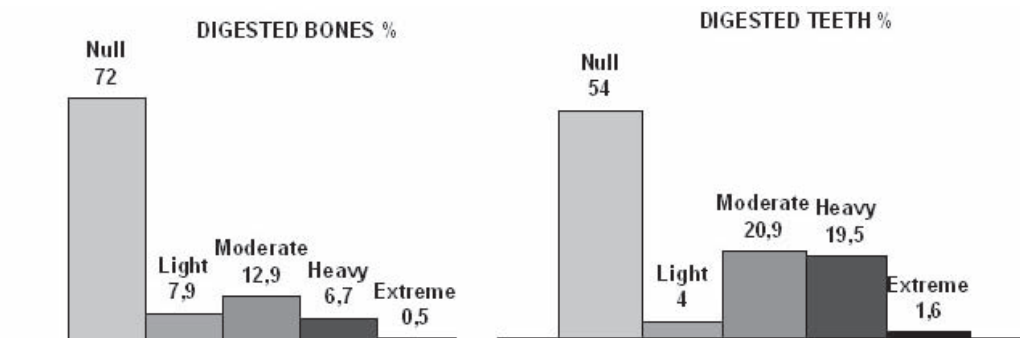


FIGURE 10

Leporid sample from Arbreda Cave. Percentage of bone and dental remains included in each digestion category.

Digestion in Dental Remains	Null		Light		Moderate		Heavy		Extreme	
	N	%	N	%	N	%	N	%	N	%
incisors	72	49.3	10	6.8	40	27.4	23	15.8	1	0.7
upper molars	141	50.5	10	3.6	62	22.2	61	21.9	5	1.8
lower molars	95	65.5	3	2.1	17	11.7	27	18.6	3	2.1

TABLE 7

Number and percentages of rabbit teeth included in each digestion category.

As far as long bone breakage is concerned, data are not coincident with the kind of assemblages produced by an anthropic agent, which aiming at marrow procurement often creates assemblages rich in long bone cylinders and fragments of epiphyses (Hockett, 1991; Cochard, 2004a; Pérez Ripoll, 2004). In the Arbreda samples the number of cylinders is very scarce and fragments of epiphyses are numerous only in the case of the distal humerus. The percentage of complete bones (43.4%) and of complete long bones (2.4%) is very similar to that registered in the actualistic study carried out on the Iberian lynx (43% and 2.5%, respectively; Table 2). However one should also consider that this is a parameter that may display a great degree of variability depending on the origin of the assemblage (i.e., if the sample derives from pellets, scats, not ingested remains or a mixture of both situations).

Most long bone fractures are curved, at oblique angles and V-shaped. Their smooth surface indicates that they were done on green bones (Villa & Maiheu, 1991) and often are also associated with

tooth marks. All these traces are indicative of carnivore activity. Yet, the recorded value of digestion damage (33%) appears to be lower than those in our actualistic studies (Table 2). This is not totally unexpected given the variations that have been reported among terrestrial carnivore assemblages. In an accumulation composed exclusively by scats the frequency of digested remains could be close to 100% (see Table 2) whereas digestion damage in an assemblage comprising a mixture of ingested and not ingested remains this may go down to 12% (Cochard, 2004b). In any case, the frequency of digested remains in Arbreda Cave can be considered high and once again points to the activities of a non human predator.

An additional factor worth examining is the degree of digestion displayed on the surface of the remains. This parameter tends to be underestimated in archaeological samples in comparison with modern referential material because, due to their fragility, strongly digested remains do not preserve well. The Arbreda leporid sample presents a moderate – heavy degree of corrosion. The low

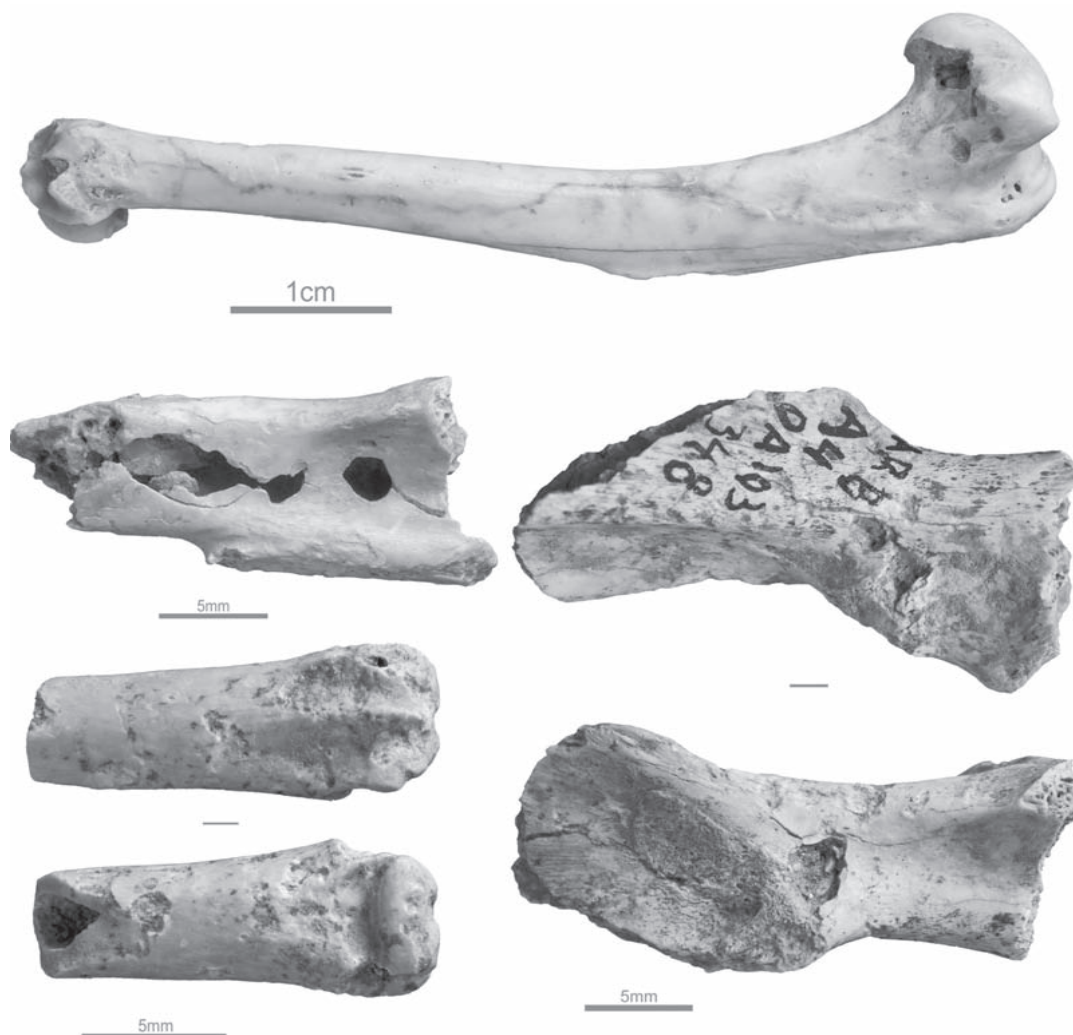


FIGURE 11

Tooth marks on rabbit remains recovered from level I of Arbreda Cave.

percentage of remains with light digestion damage discards the Eagle Owl as a possible accumulator (Table 2). The pattern observed is compatible with those registered on assemblages of eagle pellets and of terrestrial carnivores' assemblages of mixed origin (including scats and non-ingested remains; Table 2).

Finally, tooth damage results point yet again to the presence of a small carnivore. Our reference sample from scats of red fox shows values of 1.7% of leporid bones presenting tooth marks whereas Archaeofauna 19 (2010): 99-119

the sample derived from non ingested remains displayed a higher value: 9.5% (Table 2). Cochard (2004b) notes that most tooth punctures on leporid remains consumed by foxes are situated in the humerus and innominate. These two bones are also those that preferentially hold tooth marks in the Arbreda sample. Further, some limb and innominate bones show opposite tooth punctures on the distal end and the acetabulum area respectively, which is typical of small carnivore activity (Hockett, 1999).

SPECIES	% ADULTS	REFERENCE
Iberian Lynx	25	Personal data not published yet
Fox 1	50	Cochard, 2004
Fox 2	80	Personal data not published yet
Eagle Owl 1	50	Lloveras <i>et al.</i> , 2008c
Eagle Owl 2	10	Lloveras <i>et al.</i> , 2008c
Diurnal raptors	?	No data

TABLE 8

Percentage of adult individuals recovered in different samples of modern rabbit accumulations.

There are no cut marks and the presence and location of burnt damage is anecdotic, reinforcing the low contribution of anthropic activity on the Mousterian leporid accumulation in the cave.

To summarize, one can say that Maroto *et al.* (1996) hypothesis postulating a minimal procurement of rabbits by humans at this time in Arbreda Cave appears to be confirmed by our taphonomical analysis. Small terrestrial carnivores such as the Iberian lynx, red fox or wild cat, that were identified in the archaeological faunal sample (Table 1), might well have been the accumulators of the leporid remains analysed here.

CONCLUSIONS

The present study demonstrates that identification of the agent(s) responsible for a leporid archaeological assemblage is not a straightforward issue. Systematic actualistic studies conducted thus far evidence that taphonomical traces left by the same predator are not uniform. Similar vestiges are evident on scats and pellets or among non-ingested remains found in nests and dens. For this reason, distinction between terrestrial carnivores and raptors or among different carnivores and diurnal and nocturnal birds of prey is complicated. In fact, and given that cut marks and burning damage cannot be caused by any other predator, it appears that humans might be the agent easiest to detect. The approach followed here corroborates that taphonomical analyses on archaeological samples cannot be restricted to the study of only one or two variables. It has been the comprehensive combination of data (frequency indexes, measurements and quantitative data) obtained for anatomical

representation, breakage and digestive corrosion what allowed us to conclude that terrestrial carnivores played an important role in the formation of the Mousterian rabbit assemblage at Arbreda Cave. The breakage pattern and the frequency of digested bones and teeth are consistent with modern samples of mixed non-ingested and scats remains. From this perspective, our work highlights that the role played by medium-sized carnivores (*i.e.*, red fox, Iberian lynx and wild cat) on the site may have been more relevant than the low numbers of their remains suggest. Although anthropic occupation of the cave is documented by the presence of lithic industry and butchery activity mainly on ungulates, the occurrence of a large leporid assemblage accumulated by terrestrial carnivores indicates that during the Mousterian the cave functioned as a carnivore den being occupied by humans only intermittently. In conclusion, the anthropic activity on leporids, when real, was insignificant and therefore the contribution of rabbits and hares to the subsistence pattern of this human group must have been occasional.

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