The Hares from Cova Fosca (Castellón, Spain)

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ABSTRACT: This paper analyzes the finds of Iberian hare (*Lepus granatensis* Rosenhauer 1856) recovered from the shelter of Cova Fosca (Castellón, Spain). Human presence in the cave expands from the Epipalaeolithic to the Middle Neolithic. Along with a description of the remains from an anatomical and taphonomic standpoint, the paper incorporates a preliminary analysis of the diagnostic osteological characters that set the Iberian hare apart from the brown hare (*Lepus europaeus*, Pallas 1778) and the rabbit (*Oryctolagus cuniculus*, Linnaeus 1758). A preliminary biometric analysis of the two hare species completes this comparative study. The nature of the accumulation of the hare remains is discussed and it is concluded that most probably, and despite the fact that a comparatively large number of bones exhibit burning marks, the hares at Fosca do not represent items hunted by people but instead leftovers of meals from predators, in particular the eagle owl (*Bubo bubo*, Linnaeus 1758).

KEYWORDS: HARE, *Lepus granatensis*, SPAIN, EPIPALAEOLITHIC, MESOLITHIC, NEOLITHIC, OSTEOLOGY, OSTEOMETRY, TAPHONOMY

RESUMEN: En este trabajo se presenta un estudio de los restos de liebre ibérica (*Lepus granatensis*, Rosenhauer, 1856) recuperados en el yacimiento de Cova Fosca, cuya ocupación humana abarca desde el Epipaleolítico hasta el Neolítico Medio. Junto con una descripción anatómica y tafonómica de los restos, se incorpora un análisis preliminar sobre los rasgos osteológicos diagnósticos que diferencian la liebre ibérica de la europea (*Lepus europaeus*, Pallas 1778) y del conejo (*Oryctolagus cuniculus*, Linnaeus 1758). Un análisis biométrico de las dos especies de liebres completa este estudio comparado. El trabajo valora la contribución de los potenciales agentes acumuladores de la liebre en Cova Fosca y concluye que, a pesar de que un elevado número de restos presenta termoalteraciones, la especie no parece representar un acúmulo cinegético, tratándose más bien de una muestra producto del consumo de algún depredador entre los que destacaría el búho real (*Bubo bubo*, Linnaeus 1758).

PALABRAS CLAVE: LIEBRE, *Lepus granatensis*, ESPAÑA, EPIPALEOLÍTICO, MESOLÍTICO, NEOLITÍCO, OSTEOLOGÍA, OSTEOMETRÍA, TAFONOMÍA

INTRODUCTION

Hares (genus *Lepus*; family Leporidae) constitute one of the most fascinating case studies of evolutionary biogeography among the mammals. Although their oldest record in Europe dates back to the Late Pliocene (2.5 my; López-Martínez, 2008) and hare remains have been routinely found in European paleontological and archaeological sites, the taxonomic status of these remains is not always clear and that of the living species still a matter of debate.

Since the seminal paper by Petter (1961), a tradition existed to lump all European hares as subspecies of the cape hare *Lepus capensis* (Linnaeus 1758) (Flux & Angermann, 1990). Molecular analyses over the past twenty years, however, have revealed that, despite subtle differences, there exists six species of hares in the European subcontinent (Figure 1). One peculiar problem that many of these studies have revealed is that whereas these taxa can be considered valid species at the nuclear level, at the mitochondrial level they all exhibit a considerable degree of introgression that evidences recurrent hybridization events taking place at different times among populations (see, for an updated yet highly readable review, Melo-Ferreira & Alves, 2009). Under such circumstances a reticulated evolution ensued that has, among other things, generated a considerable degree of homogeneity at the anatomical level. Obviously, as is so often the case with molecular studies, not all the authors agree on the subject. In this way, Ben Slimen *et al*. (2008) have recently insisted that *L. europaeus* and *L. capensis* could be the same species and that it is dangerous to rely only on mtDNA to determine species' status for hares.

The present day consensus is that three species of hares inhabit the Iberian Peninsula (Figure 1): the Iberian hare (*Lepus granatensis*, Rosenhauer 1856) occupies most of the territory except for the north-eastern border (ie., eastern Cantabria, Pyrenees and northern half of the Ebro valley including Catalonia), where the brown hare (*Lepus europaeus*, Pallas 1778) takes over (Mitchell-Jones *et al*., 1999; Palomo & Gisbert, 2002; Acevedo *et al.*, 2009). An endemism of the central Cantabrian mountains, the broom hare (*Lepus castroviejoi*, Palacios 1977) constitutes a remnant of an apparently far wider distributed species with loose resemblances to the Corsican hare (*Lepus corsicanus*, Winton, 1899) and an extensive amount of mitochondrial introgression with the mountain hare (*Lepus timidus*, Linnaeus 1758) (Mitchell-Jones *et al*., 1999; Palomo & Gisbert, 2002; Acevedo *et al*., 2009; Ballesteros, 2009).

It has been difficult for archaeozoologists to keep track of these developments on the Systematics of the genus. As a result, in Iberia very often one has to figure out through the nomenclature and location of a particular site in order to see what species the analyst might have been dealing with. In Iberian archaeozoology, acknowledgement that *L. granatensis* was a valid species has only taken place over the last decade, and most scholars, following the criteria put forward by German authors in the «*Studien über frühe Tierknochenfunde von der Iberischen Halbinsel*» series (1969-1990), considered all hares to represent members of the species *L. capensis*. Palaeontologists and archaeozoologists working on NE Iberia, on the other hand, have been regularly assigning hare remains to the species *L. europaeus* more as a matter of inertia than of a systematic application of sound discriminating criteria (eg., Castaños, 1986).

Hares constitute a marginal though regular item in most archaeozoological assemblages from the Iberian Peninsula. By this we mean that remains of the genus *Lepus* seldom represent more than 5% of the mammalian NISPs, despite their widespread presence. This has been taken to indicate that hares have been a prevalent hunted item at least since the Upper Palaeolithic, but the possibility exists that hare remains occasionally represent hunting by alternative agents. In this context, it should be noted that although no Iberian predator has specialized in the capture of such swift animals, the range of those that occasionally bag hares is ample and includes diurnal raptors such as the Golden eagle (*Aquila chrysäetos*, Linnaeus 1758), nocturnal raptors, in particular the Eagle owl (*Bubo bubo*, Linnaeus 1758) (Palomo & Gisbert, 2002; Lloveras *et al*., 2007, 2009) and almost all of the Iberian carnivores with the exception of the brown bear (*Ursus arctos*, Linnaeus 1758), the mink (*Mustela lutreola*, Linnaeus 1761) and the weasel (*Mustela nivalis*, Linnaeus 1766) (Jaksic & Soriguer, 1981; Palomo & Gisbert, 2002). It is for this reason that faunal analysts have no easy job when trying to identify the accumulating agent of hare remains in archaeological collections. With exceptions, man has been often considered as the accumulator agent, more as a matter of routine than as a result of the application of taphonomical criteria (Davis *et al*., 2007).

It is with these provisos in mind that the analysis of the hare remains at the site of Cova Fosca was undertaken.

AIMS

Since leporid species are so similar anatomically, the tradition in Iberian archaeozoology has been to identify them on the basis of metrical criteria. Yet, because the Iberian hare is the smallest of those inhabiting the peninsula (see below), and because the size of the rabbit has been documented to decrease since the Late Pleistocene (Davis, 2008), it was critical to ascertain, first of all, whether the hares from Cova Fosca could not have been mistaken for rabbits.

At Cova Fosca the problem of a correct identification was rendered more critical because the brown hare, presently reaching to the foothills of the Pyrenees and upper Ebro valley (Gortázar *et al*., 2007; Figure 1) could have extended further South during the Late Pleistocene and Early Holocene. Such phenomenon has been detected in our ongoing faunal analyses at Cova Fosca with the pine marten (*Martes martes,* Linnaeus 1758), another species nowadays restricted to the Pyrenees that has been recorded in comparatively large numbers (Morales *et al*., 2009). To decide unequivocally which species of hare was present at Cova Fosca, thus required not only knowledge on the osteological features discriminating the Iberian hare from the brown hare and the rabbit, but also about biometrical data setting apart the ranges of values of particular bones from the two hare species.

The subject of morphological and biometrical differences among the hares of Iberia has been dealt extensively by Palacios who described the broom hare as a distinct species in 1977 (Palacios, 1978, 1983, 1989). As a result of these studies, it became clear that this species, with an average weight of 2,905 g (+/- 245 g), was intermediate in size between the Iberian hare (2,335 g +/- 238 g)

FIGURE 1

Geographical distribution of the European and North-African hares (taken from Melo-Ferreira, 2009). The star marks the location of the site of Cova Fosca in the territory of the Iberian hare, very close to the range of the brown hare.

and the brown hares from Iberia (4,055g +/- 614 g) (Palacios, 1989).

Several problems remain concerning the diagnosis of species when one considers the skeletal elements:

1) At the morphological level, and whereas Palacios undertook very detailed studies in the case of the skull, mandibles and teeth, none were carried out at the level of the postcranial skeleton. This is unfortunate because in archaeozoological assemblages, hare remains are most often represented by fragments of the postcranial bones, and except for mandibles, the cranial elements are seldom encountered and extensively fragmented, precluding an application of the discriminating features mentioned by Palacios.

2) As for the biometry, this same problem applies with an additional complication due to the now amply documented fact that many mammalian species have changed size through time (Davis, 1981).

In the case of the Iberian leporids, such a change has been monitored for the rabbit to the extent of allowing one to use size as a «thermometer» (Davis, 1981; Davis & Moreno, 2007). For such reason, the biometric analysis of the postcranial elements from the hare aimed at: (a) checking whether osteometrical differences existed among the two common species of hares in Iberia, and (b) monitor whether putative size differences through time could obscure the taxonomic diagnosis of archaeological remains.

COVA FOSCA

The site of Cova Fosca is located in the municipality of Ares del Maestrat (province of Castellón, Spain; Figure 1) placed at an altitude of 900m and a distance of 46 Km to the present day coastline of the Mediterranean Sea.

The entrance to the shelter (18m wide x 4m high) is connected to a single chamber 20m deep x 27m wide, whose roof reaches from 5m to 2m in height. Rock outcrops and stalagmitic columns invade the westernmost corner of the chamber. This, along with a quite irregular floor in some areas, considerably restricts the space for habitation. Traditionally, Cova Fosca was used by her-

ders as a natural corral up until the second half of the twentieth century (Olària, 1988).

Two areas of the site have been excavated thus far. The inside of the cave saw campaigns from 1975 to 1979 and in 1982, whose faunal analyses were incorporated in the 1988 monograph edited by Olària (eg., Estévez, 1988). Our materials come from the campaigns carried out between 1999-2003 at the entrance of the shelter (Sector C), apparently the only area neither sacked nor disturbed (Olària, 1988).

The stratigraphy of Sector C incorporates the following stages:

1) Superficial levels (+14.75/-32.3 cm). This constitutes a mixed sedimentary deposit of no archaeological value.

2) Middle Neolithic (-34/ -130 cm), also referred to as Neolithic B, constitutes a one meter deep sedimentary package with burned soils and ashes apparently deriving from a complex superposition of hearths. Although the C14 dates were taken on long-lived materials for the most part, those carried out on bones offer a range of dates between 4,850-4,540 (cal. BC) (Table 1).

3) Early Neolithic (-125/ -250), also referred to as Neolithic A, constitutes a 1.2 meters deep series of levels of «anthropic nature» (Olària, pers. com.) where ceramics are very abundant. C14 dates on two horse bones set the chronology of this lot between 5,300-5,040 (cal. BC) (Table 1).

4) Mesolithic (-250/-298), a 0.5 meters deep package identified by the excavators on the basis of its geometric industries and absence of ceramics. The Mesolithic presently lacks C14 datings on short lived materials. The dates offered by a charcoal sample from this site set the range between 10,720-10,260 (2σ, cal. BP) (C. Olària, pers. com.).

5) Epipalaeolithic (-298 downwards), constitutes a +3 meters deep package identified on the basis of its lithic industries (evolued and microlaminar) (Table 1). Although at places it reaches down to 6m below the surface, we have thus far analyzed faunas lying between 3-4m. For this range of depths there exists no C14 dating based on short lived materials, and those obtained on charcoal samples offer a range of values between 13,360-10,520 (cal. BC) (Table 1).

UE	CODE	C14 BP (AMS)	2σ CAL BP (95%)	BC	2σ CAL BC (95%)	Cultural assignal	Sample
-34/-48	Beta 148996	5850±70	6790-6480	3900±70	4840-4530	Middle Neolithic	Charcoal
-44/-51	Beta 247466	5820±50	6740-6490	3870±50	4790-4540	Middle Neolithic	Red deer
-44/-51	Beta 247467	5860±40	6750-6620 6590-6570	3910±40	4800-4670 4640-4620	Middle Neolithic	Sheep
-45/-57	Beta 148997	5870±80	6870-6480	3920±80	4920-4530	Middle Neolithic	Charcoal
-45/-83	Beta 148999	5980±70	6990-6660	4030±70	5040-4710	Middle Neolithic	Charcoal
-47/-71	Beta 247468	5800±40	6680-6490	3850±40	4730-4540	Middle Neolithic	Sheep
-47/-71	Beta 247469	5860±40	6750-6620 6800-6630	3910±40	4800-4670 4640-4620	Middle Neolithic	Wild goat
-47/-71	Beta 247470	5890±50	6840-6820 6800-6630	3890 ±50	4850-4680	Middle Neolithic	Red deer
-49/-78	Beta 149000	6080±80	7190-6730	4130±80	5240-4780	Middle Neolithic	Charcoal
-65/-79	Beta 149001	6140±90	7260-6760	4190±90	5310-4810	Middle Neolithic	Charcoal
-77/-89	Beta 149003	5440±140	6490-5920	3490±140	4540-3970	Middle Neolithic	Charcoal
-111/-120	Beta 149004	6150±70	7240-6850	4200±70	5290-4900	Middle Neolithic	Charcoal
-118/-120	Beta 149005	6070±80	7180-6730	4120±80	5230-4780	Middle Neolithic	Charcoal
-119	Beta 149006	6250±80	7320-6940	4300±80	5370-4990	Middle Neolithic	Charcoal
-120/-130	Beta 149007	6130±60	7200-6850	4180±60	5260-4900	Middle Neolithic	Charcoal
-126	Beta 149008	5900±110	7170-6560	4040±110	5220-4600	Middle Neolithic	Charcoal
-135	Beta 149009	6390±40	7420-7250	4440±40	5470-5300	Middle Neolithic	Charcoal
-196/-211	Beta 222754	6230±50	7260-7000		5310-5040	Early Neolithic	Horse
-196/-211	Beta 227420	6200±50			5300-5010	Early Neolithic	Horse
-304/-319	Beta 184513	10920±100	13160-12800	8970±100	11210-10850	Evolved Epipalaeolithic	Charcoal
-311	Beta 184499	11630±110	14020-13300	9680±110	12070-11350	Microlaminar Epipalaeolithic	Charcoal
-319/-365	Beta 184500	10700±110	13000-12600	8750±110	11150-10640	Evolved Epipalaeolithic	Charcoal
-347	Beta 184501	11750±170	15070-14830	9800±170	13120-12880	Microlaminar Epipalaeolithic	Charcoal
-357	Beta 184503	11830±240	15290-14660	9880±240	13240-12710	Microlaminar Epipalaeolithic	Charcoal
-365	Beta 184504	10350±40	12640-12470	8400±40	10690-10520	Evolved Epipalaeolithic	Charcoal
-379/-380	Beta 184509	12130±100	15310-14650	10180±100	13360-12700	Microlaminar Epipalaeolithic	Charcoal
-407	Beta 184511	11340±50	13770-13690	9390±50	11820-11740	Microlaminar Epipalaeolithic	Charcoal
-600	Beta 184512	10320±40	12620-12480	8370±40	10670-10530	Evolved Epipalaeolithic	Charcoal

TABLE 1
C14 dates from Cova Fosca.

MATERIALS AND METHODS

Hare remains were retrieved from nineteen levels from Sector C at Cova Fosca (Table 9). These include five levels from the Middle Neolithic (i.e., 47-120 cm below surface), eight additional ones from the Early Neolithic (125-224 cm below surface), four from the Mesolithic (255-298 cm below surface), and a further two from the Epi-

palaeolithic (298-388 cm below surface). These levels constitute 40% of those recognized in Sector C. Hare NISPs (i.e., number of identified remains) represent 0.5% of the total NISP of the vertebrates and molluscs from these levels (Llorente, unpublished data). All remains were sieved through 0.5 mm and 0.3 mm wide screens.

For identification, use was made of the collections of Arturo Morales-Muñiz housed at the

Laboratorio de Arqueozoología-Universidad Autónoma de Madrid (LAZ-UAM) as well as of criteria taken from various publications (eg., Palacios, 1978, 1989; Peltier, 1985; Callou, 1997).

Both osteological and bibliographical data were incorporated to the anatomical study. To this end, the seminal paper by Callou (1997) proved instrumental as well as the reference from which most of the illustrations and the list of morphological characters and codes were taken (see the comparative osteology and Figures 2-7). The anatomical analysis section excluded the skulls (but not the mandibles) as in archaeological contexts the former appear mostly fragmented. Teeth were also left out of the analysis since their identification is time consuming. A comprehensive review including all these elements is presently in progress (Llorente, in preparation).

In the case of the biometry, use was made of specimens of Iberian hares housed at the Laboratorio de Arqueozoología (UAM, Madrid) and of brown hares from the Zoologisk Museum of the University of Copenhaguen (Denmark) (Appendixes A and B). In addition, data from Iberian hares housed at the CIPA IGESPAR I.P. (Lisbon, Portugal), the Museu Bocage (Lisbon, Portugal), and the Museo de Ciencias Naturales (Madrid), measured by Simon Davis, were incorporated (Appendix A). Dr. Davis also provided data from brown hares from the collection housed at the Museum National d'Histoire Naturelle (Paris), and from the private collection of Armelle Gardeisen (Appendix B). Measurements from subfossil hares were taken from the literature (Driesch, 1972; Castaños, 1986; Morales, 1991).

All measurements were taken with a digital calliper «Powerfix» (Estimated error ± 0.5 mm), and follow von den Driesch (1976) except for the trochlear height of the humerus (HTC) that follows Davis *et al*. (2008).

Abundances were calculated following the classical estimators in archaeozoology, namely the NISP, the MNE (Minimum number of elements) and the MNI (Minimum number of individuals) (Andrews, 1990; Lyman, 1994; Reitz & Wing, 1999).

Taphonomical groups were assigned following the criteria expressed by Gautier (1987) and Lyman (1994). Three works that have been of value to evaluate the post-mortem survival of bone are the classical ones by Brain (1967, 1969, 1981), although for them medium, rather than small size

mammals, are the subject of interest. Bone density values as they appear in Figure 8 and Appendix D refer to what Pavao & Stahl (1999) defined as «Shape-Adjusted Volume Densities» (VDsa). The scan sites whose codes appear in Appendix D, are illustrated in the work of these same authors (Pavao & Stahl, 1999: Figure 1).

Traces on the bones follow the criteria expressed by Pérez Ripoll (1992) and Liesau (1998). Marks were analysed both by ocular inspection and on a Wild M5A binocular microscope (X10-X40 magnification). Burnt bones were identified by visual examination, and colour of burning was recorded (Stiner *et al*., 1995). Burnt areas were recorded for each specimen. The criteria for characterizing digestion damage follow Andrews (1990) and Fernández-Jalvo & Andrews (2000).

RESULTS

A. *Comparative osteometry*

As can be seen in Table 2, the main limb bones of recent Iberian and brown hares appear to exhibit non-overlapping ranges of values. In the case of the Iberian hare the mean values provided by Palacios (1983) fall neatly within the range of values from adult specimens, both males and females, that were incorporated into our study (see Appendix A).

In the case of the brown hare, the scarce number of Iberian specimens measured by Palacios falls well above the maximum values of the Iberian hare yet clearly below the minimum values of the Danish hares we measured at the Zoologisk Museum (Appendix B). For such reason, although the Iberian brown hare values need to be taken with caution, on the basis of the available data, a distinction of Iberian and brown hares based on metrical data should pose no problems to the faunal analyst provided one deals with adult specimens and complete appendicular bones.

The same essentially applies when dealing with breadths, heights and bones of smaller size as well as with subfossil specimens although matters at times are not so straightforward. Table 3 incorporates a selection of measurements from recent and subfossil populations. The subfossil collections derive from sites in Southern Spain where the putative species must have been the Iberian hare (Driesch, 1972). The data from this last paper and those from Driesch & Boessneck (1970) evidence

Humerus	Radius	Femur	Tibia	Sample
82 (9)	92.7 (7)	101.7 (11)	117.4 (8)	*L. granatensis*, Recent (Palacios, 1983)
98.7 (2)	106.2 (2)	123.6 (2)	140.4 (2)	*L. europaeus*, Recent Iberia (Palacios, 1983)
79.6-86 (8)	87.6-101.3 (8)	99.6-112.5 (8)	113-127.2 (8)	*L. granatensis*, Recent (own data, Spain and Portugal)
102-112.5 (14)	109.5-124 (12)	126.5-146 (12)	144-160 (10)	*L. europaeus*, Recent (own data, Denmark)

TABLE 2

Values of the greatest lengths (Gl) of the main appendicular bones in selected populations of the Iberian and brown hares. Data from Palacios refers to mean values (size of the sample within brackets).

that the largest of the subfossil Spanish rabbits are far smaller than the smallest hares we have either measured or found in the literature. For this reason, the bones assigned to hare at Cova Fosca (Appendix C) cannot possibly be mistaken for rabbits. This essentially settles the issue of a correct diagnosis between the genera *Oryctolagus* and *Lepus* at the level of the osteometry.

As can be seen in Table 3, both the size differences between the European and Iberian brown hares and between these and the Iberian hares hold to a rather large extent although an overlapping of values does occasionally occur. In this way, the distal breadth of the radius, an often recorded measurement on archaeological specimens, not only overlaps slightly in the case of the Danish and Iberian brown hares but also between this species and the largest of the Iberian hares from Bronze Age sites such as Monachil + Purullena (province of Granada) and Azuer (province of Ciudad Real) (Table 3). The same occurs in the case of the greatest length of the calcaneus from recent brown hares from northern Iberia (Vizcaya) and some of the largest Iberian hares at sites such as Azuer and the Cerro del Coscojar (province of Almería). In the later case, the maximum values of the Iberian hares are, in fact, a bit above those of the brown hares from Vizcaya (Table 3). This should come as no surprise given that, among other things, sexual dimorphism remains unknown in most of these samples. Female hares of all species are slightly larger than males (Petter, 1961; Palacios, 1978, 1983, 1989) so that a sample dominated by females should in theory exhibit higher values than another one with an abundance of males from the same population. Although in our present day samples, much too restricted in size and occasionally

incorporating specimens of unknown sex, there does not seem to exist a bias favouring males or females (Appendixes A & B), we do not know whether this has also been the case on the subfossil samples taken from the literature.

These facts notwithstanding, one element that appears to be evident in this preliminary analysis of the postcranial biometry of Iberian hares is that present-day animals have apparently decreased in size compared to their Bronze Age equivalents. To make a stronger statement one would need to monitor other potential sources of variation in the samples (eg., geographical, sexual) and also to have all the measurements checked by the same analyst (we know from experience that different people end up with different values when measuring the same bone). Still, the fact that in most of the Southern Spanish archaeological samples of Iberian hares both maximum and minimum values exceed those of their recent equivalents suggests that there exist sound arguments supporting a discrimination of species based solely on size. The finding is relevant in that climate can be safely ruled out of the equation given that the past four millennia have not witnessed any drastic reduction of the temperature and temperature is one of the key items accounting for size changes in wild mammals (Davis, 1981).

To summarize, the biometrical analysis undertaken reveals that (1) there exist, for the most part, clear-cut differences between *L. granatensis* and *L. europaeus* in Iberia that, notwithstanding temporal and geographical variation, (2) should allow for a clear discrimination of archaeological specimens, be these complete bones or bone portions, on the sole basis of measurements. When the biometric data from Cova Fosca (Appendix C) are

Measurements and samples		n	Range	$\overline{Y}$
HUMERUS (BD)				
	Cova Fosca	3	9.8-10.4	10.1
	Recent, Iberia	12	9.6-10.7	10.1
	Cabezo Redondo	12	9.8-11	10.3
L. granatensis	Monachil+Purullena	5	8-10.6	9.7
	Azuer	20	9.5-11	10.4
	Cerro del Coscojar	3	10.7-11.3	11.1
	Recent, Europe	23	11.3-14	12.5
L. europaeus	Recent, Guipúzcoa	3	11.5-12.2	11.9
	Recent, Vizcaya	6	10.9-12.6	11.7
HUMERUS (HTC)				
	Cova Fosca	3	4.7-5.6	5.3
L. granatensis	Recent, Iberia	12	4.7-5.5	5.2
L. europaeus	Recent, Europe	8	5.8-6.6	6.2
RADIUS (BP)				
Cova Fosca		5	7.7-8.2	7.9
	Recent, Iberia	8	7.3-8.2	7.6
	Morra del Quintanar	6	7-8.8	7.6
	Cerro de la Virgen	6	7.5-8	7.7
	Cabezo Redondo	8	7.5-8	7.7
L. granatensis	Monachil+Purullena	2	7.8-8.5	8.1
	Azuer	29	7.3-8.5	7.8
	Sacaojos	6	7.8-8.2	7.9
	Valencina	4	7.8-8.3	7.6
	Cerro del Coscojar	5	7.7-8	7.8
L. europaeus	Recent, Denmark	14	9-10	9.5
	Recent, Vizcaya	5	8.3-9.5	8.9

Measurements and samples		n	Range	$\overline{Y}$
TIBIA(BD)				
	Cova Fosca	5	12.8-14.2	13.6
	Recent, Iberia	12	12.1-13.6	12
L. granatensis	Morra del Quintanar	12	13-14.5	13.5
	Cerro de la Virgen	5	13.5-14.2	13.9
	Cabezo Redondo	4	12.5-14.6	13.5
L. europaeus	Recent, Europe	20	14.2-17.5	16.9
CALCANEUS (GL)				
	Cova Fosca	12	27.3-30.6	29.6
	Recent, Iberia	11	26.2-30.3	27.9
	Morra del Quintanar	3	29.5-30	29.8
L. granatensis	Cabezo Redondo	8	27.5-29.8	28.8
	Azuer	11	28-31	29.4
	Sacaojos	3	28-28.9	28.5
	Cerro del Coscojar	8	28.8-33	29.7
L. europaeus	Recent, Europe	11	30.6-37	33.5
	Recent, Vizcaya	4	30-32	31.4
ASTRAGALUS (BD)				
	Cova Fosca	7	6.3-7.5	7.1
L. granatensis	Recent, Iberia	8	5.2-7.6	6.5
L. europaeus	Recent, Denmark	3	17-18	17.7

TABLE 3

Comparative biometry of Iberian and brown hare from recent and subfossil populations. Measurements follow Driesch (1976) except for HTC that follows Davis (2008). Values of hares from Iberian Bronze and Iron Age sites in Southern Spain taken from Driesch (1972) and Morales (1991). Values from the Basque country (Vizcaya, Guipúzcoa) taken from Castaños (1986). Values of some of the recent Iberian and brown hares supplied by Simon Davis.

taken into account, one can see that (3) almost half of the sample (NISP = 61) could be measured, and even though almost a third of these values are not that reliable due to damage of the bones (ie., values within brackets in Appendix C), in those cases that could be safely confronted with our comparative data, (4) the Cova Fosca specimens fall neatly within the ranges of the Iberian hare (Table 3), and (5) conform best to Iberian hares from the Bronze and Iron Age sites from Southern Iberia (i.e, their means being systematically higher than those from recent Iberian hares). This, in turn, suggests that (6) at least since the second millennium B.C., the size of the Iberian hare diminished

all throughout its territory until today. This is a hypothesis that will obviously require statistical confirmation once a more systematic analysis of the data is completed (Llorente, in preparation).

B. *Comparative osteology*

1. Mandible

The two most diagnostic features given by Callou (1997), the location and size of the mandibular foramen (foramen mentale) are of unequal value to set apart the Iberian hare from the two

other leporid species. Mental foramina in *L. granatensis* are comparatively small (large in the rabbit) and placed well before the root socket (alveole) of the P_3 as is the case for the brown hare (in the rabbit, the large foramen mentale is very close to the alveole of the P_3). But very often two foramina, not a single one, appear on the diastema of Iberian hares (i.e., 38% of our reference specimens). Although until a more systematic analysis is completed in order to decide the reliability and frequency of this condition, the fact that this feature has been recorded on specimens from different locations in Spain and Portugal, as well as on mandibles from archaeological sites in Southern Iberia where only *L. granatensis* appears, lends support to the observation that the double mental foramen might be a diagnostic character of the Iberian hare (Llorente, in preparation).

The length and width of the diastema from *L. granatensis* exhibits an intermediate condition between the far larger and comparatively narrower diastema of the brown hare and the shorter and wider one of the rabbit. Although the overall impression in the Iberian hare is that of a «hare diastema», at this moment we would refrain from providing a species identification of the Iberian hare's mandibles based solely on this character.

2. Scapula (Figure 2)

(H-a) *Processus hamatus*. Although fragile to the extent of disappearing on most of the archaeological scapulae, the *processus hamatus* of the acromion in the Iberian hare is not blunt distally as in the brown hare, but ends instead in a point as is
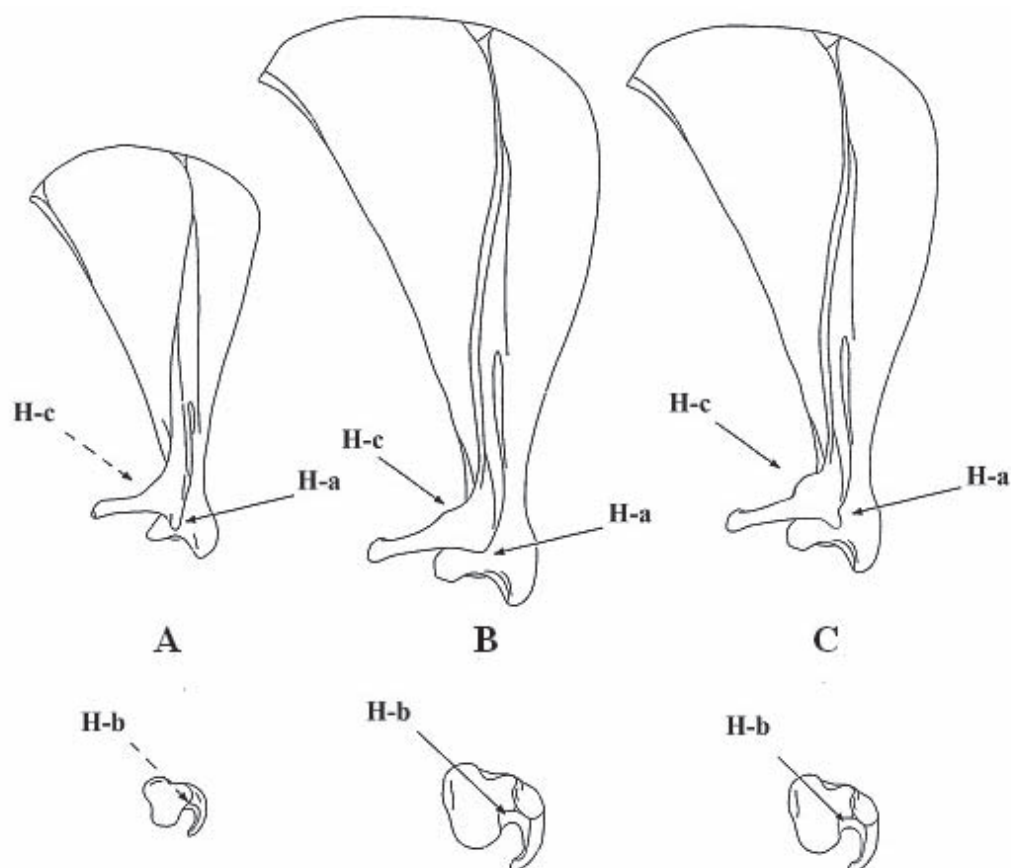

FIGURE 2
Scapula: Diagnostic traits for the rabbit (A), brown (B) and Iberian hare (C) (A and B taken from Callou, 1997).

the case of the rabbit. The difference between these two species is the orientation and shape of this point, straight in the rabbit, thus directed ventrally (ie., distally) but bent cranially (ie., dorsally) in *Lepus granatensis*.

(H-b) The non-articular surface lying between the glenoid cavity, the supraglenoid tubercle and the coracoid process is present in the Iberian hare though far less developed than in the brown hare, rendering the diagnosis with the rabbit (whose scapulae are missing this surface) not so straightforward as Callou refers (1997: 7).

(H-c) An additional difference that has been spotted in the Iberian hare refers to the proximal border of the *processus supra-hamatus* that exhibits a far more sinusoidal profile than is the case for the brown hare due to the far more developed laminar expansion connecting its base with the *processus hamatus*. Though our limited number of brown hares precludes us from considering this subtle difference as diagnostic between the two species, it apparently constitutes a clear trait for

distinguishing the Iberian hare and the rabbit, where such laminar expansion is barely visible and the proximal border of the *processus supra-hamatus* is consequently concave.

(H-d) A final difference (not shown) sets apart the scapulae of hares, both brown and Iberian, from the rabbit. This refers to the basal crest of the acromion process that penetrates further (ie., more distally) into the scapular neck (*collum scapulare*) in the case of the rabbit and is shorter in both species of hares. This difference is subtle in that it requires use of comparative material to reach a decision, yet we believe it is useful from an archaeozoological perspective given that this dense portion of the scapula is systematically retrieved in collections of leporids.

3. Humerus (Figure 3)

(I-a) The width of the intertubercular groove exhibits in the Iberian hare an intermediate condition between that of the brown hare (constant
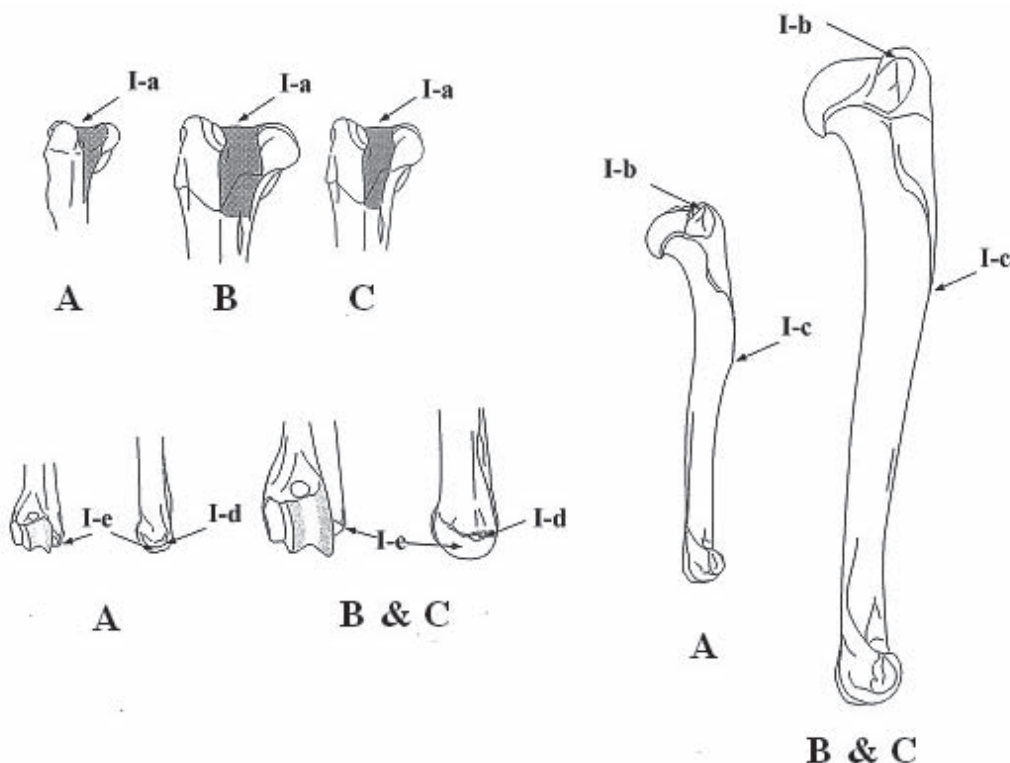

FIGURE 3
Humerus: Diagnostic traits for the rabbit (A), brown (B) and Iberian hare (C) (A and B taken from Callou, 1997).

width throughout) and the rabbit, where this width decreases distally. The minor tubercle projected more medially in the rabbit, provides the clearest difference with the Iberian hare.

(I-b) The features associated with the major process (*tuberculum majus*) that Callou (1997: 7) mentions as diagnostic between the brown hare and the rabbit are not considered such due to the larger variability that we have spotted on our Iberian rabbits. In the case of the Iberian hare the morphology sometimes resembles the condition described for the brown hare, but also varies from that condition.

(I-c) In the Iberian hare the deltoid crest slopes gradually and merges smoothly with the cranial border of the diaphysis as is the case with the brown hare (in the rabbit this transition is more abrupt) but the restriction of this crest to the upper third of the humerus is not so clear as in the brown hare since some of the rabbits that we have examined exhibit a gradual sloping of the deltoid crest into the diaphysis too. Difficulties thus exist for setting apart the Iberian hare from the rabbit.

(I-d) The medial epicondyle (*epicondylus medialis*) of the Iberian hare, as is the case in the brown hare, does not project medially as much as it does in the rabbit and exhibits a round («eroded») contour that contrasts with the sharp borders it features in the rabbit.

(I-e) The distal extremity of the humerus of both hares is also similar with a higher (ie., deeper) trochlea than that of the rabbit and a medial epicondyle that barely reaches distally beyond the proximal half of the trochlea (in the rabbit, the medial epicondyle reaches distally well beyond the proximal half of the trochlea).

4. Radius (Figure 4; left)

(J-a) The curvature of the diaphysis, in medial view, falls, in the case of the Iberian hare, midway between the pronounced bending that characterizes the rabbit and the straighter trajectory exhibited by the radius of the brown hare. As such, this character appears to be of low diagnostic value to set apart the Iberian hare from the other two species.

(J-b) In the proximal end, the caudal border of the fovea in the Iberian hare is clearly convex as in the brown hare, thus easy to set apart from the

straight or slightly concave border that the rabbit exhibits.

(J-c) The Iberian hare has, in cranial view, a distal end with almost no hints of the three grooves of the extensor muscles tendons. This character exaggerates the condition seen in the brown hare, where such grooves are more developed, and allows for an easy diagnosis with the rabbit whose thin extensor's grooves are very prominent. This condition is probably the reason why, among all three species, the perimeter of the distal end of the radius of the Iberian hare is, in distal view, the most compressed one (ie., rectangular) and that of the rabbit the more quadrangular (squared) one.

5. *Ulna* (Figure 4; right)

(K-a) The width of the diaphysis, in cranial view, is an excellent character to set apart the rabbit (constant throughout ist length) from the hares. In the Iberian hare the diaphyseal width towards the distal end decreases far more pronouncely than in the brown hare. As a result, the distal third of the Iberian hare's diaphysis is essentially filiform, a highly fragile strut that contrasts with the distal diaphysis of the brown hare.

(K-b) The proximal border of the olecranon process behaves in the Iberian hare in the same way as it does in the brown hare. Their lateral and medial crests being equally developed, allow for a straightforward diagnosis with the rabbit, whose lateral crest is clearly smaller than its medial counterpart.

(K-c) As is the case of the brown hare, the distal end of the ulna in the Iberian hare develops a lateral depression over the styloid process. This depression is far larger (x3/4) than the styloid process in the Iberian hare and the rabbit (~x2).

6. Pelvis (Figure 5)

(L-a) The overall cranial profile of the iliac wing is most variable in *L. granatensis* so that it does not allow for a clear cut distinction with those of the rabbit or the brown hare. In some Iberian hares, in fact, the more angled profile resembles the iliac wing of the rabbit than the «round right angle» that Callou (1997: 8) mentions as distinctive for the brown hare.

FIGURE 4

Radius (left) and ulna (right): Diagnostic traits for the rabbit (A), brown (B) and Iberian hare (C) (A and B taken from Callou, 1997).

(L-b) The *foramen nutricium* placed on the lateral face of the iliac wing of the Iberian hare conforms best to the location described by Callou for the brown hare (ie., placed further away cranially from the ventro-caudal spine than that of the rabbit). Also, the Iberian hare has a comparatively larger *foramen nutricium* than the rabbit, who sometimes seems to be missing the structure altogether, as is also the case of the brown hare. In some Iberian hares two *foramen nutricia* have been recor-

ded so that this condition may serve as a diagnostic trait, a conclusion that only a more substantial analysis may confirm (Llorente, in preparation).

(L-c) The ilio-pubic eminence (*eminentia iliopubica*) is mentioned by Callou (1997: 9) as presenting a single cusp/point in the brown hare and being bifid in the rabbit, a feature first noted by Peltier (1985). The Iberian hare seems to be variable in this character (ie., occasionally presenting a bifid and in others an unicuspid profile), but the
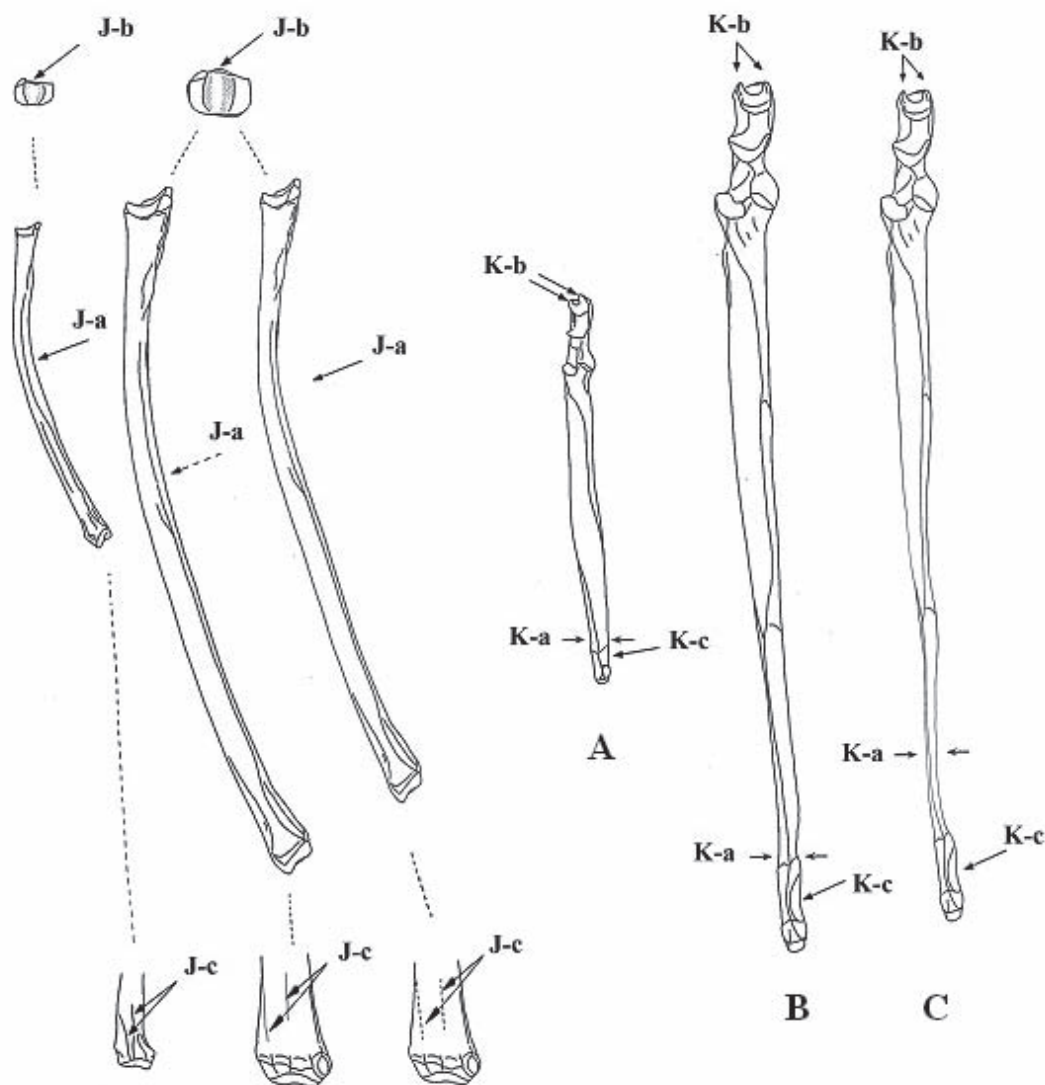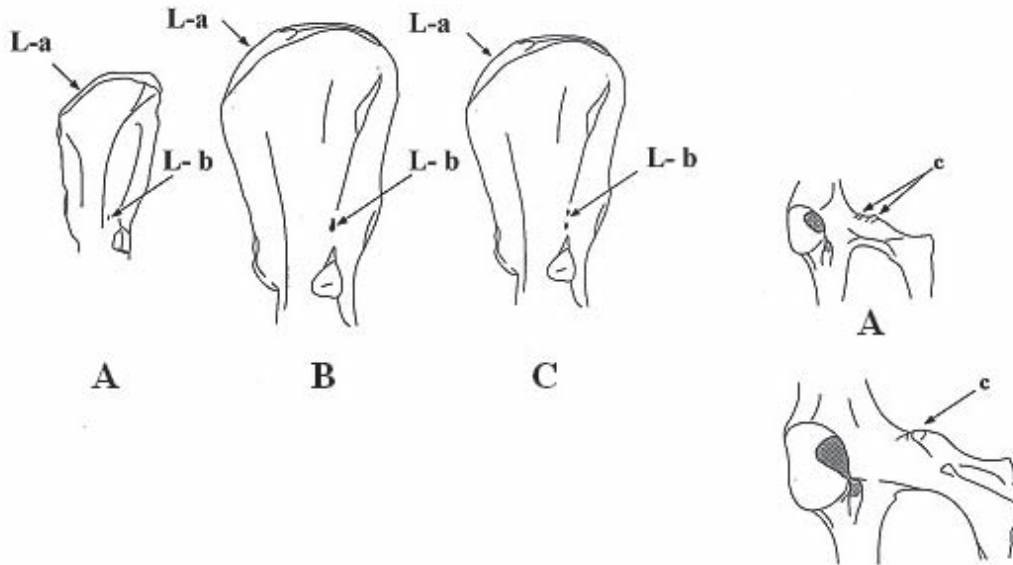
FIGURE 5
Pelvis: Diagnostic traits for the rabbit (A), brown (B) and Iberian hare (C). (A and B taken from Callou, 1997).

Iberian rabbits that have been checked also vary, evidencing a dome-shaped profile in their ilio-pubic eminences instead of the two points mentio-ned.

7. Femur (Figure 6)

(M-a) The neck of the femur (*collum ossis femoris*) is longer in the Iberian hare than that of the rabbit, conforming to the condition described by Callou (1997: 9) for the brown hare, but requi-res comparison with reference specimens for the difference may be subtle and is, to a certain extent, dependent on the size of the specimen. The profi-le, in both hares, is essentially straight but this does not always provide a reliable discrimination with the rabbit due to the fact that in some of them such profile can be rectilinear/straight also.

(M-b) The cranio-medial surface of the great trochanter (*trochanter major*) in the Iberian hare is slightly depressed, not flat, as described for the brown hare even though it also lacks the *linea intertrochanterica* (Callou, 1997: 9), distinguis-hing it from some rabbits since not all of them exhibit this character.

(M-c) The location of the proximal *foramen nutricium* conforms to the condition described for the brown hare (ie., not immediately below the distal border of the *trochanter minor* as in the rab-bit but further down the shaft).

(M-d) The cranial border of the trochlea in the Iberian hare either conform with the condition seen in the rabbit (ie., equally developed) or else have the lateral lip slightly shorter than the medial (in the brown hare the medial lip is the shorter one; Callou, 1997: 9).

8. Tibio-Fibula (Figure 7)

(N-a) The *tubercula* defining the intercondylar eminence (*eminentia intercondylaris*) are a size-dependent character. Being the Iberian hare sma-ller than the brown hare, the difference originally mentioned by Peltier (1985) of more conspicuous *tubercula* in the hare than in the rabbit is attenua-ted to the point of not being useful to discriminate *L. granatensis* from the other two leporid species.

(N-b) In the rabbit the lateral face of the tube-rosity (*tuberositas tibiae*) and the tibial crest is sta-

FIGURE 6
Femur: Diagnostic traits for the rabbit (A), brown (B) and Iberian hare (C) (A and B taken from Callou, 1997).

ted to develop a sharp ridge bent towards the lateral side that in the brown hare is only seen in the tuberosity, the border of the crest being rounder (Callou, 1997: 9). In the Iberian hare we have detected a wide margin of variation with some exhibiting a condition very similar to that of the rabbit whereas others lack the ridge in both the crest and the tuberosity.

(N-c) The distal diaphysis right above the cochlea seems to be diagnostic for the three species of leporids. Seen in cranial view, the rabbit features a medial depression located at the level of the small tuberosity that both hares lack (Figure 7). In addition, the area lying below this depression is flat in both the brown hare and the rabbit whereas in the Iberian hare this area is convex, providing the cochlea with a «doomed» cranial profile that contrasts with the straight profile of both the rabbit and to a lesser extent, the brown hare.

(N-d) The lateral maleole (*malleolus lateralis*) of the Iberian hare, as is the case in the brown hare, does not extend distally as much as it does in the rabbit. Again, this being a rather subtle character, it requires direct comparison with reference specimens in order to be ascertained.

(N-e) The caudal contour of the cochlea when seen in caudal view is essentially similar in both the rabbit and the Iberian hare since it is uniformly smooth, lacking the characteristic indentation featured by the tibia of the brown hare. To be honest, such indentation is insinuated in some specimens of both *Oryctolagus cuniculus* and *L. granatensis* but only spotted when looked under the binocular.

(N-f) In cranio-lateral view, the sharp crest that Callou (1997: 9) mentions as diagnostic of the brown hare's fibula is often replaced in both the Iberian hare and one of the brown hares from our reference collection by two protuberances separated by a groove. As such, even though the discrimination with the rabbit does not pose major problems due to the presence of an essentially flat area, the character would need to be reviewed and rephrased in order to incorporate this second morphological alternative.

The morphological confrontation of the presumably non-rabbit leporids from Cova Fosca with the data obtained in our previous analyses indicate that all of the archaeological specimens retaining
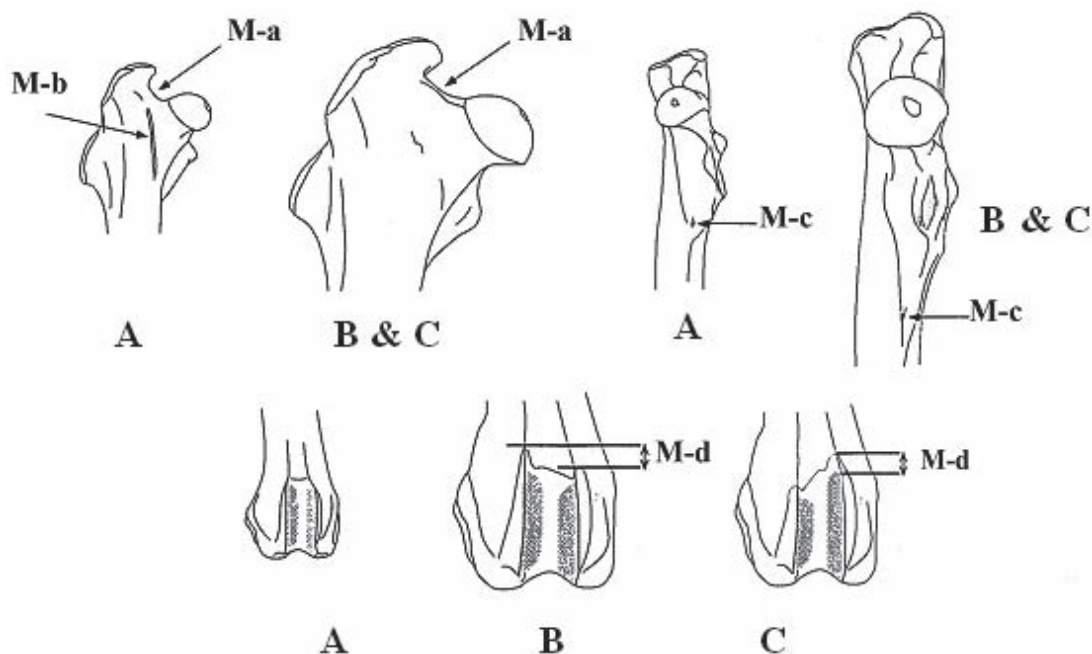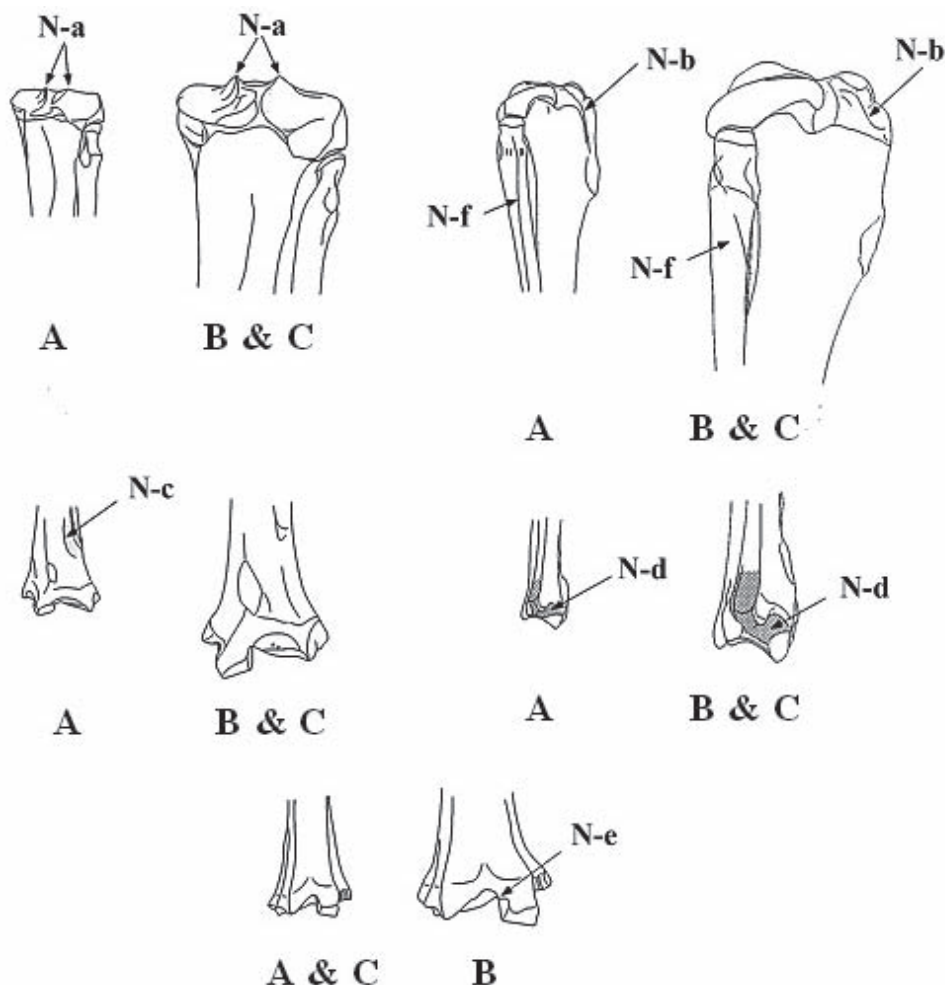
FIGURE 7

Tibia: Diagnostic traits for the rabbit (A), brown (B) and Iberian hare (C) (A and B taken from Callou, 1997).

bone portions with diagnostic features could be straightforwardly identified as Iberian hare. Of particular relevance here were the five distal portions of the radii, without a hint of the grooves of the extensor muscles' tendons (Figure 4: j-c), and the four ulnae whose diaphyses exhibited the filiform (ie., strut-like) morphology that sets this species apart from the brown hare (Figure 4: k-a).

C. *Archaeozoology*

Tables 4-7 provide the essentials of the hare samples from Cova Fosca. The very good general

condition of the bones indicates a rapid burial or else a restricted action of the weathering agents. The skeletal profiles (Tables 4 & 5; Figure 15) evidence samples with an overrepresentation of the limb bones (ie., 76% vs. 53% expected for a complete animal), and an underrepresentation of axial elements (ie., 4% vs. the 32% expected for a complete animal) (Llorente, unpublished data). Given the abundance of rabbits among the leporid remains at Cova Fosca (Table 9), it is possible that some teeth, vertebrae and ribs from hares have been misidentified. This will probably require placing all of the rabbit's axial elements (6-15% of this species' NISPs) in a taxonomically unspeci-
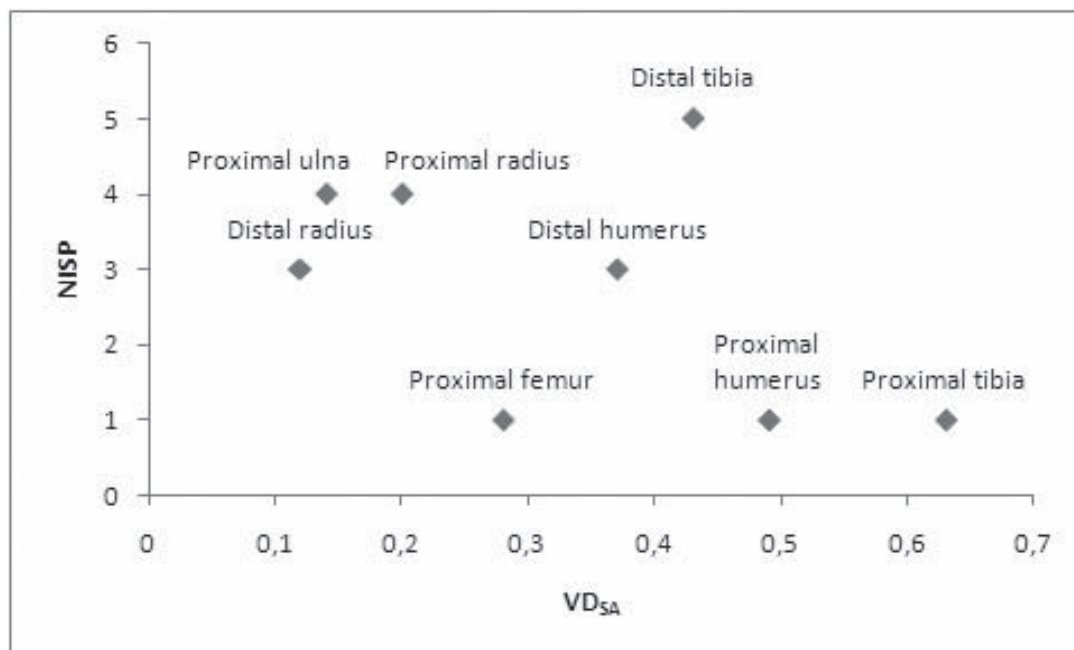
FIGURE 8

Appendicular bone portions (NISP) against bone densities expressed as VD_{SA} values (Pavao & Stahl, 1999).

Period	Middle Neolithic					Early Neolithic								Mesolithic				Epipalaeolithic			TOTAL NISP (MNI)	%	MNE
Category	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t			
Skull						3	2	2			3		2								12 (3)	9.2	8
Mandible						1			1		5	1	1				1				10 (4)	7.7	8
Teeth											2										2 (1)	1.5	1
Rib														1				2			3 (1)	2.3	2
Atlas	1																				1 (1)	0.8	1
Vertebrae															o						1 (1)	0.8	1
Scapula										1		2	1								4 (2)	3.1	1
Humerus								1		1	1		1				1				5 (3)	3.8	4
Radius							1				2	4	1						1		9 (4)	6.9	6
Ulna		1			1	2		1	2	1		1	1						1		11 (4)	7.7	6
Metacarpal												1									1 (1)	0.8	1
Pelvis			2								2	5				1	1	2			13 (6)	11.5	10
Femur							1				1										2 (1)	1.5	2
Tibia				1			2	1	4		3	1		1				2			15 (3)	12.3	12
Fibula						1								1							2 (2)	1.5	2
Calcaneus								2	1		4	3	3		1						14 (9)	10.8	14
Astragalus								2			1	1	3								7 (6)	5.4	7
Centrotarsal											1	1									2 (1)	1.5	2
Metatarsal						1						1		1			1	1		2	7 (2)	4.6	7
1st phalanx															1						1 (1)	0.8	1
TOTAL	1	1	2	1	1	3	6	9	8	8	21	23	15	3	3	2	4	7	2	2	122 (9)	100	97

TABLE 4

The hare collection from Cova Fosca expressed as NISPs according to skeletal category and stratigraphical levels. Level codes are as follows: a: -47/-71; b: -77/-89; c: -89/-128; d: -118/-120; e: -120; f: -125/-142; g: -142/-10; h: -150/-170; i: -170/-177; j: -177/-196; k: -196/-211; l: -211/-220; m: -220/-224; n: -255/-262; o: -262/-275; p: -265; q: -279/-298; r: -298/-308; s: -304/-319; t: -365/-388. (MNI and MNE refer to the total NISP).

Period	Middle Neolithic			Early Neolithic			Mesolithic			Epipalaeolithic			TOTAL		
Category	NISP	MNI	MNE	NISP	MNI	MNE	NISP	MNI	MNE	NISP	MNI	MNE	NISP	MNI	MNE
Skull				12	5	8							12	5	8
Mandible				9	4	7	1	1	1				10	5	8
Teeth				2	1	1							2	1	1
Rib							1	1	1	2	1	1	3	2	2
Atlas	1	1	1										1	1	1
Vertebrae							1	1	1				1	1	1
Scapula				4	2	2							4	2	2
Humerus				4	2	3	1	1	1				5	3	4
Radius				8	4	5				1	1	1	9	5	6
Ulna	2	1	1	8	3	4				1	1	1	11	5	6
Metacarpal				1	1	1							1	1	1
Pelvis	2	1	2	7	4	7	2	1	2	2	1	2	13	7	10
Femur				2	1	2							2	1	2
Tibia	1	1	1	11	4	6	1	1	1	2	1	2	15	7	12
Fibula				1	1	1	1	1	1				2	2	2
Calcaneus				13	8	13	1	1	1				14	9	14
Astragalus				7	5	7							7	5	7
Centrotarsal				2	1	2							2	1	2
Metatarsal				2	1	2	2	1	2	3	1	3	7	3	7
1st phalanx							1	1	1				1	7	1
TOTAL	6	1	5	93	8	71	12	1	12	11	1	10	122	11	98

TABLE 5

The hare collection from Cova Fosca expressed in terms of alternative quantifiers per skeletal category and chrono-cultural stage.

fied category (ie., Leporidae indet.). Still, the conclusion one reaches when examining the skeletal spectra from Tables 4 and 5 is one of essentially complete animals reaching the deposit. Explaining the specifics of the assemblage, on the other hand, is far from straightforward.

A feature of these samples is the absence of any trend that could explain skeletal frequencies of elements at large (Tables 4 & 5), and of specific portions in particular (Table 6) on account of their density (Figure 8). Indeed, there only exists a weak positive correlation ($r = 0.27$, $P= 0.0468$, $N= 34$) between percent survivorship of specific parts expressed as the scan sites of Pavao & Stahl (1999), and their corresponding VD_{SA} density values (Appendix C).

A survey of the fragmentation reveals that only 21% of the bones in the sample are complete. Most

of these are tarsals, including all calcanei and astragali. The fracturing is peculiar in that large fragments of the diaphysis from the long limb bones are comparatively rare (i.e., some 20% of that specific group; Table 6) and the articular ends often incorporate significant portions of their diaphyses. Such pattern conveys the impression that many bones were broken along their midshaft. In the case of elements where there is no medullary cavity (eg., ulnae) remarkable also is the presence of crushing and of jagged surfaces along the breakage zone (Figure 9). The impression is that much of this fracturing appears to be disconnected with a processing of the animals reflecting instead a systematic trampling of the bones.

The diversity and frequency of traces in the hare collection is summarized in Table 7 (Figures

PORTION	Humerus	Radius	Ulna	Femur	Tibia	TOTAL
Proximal end	1	5	4	1	2	13
Shaft	-	-	1	1	7	9
Distal end	4	4	5	-	6	19
TOTAL	5	9	10	2	15	41

TABLE 6
Fragmentation of the large appendicular bones.

Mark	Middle Neolithic	Early Neolithic	Mesolithic	Epipalaeolithic	TOTAL
Roots		12	2	7	21 (33%)
Trampling	1		1		2 (3%)
Digestion	1	8			9 (14%)
Burning	1	13	2 (+2 ?)	2	17 (27%)
Gnawing		2	1		3 (5%)
Tooth marks		1			1 (1.5%)
Peelings		7			7 (11%)
Other		1			1 (1.5%)
TOTAL	3 (5%)	44 (70%)	7 (11%)	9 (14%)	68 (100%)
Lagomorph index	2.1	4	9.3	0.3	-

TABLE 7

Summary of traces on the hare bones of the various chrono-cultural stages at Cova Fosca.
For an explanation of the Lagomorphindex see text.
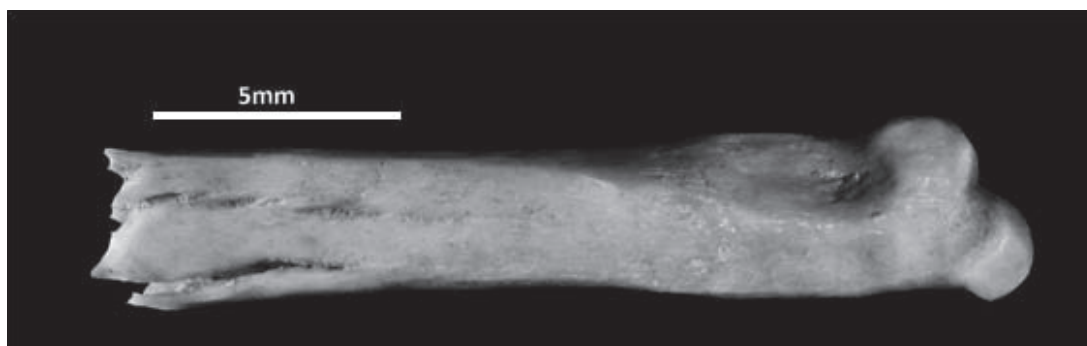
FIGURE 9

Distal portion of an ulna level (-77/-89; Middle Neolithic) with signs of crushing along the broken surface
of the midshaft (Photograph: Carmen Gutiérrez).

9-14). Almost half of the bones exhibit marks of one kind or another, although the total number of 63 cases in Table 7 does not translate into 63 specimens given that some bones exhibit more than one kind of trace (e.g., Figure 10). What seems evident is that, overall, a loose correlation exists between the percentage of recorded traces for a given period and the corresponding percentage of the total hare NISP for that period (e.g., Middle Neolithic 5% of both total hare NISP and number of traces; Early Neolithic: 75% of the NISP & 70% of the traces; Mesolithic: 10% & 11% respectively; Epipalaeolithic: 9% & 14% respectively; see Tables 5 & 7). Such a correlation would suggest a homogeneous «treatment» of remains throughout the sequence, a trend that cannot be statistically confirmed given the small size of the collections. Because of it, it is also impossible to determine whether the absence of certain traces from a parti-

cular period is indeed a feature from that period or simply a result of stochastic processes.

The largest number of traces at Cova Fosca corresponds to root marks. The fact that these have been spotted on close to a third of the bones, and are the most frequent marks in all periods indicates that (1) the place where the bones were deposited must have been illuminated as indeed, was the case of sector C, located at the entrance of the shelter, and also (2) that a good many bones must have been originally lying very close to the surface (i.e., apparently were not intentionally buried). That the entrance of the shelter constitutes the favourite roosting/nesting place for a variety of birds of prey will be a matter of future concern.

The comparatively high frequency of root marks at Cova Fosca stands in stark contrast with any clear traces of human processing marks. Inde-
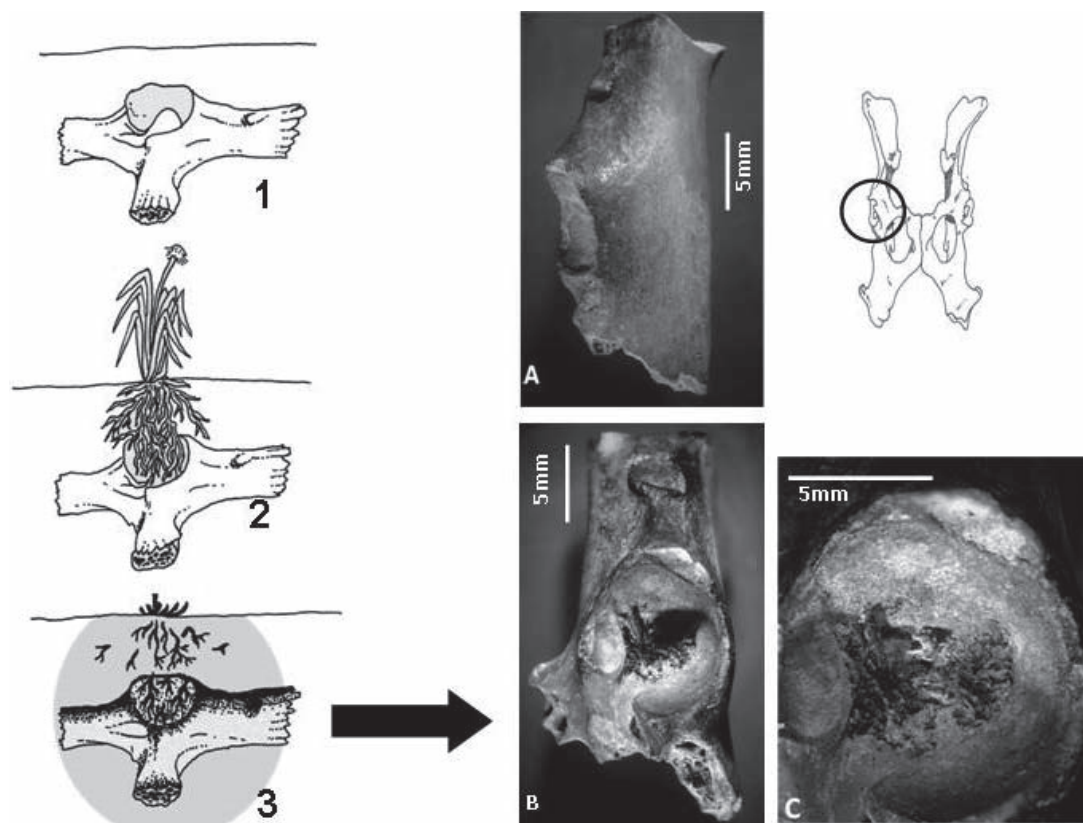
FIGURE 10

Taphonomical scenario to explain the burning of a pelvis from level -211 /-220 (Early Neolithic). 1: Pelvis buried very close to the surface with acetabulum facing upwards. 2: Roots from a plant colonize the acetabulum. 3: Burning of the soil (stippled) leads to a carbonisation of the roots and uppermost zones of the pelvis. A: pelvis seen from the medial side exhibiting a gradation of burning marks. B: view of the acetabulum with remnants of charred roots attached to its surface. C: Close-up from the previous picture (Photographs: Carmen Gutiérrez).

ed, in those few instances where an ocular inspection hinted at the presence of cutmarks, subsequent microscopic analyses either revealed incipient root attacks mimicking incisions (Figure 11), or else scratch marks of undefined origin (i.e., gnaw marks?; Figure 14C). Likewise, the very few putative percussion marks upon ocular inspection failed to reveal any of the typical features of an impact caused by human tools when seen under the microscope (Figures 11B and 13A). In these cases, the scars appear to constitute either removal of tissue by blows delivered by a pointed object (i.e., a beak? a talon?; Figure 13A) or spontaneous flaking of the most superficial layers after the bone laid buried (Figure 11B).

A third category of putative human traces is what we have labelled as peelings in Table 7. These correspond to a removal of bone on the horizontal plane (i.e., by pulling on the soft tissue attached to it) but where the causal agent is unknown. In general, these marks hint at the violent removal of ligaments as is the case of the calcaneis illustrated in Figures 14A & B, carrying with them the most superficial layers of the bone to which such soft tissues were attached. Both birds of prey and mammalian carnivores, in particular cats, are documented to strip bones bare of meat in this way (Domínguez Rodrigo, 1999; Lloveras *et al*., 2007, 2009). The marks left on the bone by these shearing forces range from a most superficial flaking,

FIGURE 11

Rootmarks from a pelvis (A), a tibia (B) and a radius (C) from level -211/-220 (Early Neolithic). Upon ocular inspection these marks convey the impression of cutmarks. In B a scar of yet undefined origin can be seen below the incipient rootmark (Photographs: Carmen Gutiérrez).

FIGURE 12

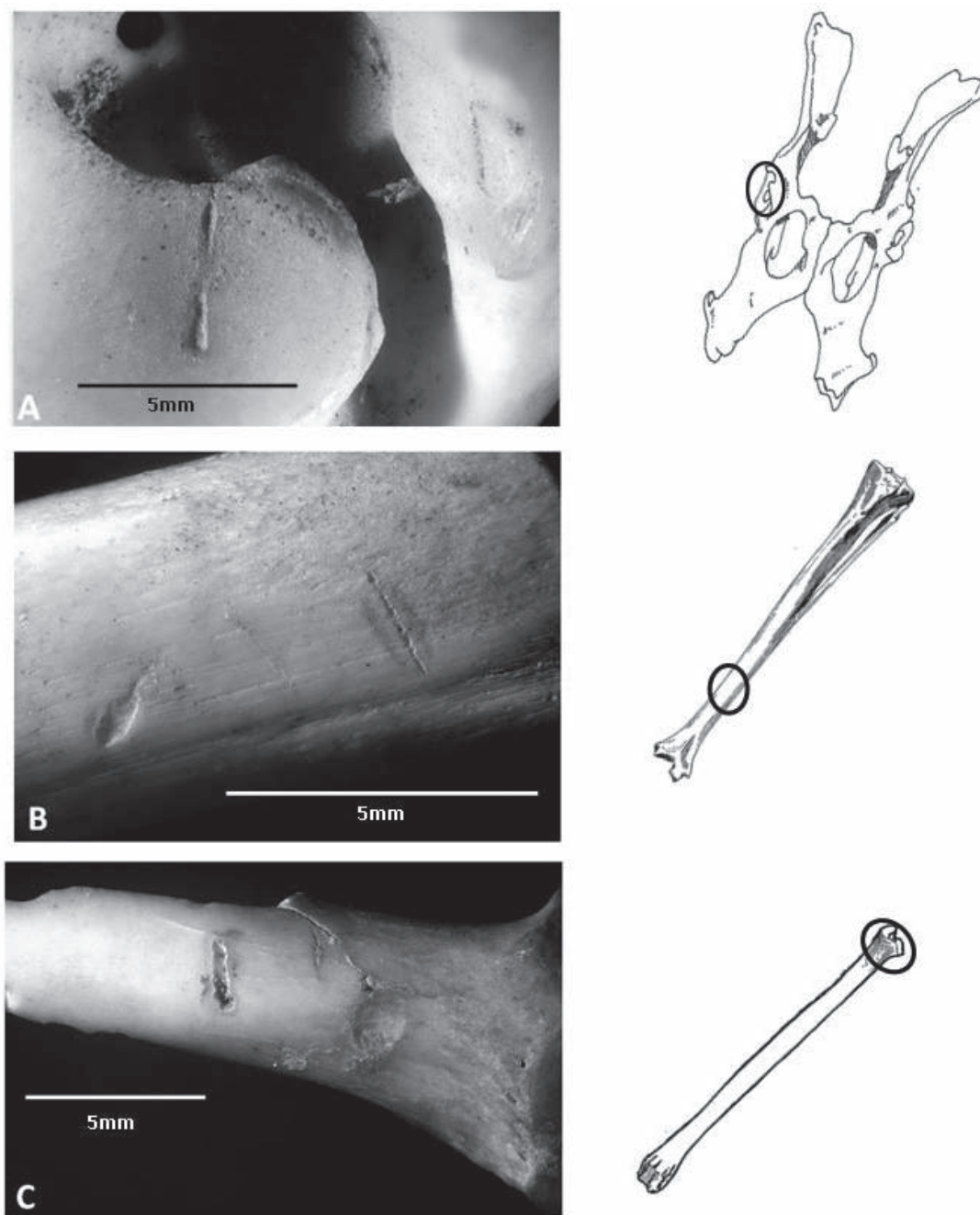Traces of digestion on the proximal portion of a humerus from level -196/-211 (Early Neolithic) (Photograph: Carmen Gutiérrez).

as seen on Figure 14B, to the deeper and stepwise alignment of scars illustrated in Figure 13B. Since we remain unsure about the causal agent(s) producing these and the remaining five similar-looking traces documented from the Early Neolithic (Table 7), we will refer to them as 'pseudo-peelings'.

In contrast with the previous category, gnawing marks, tooth marks and traces of digestion (Figure 12), comparatively frequent in the case of the later, have been quite straightforward to spot. These traces amount to some 20% of those recorded on the hare bones and reinforce the idea that human involvement with the hares at Cova Fosca has been quite restricted, to say the least. Still, in view of the comparatively high frequency of burning marks (i.e., 27% of all the traces; Table 7), the later statement requires some clarification.

Burning marks constitute a varied lot ranging from carbonized remains (8 specimens) to small specks (4 specimens). The absence of calcined bones indicates that temperatures never rose above 1,200ºC, suggesting that burning was caused by 'open' fires (i.e., hearths, not ovens). Both the carbonized specimens and those exhibiting restricted

areas of burning appear to be «disconnected» of any cooking activities. We here propose that carbonized bones became so by remaining in contact with a heat source for a prolonged period once they were stripped of meat (Figure 10). Also, those bones featuring very restricted burnt zones suggest that these were in contact not with the fire proper but with an incandescent surface. Indeed, in these cases all burned zones correspond to areas projecting from a particular face of a bone such as processes, condyles, etc., that one assumes were the first features to contact the substrate once a bone had come to rest on that particular side. Of all the burning marks recorded at Cova Fosca, four specimens (ie., a distal fibula, a shaft from an ulna, a spike on a broken zygomatic arch and an ischiatic process) exhibit a gradation of colour consistent with a burning of varying intensity caused by the distance to the heat source. The burned areas from these bones are difficult to reconcile with an intentional placing of the animals over a fire (eg., the distal fibula and the zygomatic arch were burned after they became detached from the tibia and the skull respectively, a fracturing that appears to be
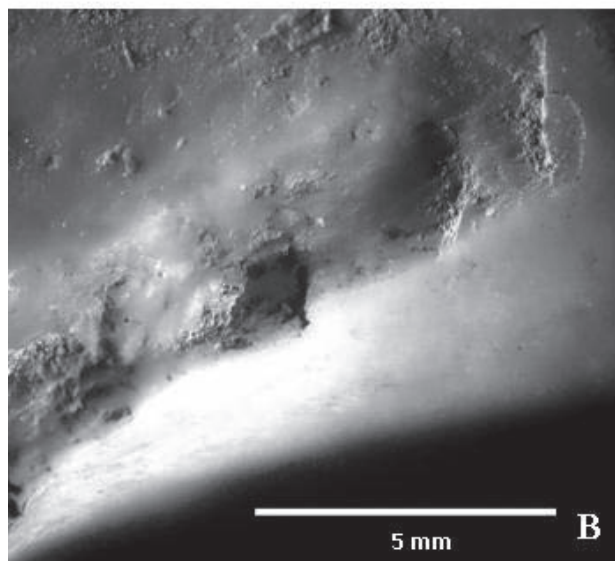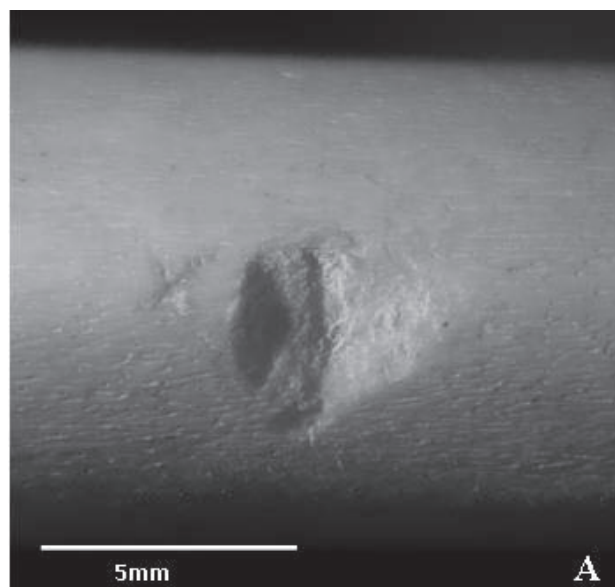
FIGURE 13

Scars on the surface of a tibia (A) from level -211/-220 and a pelvis (B) from level -196/-211 (both Early Neolithic) that might reflect a blow from a beak (A) and a violent stripping of soft tissue to which the most superficial layers of bone were attached (B) (Photographs: Carmen Gutiérrez).

inconsistent with the roasting of a hare over an open fire).

One final piece of evidence that indicates that burning at Cova Fosca appears to have been a «passive» process disconnected with any conscious human activity, is illustrated in Figure 10. In this case, a fragment from a pelvis featuring both a gradation of burning marks and the remnants of a carbonized root glued to its acetabulum indicates that the thermoalteration took place gradually on a buried bone that, lying very close to the surface, had come to function as a flower-pot of sorts.
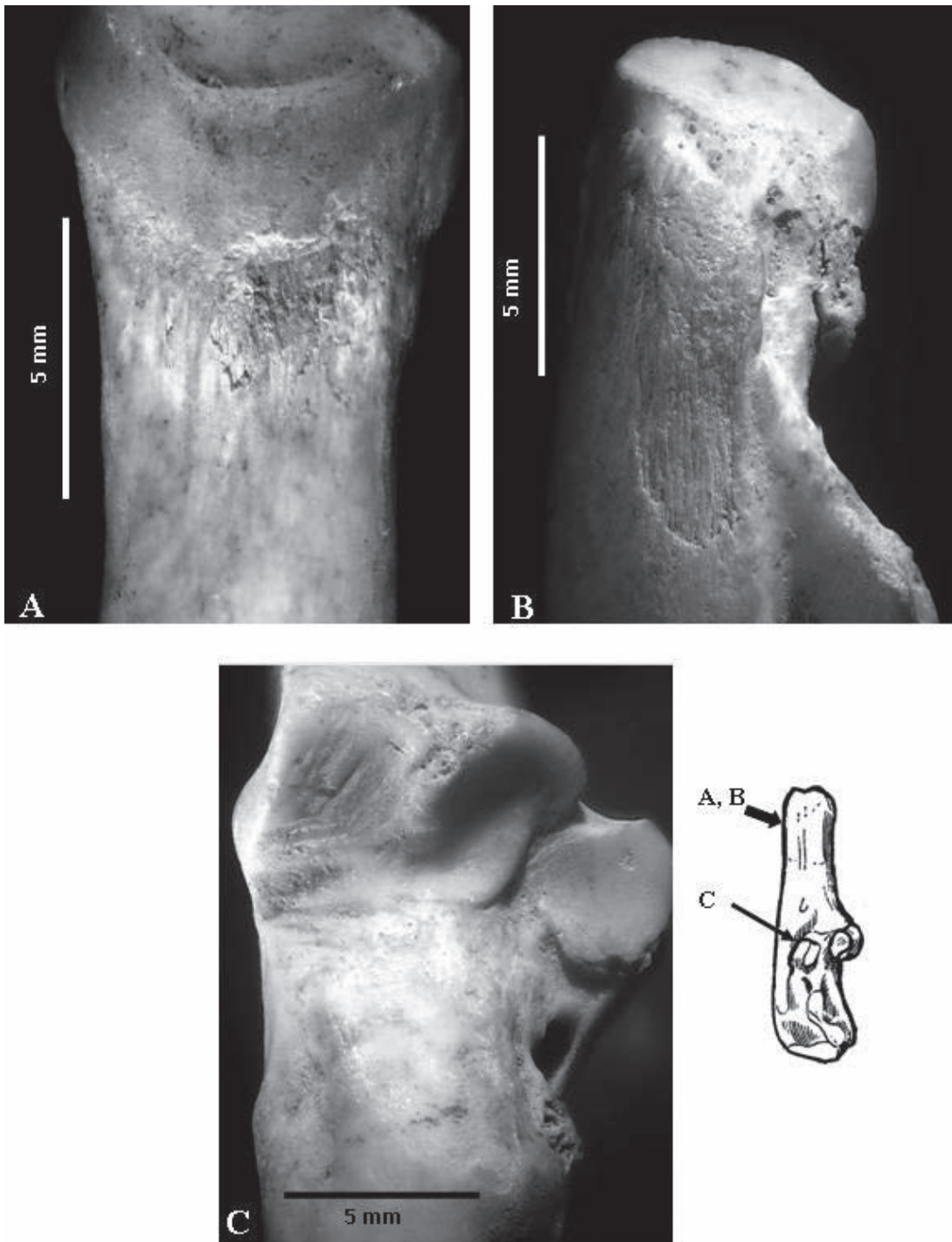
FIGURE 14

Calcanei from Early Neolithic [levels -211/-220 (A) and -220/-224 (B)] exhibiting peelings on the plantar surface of the tuberculum (A) and distal end of the bone (B). C: Scratches on the articular portion of a calcaneus from level -220/-224 of debatable origin (Photographs: Carmen Gutiérrez).

DISCUSSION

Most archaeozoological analyses dealing with leporid remains in the Iberian Peninsula refer, in fact, to rabbits. The use of the term conveys the idea that hares and rabbits constitute a homogeneous group, an apparently sound though perhaps not adequate hypothesis in our case. Indeed, although the size differences between the Iberian hare and the rabbit may not be in excess of 1 Kg, the biology of both species is so different that one should be careful to use one as a proxy of the other. Rabbits are gregarious and not particularly anthropophobic, many of them living quite close to human quarters (Palomo & Gisbert, 2002). Hares, on the other hand, tend to be solitary animals that profoundly dislike human presence. Hunting of each taxon often requires different techniques. These and other differences lie at the base of the Lagomorh index (i.e., the *Lepus*/*Sylvilagus* ratio) developed in the American Southwest two decades ago to set apart hunting close to living quarters from that carried out farther away (Driver & Woiderski, 2008).

From such a perspective, both the values of the Lagomorph indexes and the marginal contributions that hares exhibit in most faunal collections from the Spanish Levant (i.e., often below 1% of the NISP; Table 8) could be taken to indicate that at most of these places, the hunting of leporids took place very close to the living quarters. Although this might well be the case, the variability of the index values within each of the four cultural moments suggests that such an interpretation may be a bit simplistic (Table 8). Also, the comparatively high values of the index in settled communities (e.g., those from the Neolithic period) and the very high values from the pre-Neolithic occupations at Cova dels Blaus (Castellón) (Martínez-Valle, 1996) do not quite match some of the theoretical assumptions in connection with the evolution of mobility patterns, that hypothesize these to be more restricted after the appearance of modern humans in the Spanish Levant, and also after the onset of the Neolithic way of life (Villaverde *et al*., 1996; Aura *et al*., 2002). Clearly, two issues that need to be clarified first concern (1) the origin of the leporid accumulations and (2) the local availability of leporids at the time of occupation.

Concerning the first issue, it seems evident that the reasoning behind the Lagomorph index collapses if some or all of the leporid remains at a site are not the result of human activities. Likewise, unless one has a clear idea of the former proportions of hares *vs*. rabbits at a particular place it would be impossible to translate specific archaeological frequencies into past human behaviour. Although data on prehistoric abundances of leporids are non-existent, other lines of environmental eviden-

PERIOD	SITE	NISP (%)	L.Index	TOTAL
MP	Cova Beneito	1 (0.05%)	0.07	2 (0.3%)
	Cova Negra	1 (0.08%)	1.3	
UP	Els Blaus	122 (13%)	16.5	200 (32.3%)
	Cendres	74 (0.5%)	0.6	
	Cova Beneito	4 (0.7%)	0.07	
EP	Els Blaus	379 (16.5%)	23.6	385 (62.1%)
	Tossal	6 (0.3%)	0.4	
NE	Jovades	7 (1%)	7	33 (5.3%)
	Arenal	3 (1.4%)	3.3	
	Ereta	8 (0.3%)	2.9	
	Cocina	2 (0.1%)	1.3	
	Cova de l'Or	3 (0.2%)	2.4	
	Falguera	3(0.2%)	0.5	
	Cova Sarsa	7 (0.3%)	1.1	

TABLE 8

Hare remains from Iberian levantine sites (MP: Middle Paleolithic; UP: Upper Paleolithic; EP: Epipalaeolithic; NE: Neolithic). Though the scarcity of sites and remains is evident, hares represent a minor taxon during the Middle Paleolithic and decrease during the Neolithic, after exhibiting a slight peak during the Upper Palaeolithic and Epipalaeolithic. L.Index = Lagomorph index [*Lepus* (%NISP)/ *Oryctolagus* (%NISP)X100].

ce have been taken as proxies to explain the frequencies of hares and rabbits in the past. This is the approach taken by Martínez-Valle (1996: 182), who argued the abundance of hares at Cova dels Blaus on account of a local topography (i.e., the coastal plain), more conductive for the abundance of hares than other Levantine sites located on steeper terrain. In our case, the values of the Lagomorph index (Table 7) are meaningless in cultural terms unless one could prove first that both hares and rabbits have been the direct product of human activity. This requires clarifying the origin of the assemblages.

To determine the origin of the leporid assemblages, hares should exhibit less complex taphonomical trajectories than rabbits, a fossorial species long recognized as a source of bioturbation (Meadows, 1991), and a key prey for humans and most of the Iberian predators on account of its demographic output (Jaksic & Soriguer, 1981; Palomo & Gisbert, 2002). This means that, in principle, hares should provide a clearer signal about their origin in a deposit than rabbits. However, from what has been presented in the previous section, the hares from Cova Fosca do not seem to fit this picture. For one thing, these assemblages do not exhibit clear signatures of any single agent being responsible for the accumulations. Instead, the data presented suggest that several agents played a role in the process, and surprisingly, that man was probably not on this list (Andrews & Evans, 1983; Andrews, 1990; Hockett, 1991).

When one considers that people are easy to detect on account of the extremely diagnostic signatures they leave on the bones, and also that the Cova Fosca collections point to human beings as primary accumulators for a significant fraction of the fauna (Llorente, 2007), both the absence of cutmarks and percussions seem baffling. Also peculiar is the fact that burning appears to be largely disconnected of any systematic processing of the hares on the part of humans (Figure 10).

At Cova Fosca, the indicators that humans were the accumulators of the hare remains are in all cases circumstantial, and only hinted at when samples representing a temporal interval of some 5,000 years are pooled together. These indicators include:

1. Age structure. Close to 98% of the sample (i.e., 119 remains) derive from adult individuals. Such value stands well above the 85%

«threshold» that some authors (eg., Cochard, 2004; Cochard & Brugal, 2004) cite as indicative of leporid accumulations produced by humans. But (1) those values refer to rabbits (a less precocious species), (2) non-adult specimens (i.e., un-fused portions) are more likely to disappear in the case of the smaller sized rabbit, and (3) fusion in the leporid's skeleton is essentially completed in the first half year of life thus, on strictly probabilistic grounds, one always stands far lower chances of retrieving un-fused elements than elements where fusion has been completed, whether the predator hunts more adults or not.

Along with our small samples, these constraints combine to prevent one from considering humans as the accumulating agent of hares at Cova Fosca on the sole basis of the percentage that adults represent in the assemblage.

2. Fragmentation. Close to 80% of fragmentation (98% in the case of the long limb bones), at Fosca lies well above that of carnivore scats, the samples with the highest reported levels of fragmentation (Schmitt & Juell, 1994; Lloveras *et al.*, 2008). What this seems to indicate is that there existed a combined action of several agents of fragmentation that would include, in addition to attrition by the accumulating agent(s) proper, trampling and post-depositional diagenesis (Table 7). Specifically, in terms of bone portions, one feature of the samples that does not fit with the behaviour of humans is the comparatively low frequency of long bone cylinders (ie., 23%; Table 7), whose abundance in archaeological assemblages has been associated with a fracturing aimed at narrow procurement (Aura *et al.*, 2002). As was previously commented, such pattern combined with many of the epiphyseal portions incorporating large fractions of their diaphyses, a feature attributed to trampling. The human signature thus appears to be due to non-intentional activity.

3. Skeletal representativity. The pattern of highest abundances recorded, in sequential order, for the tibia, pelvis and calcaneus, followed by the skull, mandible, ulna and radius (Tables 4 and 5), appears to be loosely coincident with the spectra provided for rabbit accumulations produced by humans (eg.,

Brugal, 2006). Still, in those models, scapulae are also frequent –not so in our case-, and more importantly, femora. As can be seen in Table 4, femora exhibit a remarkably low frequency, a fact that appears all the more baffling in view of the comparatively high frequencies of the remaining hindlimb elements, from the zonal skeleton (pelvis) to the autopodium (ie., metatarsi). Such a low frequency of femora suggests, as was mentioned for the fragmentation of remains at large, the combined destructive action of several agents in addition to those responsible for the accumulation proper. In fact, if trampling was a significant process at Fosca, the low frequencies of femora, and the absence of their fragile dyaphyses, may constitute yet another indication of this activity. This fact notwithstanding, could the different frequencies simply reflect a size-related phenomenon?

In order to test whether the skeletal profiles of the Cova Fosca hares matched those from a hare assemblage hunted by humans, we compared them with those from Cova dels Blaus, the only site from the Spanish Levant where large hare assemblages have been found (Table 8). Els Blaus collections are relevant because both the abundance of cut-

marks and the standardized breakage patterns identify them as anthropic deposits (Martínez-Valle, 1996: 177). When both data sets are plotted, and despite some minor coincidences (eg., vertebrae, ulnae, metacarpal and phalanxes), quite significant differences appear, not least those of the cranial elements that at Fosca are more similar to values produced by carnivore accumulations (Figure 15). Interesting also is the fact that the two most noticeable differences between Els Blaus and Fosca (eg., the lower frequencies of the scapula and femora in the later) coincide with those reported for the rabbit assemblages (Brugal, 2006). This suggests that (1) the skeletal profiles of hunted leporids may not change much due to size differences, and (2) that the Cova Fosca hares would not conform in principle with a skeletal spectrum from a population hunted by man.

4. Specific co-variation with alternative faunal groups. A final line of enquiry to reveal whether the hares represent a hunted assemblage has been to compare hare abundances, on a per level basis, with those from faunal groups whose taphonomic origin is more or less clear (Table 9). In this way, several lines

Level	Hare	Rabbit	Birds	Rodentia	Wild goat	Red deer	Pulmonata	Chiroptera	TOTAL ID
-47/-71	0,6	11,5	-	0.6	1,1	1,7	0,6	-	173
-77/-89	1	17,6	-	1	2	1	-	-	102
-89/-128	0,1	9	0,3	-	0,3	1,7	0,1	-	722
-118/-120	0,4	18,8	0,4	0.4	8	6,6	0,4	-	244
-120	0,5	11	1,3	-	2,4	6,9	0,5	-	378
-125/-142	0,3	18,4	0,9	1.3	5	5,1	-	-	1016
-142/-150	0,7	20,7	1,1	2.7	0,8	1,7	2	-	814
-150/-170	0,5	17,7	0,4	1.1	5,7	3,5	3,3	0.1	1643
-170/-177	0,7	24,8	0,08	1.8	7,3	6	0,5	-	1120
-177/-196	0,3	14,7	0,6	2.7	13,5	11	1	-	2282
-196/-211	1	17,4	1,6	2.6	25	7,5	-	-	2093
-211/-220	1	16,7	1,25	2	26,9	8,5	0,6	-	2158
-220/-224	1	14,5	2,2	6.9	24,9	4	1	0.06	1542
-255/-262	0,5	8,2	4,4	24.8	12,8	9,6	36,9	0.2	544
-262/-275	1,4	7,7	1	-	19,9	37,4	-	-	206
-265	4	8	-	-	42,8	8,2	2	-	49
-279/-298	1,7	20,3	13,8	47.1	22,5	9,5	2,1	0.4	231
-298/-308	0,5	12,5	7	58.1	2,2	1,6	7,8	2.35	1401
-365/-388	0,1	68	3,7	8.7	7,9	3,7	0,09	-	1086

TABLE 9

Frequencies, expressed as percentages of the NISP, from selected faunal groups in levels where hare remains have been found.
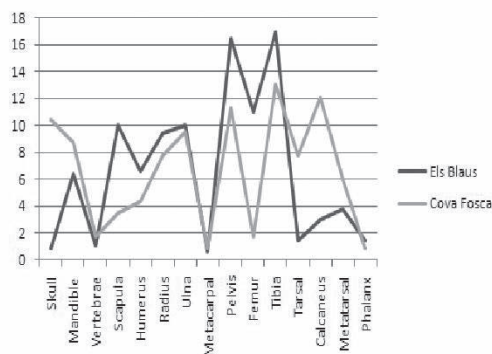
FIGURE 15

Absolute abundances of selected skeletal elements, expressed as NISPs, of hares from Cova dels Blaus and Cova Fosca.

of evidence indicate that micro-pulmonates constitute elements of the local biocenoses that reached the deposits on their own (Francisco, 2009). In contrast, both birds (passeriforms for the most part) (A. Sánchez-Marco, verb. com.) and rodents represent items hunted by raptors, whereas wild goat (*Capra pyrenaica*, Schinz 1838) and red deer (*Cervus elaphus*, Linnaeus 1758) were hunted by humans (Llorente, 2007). Taphonomically speaking, rabbits are the most heterogeneous group at Cova Fosca, incorporating penecontemporaneous intrussives (eg., newborns), as well as individuals preyed upon by humans and animals. When correlation analyses of abundances were carried out for pairs, not surprisingly, the highest values corresponded to the two groups with the presumably more homogeneous and similar taphonomic histories (ie., birds and rodents; r= 0.8808). Correlations were far lower in the case of the two ungulates (r = 0.3846), probably because their abundances not only reflect changes through time in the biotopes around the site but also different zones or times of the year when their hunting took place. This same weak positive correlation appears when birds and pulmonates and rodents and pulmonates are confronted (r = 0.2569 and $\neq$ 0.3929, respectively), presumably indicating a loose association of faunas (ie., birds of prey and molluscs) more likely to appear when people were not occupying the shelter. Finally, rabbits exhibit a weak but negative correlation with both wild

goat (r = -0,1512) and red deer (r = -0.2237), reinforcing the idea of their presumably heterogeneous taphonomic trajectories not always linked to human activity.

Provided with this background, it is revealing to note that hares exhibit essentially no correlation with the faunas presumably taken by birds of prey, be these rodents (r = 0.0057) or other birds (r = 0.0754). A negative correlation with rabbits (r = -02806) and micro-pulmonates (r = -0.0801), and a high positive correlation with the wild goat (r = 0.7903) which decreases in the case of red deer (r = 0.2532) is also noteworthy. Although these data will need to be refined by incorporating all archaeological levels, not just those where hares have been found, the overall impression is that hares covary with the hunted taxa. This is the only instance lending support to the idea that some of these hares could represent accumulations caused by intentional human activity.

As stated, at Cova Fosca the evidences for the direct involvement of agents other than humans are scarce though far clearer. A bite mark on the medial side of the iliac wing of the innominate from level -211/ -220, for example, coincides with the three major cusps of an upper fourth premolar from a medium-sized mustelid (pine marten?). One trace does not reveal the role played by the carnivore in the accumulation of the hare bones, not the least because no medium-sized mustelid has been ever recorded as a regular predator of the Iberian hare (Barea & Ballesteros, 1999). Perhaps, the animal got access to the bone after it had been deposited on the floor of the shelter. Another more circumstantial sign of carnivore activity –in this case of the Iberian lynx- could be invoked on the basis of the comparatively higher survival of hindlimb elements (49% of the hare NISP) versus the forelimb elements (22%; Table 4), and the comparatively high frequency of cranial portions (i.e., 18%) (Lloveras *et al*., 2008). But these lines of evidence are only valid in case other agents had not masked the skeletal frequencies originally generated by the carnivores, which is unlikely to have been the case. Had carnivores been routinely involved in the generation of the hare assemblages, traces of digestion, in particular moderate to high corrosion, would have been evident on a relatively large proportion of the remains.

Hare bones with traces of digestion amount to 7% of the total assemblage and are only present in the Middle Neolithic (12,5% of the NISP) and

Early Neolithic (8.6% of the NISP). These frequencies are low even for carnivore deposits comprising a mixture of ingested and non-ingested remains (Schmitt & Juell, 1994; Pavao & Stahl, 1999). The moderate levels of corrosion recorded (e.g., Figure 12) can be attributable to a variety of predators more probably avian than mammalian. In order to address this issue one needs to contrast these data with other lines of evidence. In this context, both the «pseudo-peelings» (Figures 13B & 14A, B), and the systematic damage recorded on the olecranon process on the ulnae appear more consistent with the defleshing activities of an avian predator, in particular the Eagle owl, the only nocturnal raptor known to hunt hares on a regular basis (Lloveras *et al*., 2009). Given that the signatures of any accumulating agent would have been diluted in the case of such restricted samples, truly diagnostic traces should never be dismissed as irrelevant, less so in this case where the activity of nocturnal raptors has been clearly evidenced in

the assemblages of both birds and micromammals (C. Sesé, A. Sánchez, both pers. comm.).

Other agent(s) that could have played a role in shaping the hare assemblages at Fosca are the animals that gnawed some of the bones. Again, gnawing is a marginal kind of trace, amounting to barely 2.5% of the identified sample and, again, the agents producing these traces have not been identified, and perhaps they even did not play a role as bone accumulators. Their presence, nevertheless, stresses the need to consider the hare assemblages at Cova Fosca as yet another case of a cave deposit palimpsest (Davis *et al.,* 2007) (Figure 16).

CONCLUSIONS

Though our study has proved successful mainly at the taxonomic level, evidencing the existence of only one species of hare at Cova Fosca, one result of the taphonomical analysis presented is the
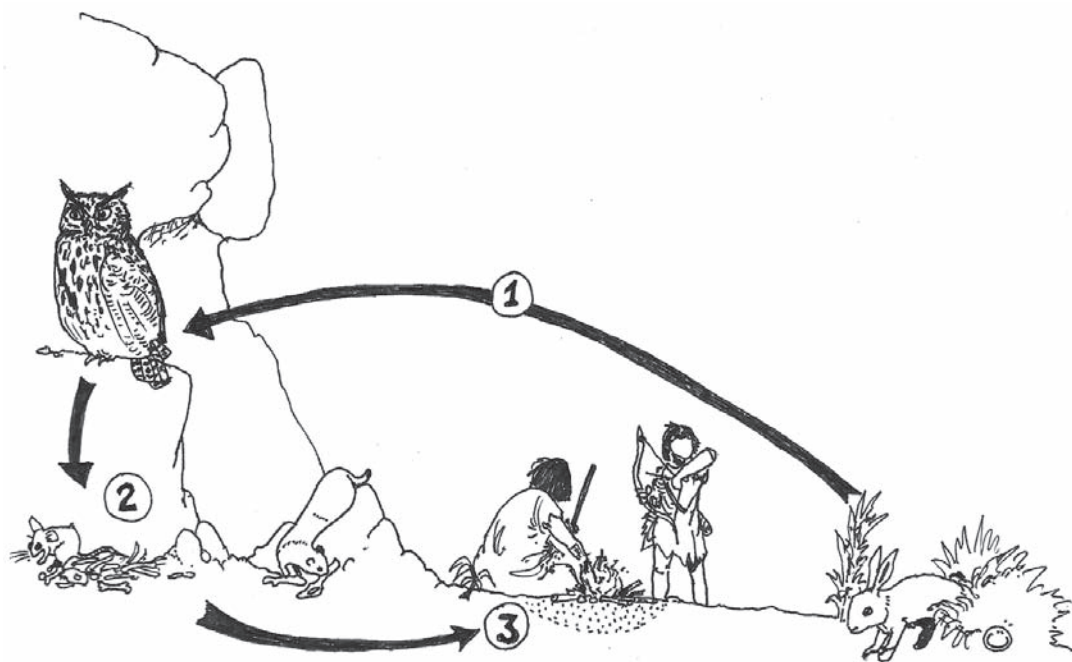
FIGURE 16

A possible scenario for the hare remains at Cova Fosca. (1) Though traces are scarce, the most diagnostic marks on the hare bones suggest that these animals were hunted by an avian predator, most probably the Eagle owl. (2) The regurgitated remains and leftovers from the hare carcasses were dispersed on the floor of the rockshelter and exhibit the attack of different agents as indicated by occasional gnawing marks, toothmarks and evidences of trampling and possibly passive burning. (3) After burial, additional burning might have taken place when bones lying close to the surface were located below a hearth. Also, rootmarks were produced after burial. As the evidence presented in the text suggests, direct human involvement might have been scarce or nil. (Drawing: Arturo Morales).

absence of any clear traces of humans being directly involved in the accumulation of the hare remains. Evidences for human involvement are either indirect or else circumstantial despite the fact that diagnostic features for the involvement of alternative agents (eg., birds of prey, carnivores and possibly rodents or even leporids), although scarce, seem beyond question. When combined, these evidences point to the Eagle owl as the main accumulator of hare remains at Fosca. Given that since the Upper Palaeolithic leporid remains from archaeological sites have been taken to represent hunted items, and their rising numbers an indication of a shift towards higher residential times and lower mobility patterns as soon as modern humans reach the Spanish Levant, the findings of the Cova Fosca hare assemblages semm to represent a peculiar exception to the rule.

Moreover, it appears that the taphonomically non-anthropogenic and quite heterogeneous nature of the hare deposits might not be specifically restricted to this species but reflects instead a more prevalent feature of the leporid remains from Cova Fosca. Indeed, as of this writing, it seems that only a small percentage among the thousands of rabbit remains exhibit those cutmarks and stereotyped fracturing so typical of assemblages produced by human activity (Morales & Llorente, in preparation). Whether such feature may eventually reveal a completely different way to process leporids in the uplands of the Maestrazgo should obviously figure as a priority on the research agenda. Until that confirmation arrives, the data presented in this paper indicate that hares join a large sector of the fauna from Cova Fosca whose presence appears to be disconnected with the recurrent human occupation of the shelter during prehistoric times.

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APPENDIX A. ISOLATED MEASUREMENTS FROM IBERIAN HARES

List of measurements of recent hares from the collections housed at the L.A.Z.-U.A.M. (Madrid, Spain), CIPA (Lisboa, Portugal) and Museo Bocage (Lisboa, Portugal).

SCAPULA

Reference	Lep gra 1		Lep gra 3		Lep gra 5		1455		381	83.02.02	2194	1985-39
D/S	D	S	D	S	D	S	D	S	-	-	-	-
HS	70.4	68.3	68	68.4	76.5	76.4	72.5	71	-	-	-	-
SLC	6.2	6.3	5.8	5.6	6	6	5.3	5.2	5	6.2	5.8	5.8
GLP	14.2	13.8	12.6	13	14	13.7	12.7	13	-	-	-	-
LG	9	8.9	8.7	8.8	9.3	9.3	8.6	8.8	-	-	-	-
Sex	♂		-		♀		♂		-	-	-	-

HUMERUS

Reference	Lep gra 1		Lep gra 3		Lep gra5		1454		381	83.02.02	2194	1985-39
D/S	D	S	D	S	D	S	D	S	-	-	-	-
GL	82.5	82.4	79.6	79.8	91.6	91.7	86	85.7	-	-	-	-
BP	14.8	14.7	14.5	14.6	15.2	15.5	14.2	14.6	-	-	-	-
SD	4.6	4.4	4.3	4.2	5.2	5.2	4.2	4.2	-	-	-	-
BD	10	9.7	9.8	9.7	10.4	10	10.5	10.5	9.6	10.5	10.7	9.8
HTC	5.1	5.4	5.1	5.1	5.2	5.5	5.1	5.1	4.7	5.3	5.5	5.2
Sex	♂		-		♀		♂		-	-	-	-

RADIUS (* Specimen with fused ulna)

Reference	Lep gra 1		Lep gra 3*		Lep gra 5		1455	
D/S	D	S	D	S	D	S	D	S
GL	93.8	93.7	(87.6)	(87.8)	101.2	101.3	88	88.2
BP	7.6	7.6	(7.3)	(7.4)	7.4	7.6	8.2	7.8
SD	4.4	4.3	3.8	3.9	4	4	3.8	4.1
BD	8	8	(8.3)	(8.2)	8.8	8.9	8.1	8.4
Sex	♂		-		♀		♂	

ULNA

Reference	Lep gra 1		Lep gra 3		Lg5		1455	
D/S	D	S	D	S	D	S	D	S
GL	105.6	106.3	101.3	101.3	114.5	115	99.6	99.8
BPC	6.8	6.8	(66)	(6.2)	7.5	7.4	7.3	7.3
DPA	9.2	9.1	9	8.9	9.8	9.6	9.6	9.5
SDO	9.4	9.3	8.9	8.6	10.2	10	9.5	9.5
α/ β	2.5	2.8			2.8	2.9	3	2.9
Sex	♂		-		♀		♂	

FEMUR

Reference	Lep gra 1		Lep gra 3		Lep gra 5		1455	
D/S	D	S	D	S	D	S	D	S
GL	104.6	104	99.9	99.6	112.5	112.6	102	102.8
BP	21	21.3	21.4	21.7	22.9	22.9	22	21.3
BTR	24.6	25	24.9	24.1	26.2	26.2	25	25.7
SD	7.5	7.6	7	7.2	8.5	8.4	7.3	7
BD	15.9	15.8	16	15.7	16.8	16.9	16	16
DD	17.3	14.5	14.8	14.2	14.8	14.8	13.7	13.8
Sex	♂		-		♀		♂	

TIBIA

Reference	Lep gra 1		Lep gra 3	Lep gra 5		1455		381	83.02.02	2194	1985-39
D/S	D	S	D	D	S	D	S	-	-	-	-
GL	120	120.2	113.2	127.3	127.2	115.5	115.4	-	-	-	-
BP	16.5	16.1	16.2	16.8	16.7	16.5	16.1	-	-	-	-
SD	6	6.1	5.6	6.6	6.6	4.8	5.1	-	-	-	-
BD	12.8	12.9	12.1	13.5	13.6	13	13	12.2	13.7	13.7	12.9
BDA	10.7	10.7	11.9	11.4	11.2	10.3	10.7	-	-	-	-
Sex	♂		-	♀		♂		-	-	-	-

CALCANEUS

Reference	Lg 1		Lg3	Lg3	Lg5	Lg5	1455	1455	381	83.02.02	2194	1985-39
D/S	D	S	D	S	D	S	D	S	-	-	-	-
GL	28	27.7	26.2	-	28.6	27.8	28.1	28.2	26.3	28.1	30.3	27.6
BD	10.3	10.7	10.5	-	11.1	11	19.8	10.2	-	-	-	-
Sex	♂		-		♀		♂		-	-	-	-

ASTRAGALUS

Reference	Lg1		Lg3		Lg5		Lg1455		381	83.02.02	2194	1985-39
D/S	D	S	D	S	D	S	D	S	-	-	-	-
GL	13	12.8	13.3	-	14.2	14.3	13.8	13.3	13.2	14.2	14.5	13.6
DP	6.1	6.7	7.6	-	6.7	6.7	6.7	6.6	-	-	-	-
BD	6.3	6.6	6.7	-	7	6.8	6.7	6.7	-	-	-	-
Sex	♂		-		♀		♂		-	-	-	-

APPENDIX B: ISOLATED MEASUREMENTS FROM EUROPEAN HARES

List of measurements of recent brown hares from the collections housed at the L.A.Z.-U.A.M., the Zoologisk Museum of Copenhagen, the Musèum National d'Histoire Naturelle and the collection of Armelle Gardeisen.

SCAPULA

Reference	Lep eur 1	CN 1431 D	CN 1431 S	CN 1878 D	CN 1878 S	CN 1897 D	CN 1897 S	CN 1880 D	CN 1880 S	CN 3766 D	CN 3766 S	CN 4427 D	CN 4427 S	CN 4472 D	CN 4472 S	CN 9138 D	CN 9138 S	1992-1640	1992-1277	1992-1480	1992-1639	1992-2033	1992-2957
D/S	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S						
HS	84	86	87	87.5	87.5	93.5	92.5	91.8	91.5	86	87	87	87.5	90	90	-	86	72	68	69	69	67	73
SLC	7.4	8	7.5	8	8	8	8	8	8.3	8	8	8	8	7.5	7.5	-	8						
GLP	15	16	16	14	14	14	14	14	13.8	16	15	16	17	16	17	-	15						
LG	10.4	11.5	11.5	11.5	11.5	11.5	11.5	12	12	11	11	11.5	11.5	12	12	-	11.5						
Sex	♂	♂		♂		♀		♀		♀		♀		♂		-		♀	-	♂	♂	-	♂

HUMERUS

Reference	Lep eur 1	CN 1431 D	CN 1431 S	CN 1878 D	CN 1878 S	CN 1897 D	CN 1897 S	CN 1880 D	CN 1880 S	CN 3766 D	CN 3766 S	CN 4427 D	CN 4427 S	CN 4472 D	CN 4472 S	CN 9138 D	CN 9138 S	1992-1640	1992-1277	1992-1480	1992-1639	1992-2033	1992-2957	Lepus "1"
D/S	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	S	S					
GL	102.4	104.5	104.5	108	107.5	-	110	112.5	-	102.5	102.5	102.5	103	109	109.5	102.5	103							
BP	16.6	17	19	18.5	18.5	18	18	18	18.5	17.5	16.5	17.5	18	18.5	18	17.5	18							
SD	5	6	6	7	7	7.5	7	7.5	7.5	6	6	6	6	7	6	6	7							
BD	14.3	13	13	13	13	-	13	13	13	12	12	12	12.5	14	13.5	12	12	11.5	11.5	11.3	11.6	11.6	12.6	11.5
HTC	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.9	5.8	6.1	6.5	6.1	6.4	6.1
Sex	♂	♂		♂		♀		♀		♀		♀		♂		?		♀	-	♂	♂	-	♂	-

RADIUS (* Specimens with fused ulna)

Reference	Lep eur 1*	CN 1431		CN 1878		CN 1897		CN 1880		CN 3766		CN 4427		CN 9138	
D/S	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S
GL	(109.5)	110.5	111	120.5	-	124	122.5	-	120.5	113.5	114	115.5	115.5	109.5	109.5
BP	(9.6)	10	10	9	9.5	10	9.5	9.5	10	9	9	9	9.5	9.5	9.5
SD	4.5	5	5.5	6	6	5.5	5	5.5	5.5	5	5	5.5	5.5	5.5	5.5
BD	(10)	11	11	12.5	-	11	11	-	12.2	10	10.5	10.5	10	10	9.5
Sex	♂	♂		♂		♀		♀		♀		♀		?	

ULNA

Reference	Lep eur 1	Le 2		CN 1431		CN 1897		CN 1880		CN 3766		CN 4427		CN 9138	
D/S	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S
GL	126.3			128.5	129	141.5	-	-	-	128.5	129	133	133.5	124	124.5
BPC	((7.8))			9.5	9	9.5	-	9.5	9.5	8.5	8.5	9	9	8.5	9
DPA	11			13	12.5	12.5	-	12.5	12.5	11.5	11.5	12	12.5	12	12.5
SDO	11.6			12.5	12.5	12.5	-	12.5	12.5	12	11.5	12	12.5	12	11.5
α/β	-	2.1	2.1	-	-	-	-	-	-	-	-	-	-	-	-
Sex	♂			♂		♀		♀		♀		♀		?	

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FEMUR

Reference	Lep eur 1	CN 1431		CN 1878		CN 1897		CN 1880		CN 3766		CN 4427		CN 4472		CN 9124		CN 9138	
D/S	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S
GL	127.8	-	134	142	-	142.5	-	146	-	129	128	132.5	132	136.5	-	-	129	126.5	126.5
BP	26																		
BTR	29	30.5	30.5	27.5	28	32.5	32	31	30	29.5	29	30.5	30.5	31.5	31.5	30	30	31.5	31
SD	8.4	9	9.5	10.5	11	10.5	10.8	10.5	-	9	9.5	10.5	10	10	-	9.5	9.5	10.5	10.5
BD	19.6	22	22	21.5	22.5	21	21	20.5	21.5	19	19.5	21	21	21.5	21.5	20	20	21	21
DD	17.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sex	♂	♂		♂		♀		♀		♀		♀		♂		?		?	

TIBIA

Reference	Lep eur 1	CN 1431		CN 1878		CN 1897		CN 1880		CN 3766		CN 4427		CN ?		CN 9138		1992-1640	1992-1480	1992-1639	1992-2033	1992-2957	Lepus "1"
D/S	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S						
GL	146.5	148.5	148	-	-	160	-	-	-	146	146	149	148.5	149	-	144.5	144						
BP	19.6	21.5	21.5	22	21.5	21	21.5	21	21.5	20.5	20	21	21	20	21	20	21						
SD	6.6	8	8	-	-	7.5	8	8	-	7.5	7.5	8	7	8	8	8	8						
BD	15.4	17	17	16.5	16	16	16	17.5	-	16	16	17	16.5	16	16	16.5	17	15.8	14.6	15.5	14.7	16	14.2
BDA	13.2	-		-		-		-		-		-		-		-							
Sex	♂	♂		♂		♀		♀		♀		♀		?		?		♀	♀	♀	-	♂	-

CALCANEUS

Reference	Lep eur 1	CN 1878		CN 1897		CN 3766		CN 9138		1992-1640	1992-1277	1992-1480	1992-1639	1992-2957
D/S	S	D	S	D	S	D	S	D	S					
GL	31.7	-	37	-	37	33	33	34.5	-	31.2	30.6	31.6	33.5	35.1
BD	12.1	-	13.5	-	13.5	12.5	12.5	14.5	-					
Sex	♂	♂		♀		♀		?		♀	-	♂	♂	♂

ASTRAGALUS

Reference	Lep eur 1	CN 1878		CN 1897		CN 9138		1992-1640	1992-1277	1992-1480	1992-1639	1992-2033	1992-2957
D/S	S	D	S	D	S	D	S						
GL	15.8	-	18	-	17	18	-	15.3	15.3	15.3	16.5	15.8	16.5
DP	8.2	-	-	-	-	-	-						
BD	8.2	-	-	-	-	-	-						
Sex	♂	♂		♀		?		♀	-	♂	♂	-	♂

APPENDIX C: ISOLATED MEASUREMENTS OF HARE REMAINS FROM COVA FOSCA

SCAPULA

D/S	D	S	D
HS			10.7
LG	6.6	6.5	
UE	211/220	211/220	220/224

HUMERUS

D/S	D	D	D	D
BP		(14.2)		
BD	(10.3)		10.3	(9.7)
HTC	(5.3)		5.6	(4.7)
UE	177/196	196/211	220/224	279/298

RADIUS

D/S	D	D	D	D	S	D	S
BP	7.8	8.2	8			7.7	7.9
BD				9.2	9		
UE	196/211	196/211	211/220	211/220	211/220	211/220	220/224

ULNA

D/S	D	S	D	S
BPC	6.6	7.6	7.6	(6.8)
UE	143/150	150/170	177/196	211/220

PELVIS

D/S	D	S	D	S	S	S	S	D	D	S
LA	10.8	9.7	(10.5)	10.6	(11)	(10.2)	(11.7)	11.8	(10.2)	9.8
LAR	8.9	8.4	10	9.8	(10.5)	(9.2)	(10.4)	11	(9.3)	9.5
UE	196/211	196/211	211/220	211/220	211/220	211/220	265	279/298	298/308	298/308

FEMUR

D/S	S
DC	(8.2)
UE	196/211

TIBIA

D/S	D	S	S	D	D	D	S	D	D
BP		16					17.8	18.4	
BD	11.8		12.8	13.5	14.2	13.6			13.8
GD				8.2	8.4	7.8			(8)
UE	120	89/128	150/170	177/196	177/196	177/196	177/196	211/220	220/224

ASTRAGALUS

D/S	D	S	S	D	S	S	S
GL	13.4	14.4	14.6	14.2	14.8	13.8	14.7
BD	6.3	7.5	7.5	7.1	6.8	7.4	6.9
UE	15/170	150/170	196/211	211/220	220/224	220/224	220/224

CALCANEUS

D/S	D	S	D	D	D	S	D	D	D	D	S	S	D
GL	(29.5)	29.9	(29.3)	(30.1)	(29.6)	(30.6)	29.7	28.3	(29.8)	30.3	30.2	(28.9)	30.1
BD	(11.2)	11.2	(10.5)	(10.2)	(11)	(11.4)	10.7	10	(9.8)	10.6	10.7	(11)	10.4
UE	170/177	170/177	196/211	196/211	196/211	196/211	211/220	211/220	211/220	211/220	220/224	220/224	262/275

METATARSAL

D/S	S	D
GL	45	
BP	4.5	5.61
SD	3.1	
BD	4.6	
Number	IV	II
UE	125/142	255/262

FIRST PHALANX

GL	(21.4)
BP	(5.7)
SD	(3.4)
BD	(4.9)
UE	262/275

APPENDIX D: SCAN SITE FREQUENCIES

(A= 2.7316; B= 4.6858; R= 0.2711)

SCAN SITE	VD_{SA}	NISP
DN1	0.51	6
DN2	0.7	8
DN3	0.3	4
DN4	0.21	1
DN5	0.12	1
AC1	0.43	11
IL2	0.29	9
IS2	0.28	7
SP1	0.23	3
HU1	0.49	1
HU3	0.24	1
HU4	0.23	1
HU5	0.37	3
RA1	0.2	4
RA2	0.11	3
RA3	0.13	2
RA4	0.09	3
RA5	0.12	3

SCAN SITE	VD_{SA}	NISP
UL2	0.14	4
UL3	0.02	5
UL4	0.06	5
FE1	0.28	1
FE4	0.25	1
TI1	0.63	1
TI2	0.32	3
TI3	0.25	7
TI4	0.21	2
TI5	0.43	5
MT1	0.17	3
MT1	0.1	4
MT3	0.15	1
CA1	0.3	8
CA2	0.4	7
AS1	0.23	7