



# Recurrent Magdalenian occupation in the interior of the Iberian Peninsula: new insights from the archaeological site of La Peña de Estebanvela (Segovia, Spain)

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## Abstract

The occupation of the Iberian Peninsula during the Upper Palaeolithic is mainly known from archaeological sites located in the Cantabrian and Mediterranean regions. Numerous sites have been excavated in these two regions when few sites are found in the interior of the peninsula. Several authors explain this scarcity of sites, in the inner region during the Upper Palaeolithic, by a decrease of human population resulting from a low capacity of human groups to adapt to the cold conditions of the Marine Isotopic Stage 2 (MIS 2), i.e. the effect of cold climate on human populations might have been stronger in the interior of the peninsula than in coastal areas. Recent studies underline the evidence of prehistoric occupation during this period in that region. It has been suggested that these occupations are isolated events limited to the warmest phases of the end of the MIS 2. The present study focuses on zooarchaeological and taphonomic aspects of the Magdalenian site of La Peña de Estebanvela (Segovia, Spain). Our results show that this site was recurrently occupied during the Magdalenian period, including warm and cold phases, which provide a new evidence of sustainable presence of human populations in the interior of the Iberian Peninsula at the end of the Upper Palaeolithic. We further propose hypotheses on the subsistence strategies (e.g. availability of hunting resources) developed at La Peña de Estebanvela and in a larger context including other Magdalenian sites of the inner region of the Peninsula.

**Keywords** Upper Palaeolithic · Iberian Peninsula · Subsistence strategies · Zooarchaeology · Taphonomy · Magdalenian

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## Introduction

Since the late nineteenth century, a large number of Upper Palaeolithic sites were discovered in the Cantabrian and Mediterranean coasts of the Iberian Peninsula (Obermaier 1916; Utrilla 1981; González Sainz 1989; Davidson 1989; Straus 1992; Villaverde et al. 2012). Several authors have stressed that these regions have played a role of glacial refugium for the fauna and flora during the coldest events of the Marine Isotopic Stage 2 (MIS 2: Jochim 1987; Stewart and Stringer 2012). In contrast, the interior of the Peninsula was characterised by a stronger impact of cold climate on fauna and flora, as well as human groups, than in other regions. This might have caused a total or partial depopulation of the inner region during most of the Upper Palaeolithic (Breuil and Obermaier 1913; Sauvet and Sauvet 1983; Davidson 1986; Straus 1991; Corchón 1997; Vaquero 2006). Such climate conditions have been confirmed by the presence of glaciers in various mountain areas of the inner region at that time, e.g.

Gredos, Ayllón and Guadarrama (Acaso 2005; Palacios et al. 2012; Pedraza et al. 2013). Palaeoclimate simulations further suggest low potential of sustainable human occupations during the Late Glacial Maximum (LGM) in that region (Burke et al. 2014).

The first evidences of Upper Palaeolithic occupations in the Central part of the Peninsula correspond to the previous phases of Heinrich 3 with the Gravettian level of El Palomar, 31,850–30,690 cal year. BP (Vega and Martín 2006), the indeterminate Upper Palaeolithic levels of Portalón 10, 34,840–34,120 cal year. BP (Ortega et al. 2008), the Valle de las Orquídias (Atapuerca), 29,955–27,507 cal yr. BP, and the Gravettian, Protosolutrean and Solutrean levels of Peña Capón (Alcaraz et al. 2013) (see Table 1). Few studies provide information about human settlements from the end of the MIS 3 to the MIS 2 which make difficult to set hypotheses on human-environment interactions.

Recent works reveal the presence of Magdalenian sites in the inner region of the Peninsula (Fig. 1 and Table 1: Cacho et al. 2007, 2012; Vega et al. 2008; Utrilla et al. 2011), as well as Solutrean and Gravettian sites (Alcolea et al. 1997; Panera and Rubio 2002; Mosquera et al. 2007; Alcaraz et al. 2013, 2015). The Magdalenian and Solutrean occupations suggest that at least some inner territories were occupied by humans, even during cold and dry episodes of the MIS 2. Furthermore, a number of Palaeolithic rock art sites are known in that region, yielding both Magdalenian and pre-Magdalenian depictions, some of them showing cold-adapted fauna (Alcolea et al. 1997; Alcolea and de Balbín 2003, 2013). It can therefore be suggested that the Upper Palaeolithic settlements of the interior Iberia were not restricted to the warmest periods at the end of the MIS 2, which make a contradiction with the thoughts of several authors about a

**Table 1** Radiocarbon dating for ISO 2 deposits and rock art in the interior of the Iberian Peninsula

Site	Level	Archaeological context	Lab-Code	14C-age [BP]	Material
Portalón	10 P-1	Upper Palaeolithic	Beta-209452	16,980 ± 80	Bone
Galería Huellas,		Lower Magdalenian	GIF-1721	15,600 ± 230	Charred torch
Cueva Palomera	Parietal art	Magdalenian/Azilian	GIF-95363	10,980 ± 160	Humic sediment
Cueva Palomera	Parietal art	Magdalenian/Azilian	GIF-95229	11,130 ± 100	Charcoal
Cueva Palomera	Parietal art	Magdalenian/Azilian	GIF-96136	10,950 ± 100	Charcoal
Cueva Palomera	Parietal art	Magdalenian/Azilian	GIF-95238	11,470 ± 110	Charcoal
Cueva Palomera	Parietal art	Magdalenian/Azilian	GIF-96134	11,540 ± 100	Charcoal
P. Estebanvela	PE I	Late Magdalenian	Beta-290779	10,640 ± 60	Charred material
P. Estebanvela	PE I	Late Magdalenian	Beta-155114	11,060 ± 50	Charred material
P. Estebanvela	PE I	Late Magdalenian	Beta-155113	11,170 ± 50	Charred material
P. Estebanvela	PE I	Late Magdalenian	Beta-287754	11,330 ± 50	Charred material
P. Estebanvela	PE I	Late Magdalenian	Beta-287755*	12,220 ± 50	Charred material
P. Estebanvela	PE I	Late Magdalenian	Beta-290778*	12,400 ± 50	Charred material
P. Estebanvela	PE II	Late Magdalenian	Beta-155116	11,400 ± 120	Charred material
P. Estebanvela	PE II	Late Magdalenian	Beta-197376	11,700 ± 70	Organic sedim.
P. Estebanvela	PE II	Late Magdalenian	Beta-155115*	9950 ± 40	Charred material
P. Estebanvela	PE II	Late Magdalenian	Beta-228872	11,530 ± 70	Charred material
P. Estebanvela	PE III	Upper Magdalenian	Beta-232940	12,070 ± 40	Charred material
P. Estebanvela	PE III	Upper Magdalenian	Beta-155710	12,270 ± 40	Charred material
P. Estebanvela	PE III	Upper Magdalenian	Beta-155118	12,360 ± 50	Charred material
P. Estebanvela	PE III	Upper Magdalenian	Beta-232939	12,440 ± 50	Charred material
P. Estebanvela	PE III	Upper Magdalenian	Beta-287757	12,180 ± 50	Charred material
P. Estebanvela	PE III	Upper Magdalenian	Beta-287756*	12,900 ± 60	Charred material
P. Estebanvela	PE IV	Upper Magdalenian	Beta-197377*	12,260 ± 50	Charred material
P. Estebanvela	PE IV	Upper Magdalenian	Beta-290780	12,530 ± 60	Charred material
P. Estebanvela	PE IV	Upper Magdalenian	Beta-287758*	14,410 ± 60	Charred material
P. Estebanvela	PE VI	Middle Magdalenian	Beta-197378	14,200 ± 50	Charred material
P. Estebanvela	PE VI	Middle Magdalenian	Beta-228871	14,450 ± 80	Charred material
Alexandre	III	Early Magdalenian	GrN-23448	15,370 ± 110	Charcoal
Vergara	D	Early Magdalenian	GrN.A-8403	14,000 ± 100	Horse tooth
Gato 2	II	Archaic Magdalenian	GrA-42226	17,700 ± 70	Bone

**Table 1** (continued)

Site	Level	Archaeological context	Lab-Code	14C-age [BP]	Material
Gato 2	II	Archaic Magdalenian	GrA-30683	18,090 ± 90	Charcoal
Gato 2	II	Archaic Magdalenian	GrA-22503	18,260 ± 130	Charcoal
Gato 2	II	Archaic Magdalenian	GrA-22505	18,650 ± 140	Charcoal
P. del Diablo 1	1	Late Magdalenian	GrN-21012**	11,080 ± 540	Charcoal
P. del Diablo 1	2	Late Magdalenian	GrN-21014	10,760 ± 140	Charcoal
El Monte		Magdalenian	Beta-245813	13,570 ± 70	
El Monte		Magdalenian	Beta-245814	14,660 ± 80	
Reguerillo	Parietal art	Magdalenian		12,593 ± 1133**	
Buendía	N1C	Magdalenian	Beta-212776	14,840 ± 50	Charcoal
Buendía	N31C	Magdalenian	Beta-212777*	210 ± 40 BP	Charcoal
Buendía		Magdalenian	UtC-4006	14,380 ± 90	Charcoal
Buendía	N1W	Magdalenian	OxA-28336	32,270 ± 170	Shell
Buendía	N1W	Magdalenian	OxA-29341	13,240 ± 55	Charcoal
Buendía	N2BW	Magdalenian	OxA-28280	14,515 ± 55	Charcoal
Buendía	N2CW	Magdalenian	Beta-246578	13,790 ± 50	Charcoal
Buendía	N2CW	Magdalenian	Beta 377746	14,500 ± 50	Charcoal
Buendía	N3W	Magdalenian	OxA-28279	13,410 ± 55	Bone
Buendía	N4W	Magdalenian	OxA-28278	14,515 ± 55	Charcoal
Buendía	N5W	Magdalenian	OxA-28277	14,845 ± 55	Charcoal
Buendía	N6W	Magdalenian	OxA-28276	14,635 ± 55	Charcoal
Buendía	N2C	Magdalenian	Beta-246579	14,500 ± 50	Charcoal
Buendía	N3C	Magdalenian	OxA-29342	14,600 ± 60	Charcoal
Buendía	N5C	Magdalenian	Beta 246580	14,530 ± 50	Charcoal
Buendía	N6C	Magdalenian	OxA-28275	14,595 ± 55	Charcoal
Buendía	N7C	Magdalenian	Beta-246581	14,690 ± 80	Charcoal
Buendía	N8C	Magdalenian	Beta-246582	14,830 ± 50	Charcoal
Buendía	N31C	Magdalenian	Beta-246577	13,540 ± 60	Bone
Buendía	N33C	Magdalenian	Beta-246576	13,480 ± 50	Bone
Buendía	N33C	Magdalenian	OxA-29343	14,960 ± 60	Charcoal
Verdelpino	VA	Magdalenian	I-9841**	12,930 ± 470	
Verdelpino	VB	Magdalenian	I-9840**	14,000 ± 520	
Delicias	Sec. II-3b	Magdalenian	MAN.5566SDA**	12,028 ± 794	Organic sedim.
Delicias	Sec. I-IIb	Solutrean	MAN.5585SDA**	18,175 ± 1333	Organic sedim.
Peña Capón	2	Middle Solutrean	Beta-246880	19,930 ± 110	Bone
Peña Capón	3	ProtoSolutrean	Beta-246879	19,980 ± 110	Bone
Peña Capón	4	Gravettian	Beta-246878	21,220 ± 120	Bone

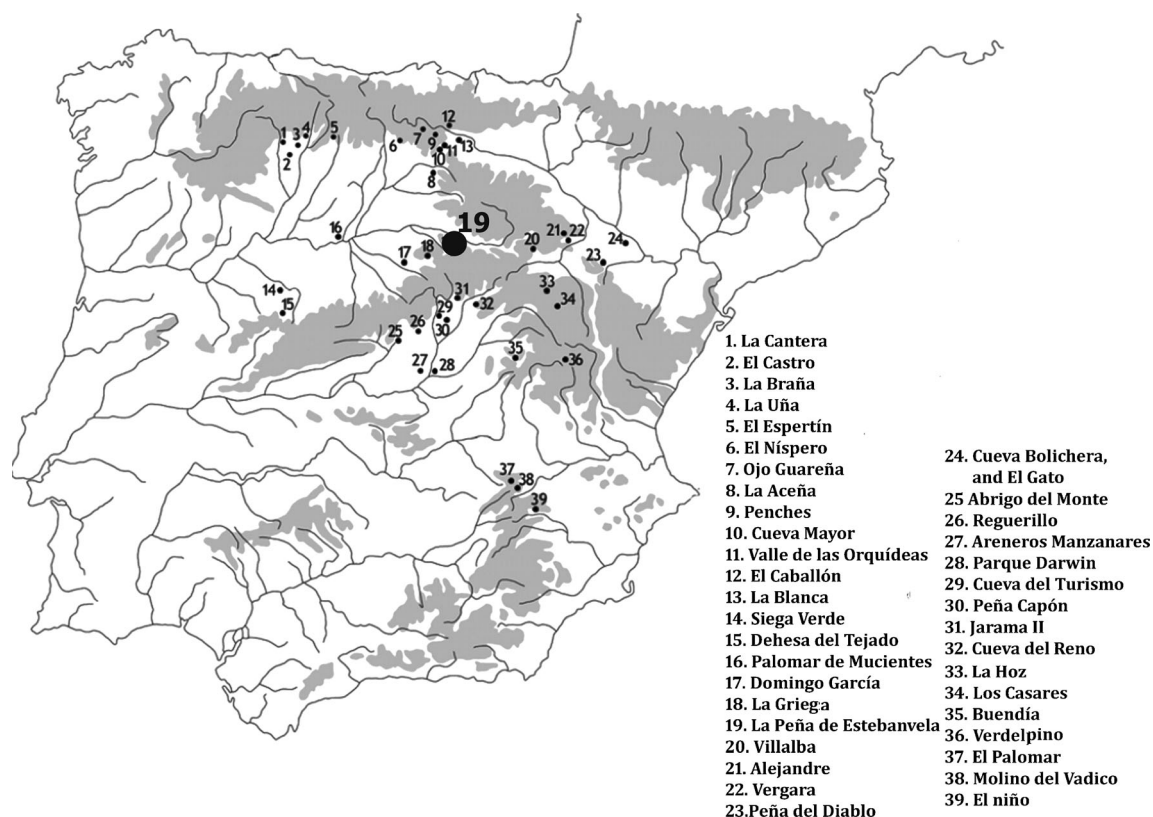
\*Non-valid date because of lack of synchronicity

\*\*Non-valid date because of insufficient precision, > 250)

depopulation of the center of Iberia related to rigorous and cold climate (Davidson 1986; Straus 1991; Corchón 1997; Straus et al. 2000; Vaquero 2006).

Technological, chronometric and symbolic information have increased significantly in recent years when economic and ecological data are virtually absent from records. It is thus difficult to assess the links between the Late Upper Palaeolithic populations and their relative climates to understand why human settlements were rare in the interior of the

Peninsula. This is not only because most of the sites in some areas (e.g. Madrid basin) were excavated in the first half of the twentieth century (Panera and Rubio 2002), resulting in a lack of suitable data for palaeoecological analyses, but also because faunal remains and other biomarkers (e.g. plant macro- and micro-remains) are very scarce in archaeological assemblages. Recent studies (Yravedra et al. 2016), however, provide important information on the subsistence strategies of Solutrean populations of Peña Capon, e.g. horses, deer, large



**Fig. 1** Major Upper Palaeolithic sites of the interior of the Iberian Peninsula

bovid and Iberian ibex were the major hunting resources exploited by human groups. Other Upper Palaeolithic sites also provide fauna and palaeobotanical information (Vega et al. 2008; De la Torre et al. 2015), but fauna samples are too small to be reliable and the palaeobotanical data are coming from preliminary studies. The knowledge about the subsistence strategies is thus poorly understood to discuss the causes of the scarcity of human settlements during the MIS 2 in the interior of the Peninsula.

The present study aims at discussing human occupation of Central Iberia during the Magdalenian period based on the subsistence strategies that have been assessed using zooarchaeological and taphonomic analyses. We focus on the Magdalenian site of La Peña de Estebanvela (Segovia) as reference site that is integrated in a larger archaeological context for the discussion. This study is the first exhaustive analysis of the faunal material of a Magdalenian site in the interior of the Peninsula.

## The Magdalenian site of La Peña de Estebanvela

La Peña de Estebanvela is a rock shelter located in Segovia (Spain) at an altitude of 1065 m in the Sierra de Ayllón on the northern part of the Spanish Central Range (Fig. 2). Its

archaeological record stretches from the Middle to Late Magdalenian. During the excavations coordinated by C. Cacho, between 1999 and 2009, large lithic (51,000 pieces) and faunal (64,155 remains of macrofauna) materials have been found, as well as personal ornaments, bone industry objects, an exceptional collection of portable art objects, and a number of hearths (Cacho et al. 2007, 2012).

The excavation area of la Peña de Estebanvela corresponds to 26 m<sup>2</sup> and six archaeological layers chronoculturally attributed to the Middle Magdalenian (V and VI), the Upper Magdalenian (III and IV) and Late Magdalenian (I and II) (Cacho et al. 2007) (Fig. 3). The radiocarbon dating of these layers are given in Table 1.

Climate and landscape information for the different archaeological layers have been obtained from faunal and archaeobotanical studies. The micromammal assemblage indicates the presence of a watercourse, forested areas, and transition zones between open landscapes including few trees and shrubs and both dry and damp meadows. The macromammal do not suggest specific environments, but reveal species of different habitats, open areas with horses, wooded areas with cervid and mountainous areas with Iberian ibex and chamois. The charcoal and phytolith analyses show distinct environments between the upper (I, II and III/IV) and bottom (V and VI) layers, and the predominance of willow in most of the layers (Ruiz et al. 2013). In general, layers V and VI are

**Fig. 2** Context and excavation area of La Peña de Estebanvela

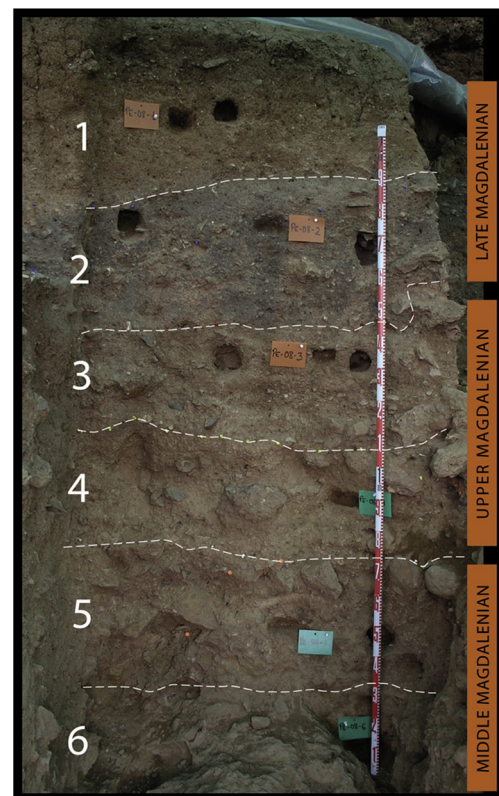


characterised by cold environments and open landscapes with grass species and few trees and shrubs, as well as the presence of micromammals such as *Microtus oeconomus* (Cacho et al. 2012). On the contrary, layers I, II and III relate more temperate environments and forest habitats with a diversity of tree species, e.g. willow, hazel, alder, oak and pine, and a large diversity of micromammals (Sesé 2012; Ruiz et al. 2013).

## Material and methods

The present study focuses on zooarchaeological and taphonomic analyses of 64,155 remains from the six archaeological layers of La Peña de Estebanvela. These remains include both identifiable and unidentifiable fragments. The taxonomical identification is based on reference materials. When the identification is not feasible, epiphyses and shaft fragments are assigned to three animal weight/size classes: (1) small-sized carcasses, < 100 kg (e.g. *Capra*), (2) medium-sized carcasses, > 100–300 kg (e.g. *Cervus*) and (3) large-sized carcasses, > 300 kg (e.g. *Equus*).

The estimation of NISP (number of specimen) and MNI (minimum number of individual) is used to determine the most appropriate features of the faunal taxonomic distribution. NISP follows Lyman's synthesis (1994), and MNI is based on bone laterality—right/left—and animal age. Furthermore,



**Fig. 3** Stratigraphic sequence at La Peña de Estebanvela

skeletal profiles and MNI consider shaft thickness, section shape and medullar surface properties (Barba and Domínguez-Rodrigo 2005). In this way, bones are divided into four anatomical regions: (1) cranial (antlers-horn, skull, mandible and dentition), (2) axial (vertebrae, ribs, pelvis and scapula, sensu Yravedra and Domínguez-Rodrigo 2009), (3) upper appendicular limbs (humerus, radius, ulna, femur, patella and tibia) and (4) lower appendicular limbs (metapodial, carpals, tarsals, phalanges and sesamoideal). The quantification of skeletal profiles considers the minimum number of elements (MNE) including shafts (Marean and Kim 1998; Barba and Domínguez-Rodrigo 2005) to assess the element sizes, sides, ages and biometrics.

Mortality patterns are divided into infant, juvenile-adult and adult. Age profiles are estimated from tooth crown wear and the emergence of the teeth. This analysis is based on Guadelli (1998) for horses and the formula proposed by Steele (2002) for deer, using the lower molars.

A systematic observation of bone surfaces to explore the presence of cut, percussion and tooth marks is also carried out with 10X–20X hand lenses and different lighting (Blumenschine 1995). Our diagnostic criteria for cut, tooth and percussion marks are the ones defined respectively by Bunn (1982), Blumenschine (1995) and Blumenschine and Selvaggio (1988). For comparative purposes, observation of bone surfaces includes the observation of epiphysis and shafts (Blumenschine 1995). Modifications of bone surfaces are also quantified by types of fragments and bone sections (Domínguez-Rodrigo 1997; Domínguez-Rodrigo and Barba 2005) based on NISP values. The presence of tooth, percussion and cut marks is recorded for the whole assemblages, and percentages of tooth, percussion and cut marks include only bones with a good surface preservation. Weathering stages are also observed following Behrensmeier (1978) to estimate time exposure and water effects on bone surfaces according to Parson and Brett (1989).

We then have calculated a bone fragmentation index dividing bones fragments into three categories according to their lengths: < 3 cm, between 3.1 and 5 cm, and > 5.1 cm.

## Results

### Taxonomical and age profiles

The taxonomical profiles are divided in two parts. The first part corresponds to the upper layers (I–II) where rabbits clearly dominate the faunal assemblages with respectively 80 and 85% of the NISP and MNI in layer I, 55 and 73% in layer II; both layers correspond to Late Magdalenian, and 20 and 32% in the Upper Magdalenian layers III and IV (Table 2 and Supplementary File Now SF Table S1). The second part, the Middle Magdalenian layers (V–VI), is characterised by much

less bone materials than in the upper layers. This differential representation could be explained by smaller excavated areas in the lower layers than in the upper layers. Note that ungulates are the major animal remains found in the lower layers.

Iberian ibex is the dominant ungulate in layers I, III, IV, V and VI, and horses are the major remains in layer II. Horses are the second most represented macro-vertebrate in layers I and III, and deer ranks third in all layers. Other species such roe deer (*Cervus elaphus*), wild boar (*Sus scrofa*), chamois (*Rupicapra rupicapra*) or wild donkey (*Equus hydruntinus*) are less recorded, and carnivore remains are very few. Carnivores are lynx, fox, wild cat and wolf with one or two individuals in layers I–IV (Table 2). The taxonomical profiles correspond to a diversity of habitats that includes open landscapes (based on horses and donkeys), wood environments (based on deer, roe deer, wild boar, lynx and wild cat) and rocky landscapes (based on Iberian ibex and chamois).

When rabbits are excluded from the analysis, the exploitation of macro-vertebrates can be assessed. The results suggest different strategies in the selection of macro-mammals depending on the surrounding landscapes. The rocky species are the main ungulates at the end of the Late Magdalenian (layer I) and in the Upper Magdalenian (layer III). The open landscape species are dominant and well represented during the Late Magdalenian (layers II and I), and they are less recorded during the Upper and Middle Magdalenian (Table 2). The species related to wood environments are observed through the whole Magdalenian. These outcomes underline a diversified hunting strategy with the exploitation of varied ecosystem, although the animals from rocky areas are important in most of the periods. These landscapes agree the geographical and topographic locations of La Peña de Estebanvela.

Age patterns show that adults dominate the demographic profiles in all layers and for all animals (Table 2).

### Skeletal profiles

Different skeletal profiles are observed. Layers I and II have reliable information with high MNE values when layers IV and VI are characterised by low values (less than 30 elements for each species; SF Table S2). Layers I and II show complete profiles for rabbits, Iberian ibex, deer and horses (SF Table S3–S4). The axial section, and both upper and lower appendicular bones are abundant throughout these two layers (See SF Table S2, S3 and S4). The cranean section is recorded in layer I, but it is underrepresented for deer in layer II (SF Table S2, S3 and S4). In layer III, only rabbit and Iberian ibex are considered reliable information, MNE values of about 95–99 (SF Table S5). These species indicate complete skeletal profiles like for layers I and II. Axial and appendicular elements are also abundant in this layer III; however, they are few for deer and horses (SF Table S5). In layers IV and VI, the

**Table 2** MNI profiles of La Peña de Estebanvela according to age pattern where A: adult, J: juvenile-prime adult and I: infants

Layer	I			II			III			IV			V			VI		
	A/J/I	MNI	%	A/J/I	MNI	%	A/J/I	MNI	%	A/J/I	MNI	%	A/J/I	MNI	%	A/J/I	MNI	%
<i>Equus ferus</i>	5/1/1	7	2.8	5/1/1	7	8.5	2/1/1	4	14.3	1/0/0	1	9.1				0/1/0	1	16.7
<i>Equus hydruntinus</i>	3/0/2	5	2.0	2/1/0	3	3.7	1/0/0	1	3.6									
<i>Cervus elaphus</i>	3/1/0	4	1.6	2/1/0	3	3.7	2/1/0	3	10.7	1/1/0	2	18.2	1/0/0	1	33	1/0/0	1	16.7
<i>Sus scrofa</i>	1/0/0	1	0.4		2	2.4												
<i>Capreolus capreolus</i>	1/0/0	1	0.4	1/0/1		0.0	1/0/0	1	3.6	1/0/0	1	9.1						
<i>Capra pyrenaica</i>	8/1/1	10	4.0	2/0/1	3	3.7	6/1/1	8	28.6	2/1/0	3	27.3	1/0/0	1	33	1/0/0	1	16.7
<i>Rupicapra pyrenaica</i>	2/0/2	4	1.6	1/0/0	1	1.2	1/0/0	1	3.6	1/0/0	1	9.1						
<i>Felis sylvestris</i>	1/0/0	1	0.4	1/0/0	1	1.2				1/0/0	1	9.1						
<i>Lynx pardinus</i>	1/0/0	1	0.4	1/0/0	1	1.2	1/0/0	1	3.6	1/0/0	1	9.1						
<i>Canis lupus</i>	1/0/0	1	0.4			0.0												
<i>Vulpes vulpes</i>	2/1/0	3	1.2	1/0/0	1	1.2										1/0/0	1	16.7
<i>Oriictolagus cuniculus</i>	196/10/4	210	84.7	56/4/0	60	73.2	7/1/1	9	32.1	1/0/0	1	9.1	1/0/0	1	33	2/0/0	2	33.3
Total		248			82			28			11			3			6	

observed species are underrepresented because of the low presence of determinable specimens due to an important fragmentation of faunal remains (SF Table S2, S6 and S7).

The observation of the three anatomical sections in all layers, including the least reliable layers, IV and VI, indicates that complete carcasses of Iberian ibex, deer, rabbits and horses have been transported to the site. Following the Shannon's evenness index calculated by Yravedra and Domínguez-Rodrigo (2009), according to Faith and Gordon (2007), the results reveal a value of 0.93 for large carcasses such as deer and horses and 0.95 for small carcasses such as ibex. It can therefore be suggested that small and large carcasses have not been affected by differential treatments and they have been evenly transported to the site. A short-distance transportation is thus supposed lower to 5 km (Yravedra and Domínguez-Rodrigo 2009).

### Taphonomical aspect

Less dense bones, axial elements and upper appendicular bones (e.g. humerus and femur), are abundant in layers I–III and reveal a good preservation of bone assemblages. The high percentage of lower appendicular bones in layer III and for some animals in layer II is affected by the numerous phalanges and sesamoids. However, humerus and femur are still abundant in comparison to dense long bones such as metapodials. Faunal remains are less abundant in layers IV–VI, which can be explained by the small extends of the excavated areas (see SF Table S8) and/or an intense bone fragmentation (i.e. only 1.5% of fragments are higher than 5 cm; see SF Table S8).

All layers are characterised by poorly preserved bone surfaces, in particular, in layers III–VI with 65% bones that are highly damaged (see SF Table S8). This probably results from various taphonomical processes. We have investigated these

processes, and the outcomes show that only 15% of bone specimens have subtle weathering marks (stages 1–2 of Behrensmeyer's (1978). Concretions and carbonates are not important, and oxidation, manganese, trampling or biochemical modifications produced by fungi or plant were observed on 12–24% of specimens, depending on the layer (see SF Table S9). The bad preservation of bones is due to water. Several specimens show modifications such as abrasion, rounding or polishing that indicate water exposure. Water did not cause the accumulation of bones, but water has certainly flowed on the deposit eroding the bone surfaces without displacing or fracturing them according to previous experiments (Thompson et al. 2011). The water may have transported small sedimentary particles that have eroded the bone surfaces producing the abrasion or rounding (see SF Table S10). The scarcity of bones with dry fractures, the predominance of shafts with green fractures (see SF Table S11) and the presence of axial bones, carpal-tarsal and phalanges in the skeletal profiles suggest that the bone assemblages were originally deposited and broken in-situ.

The impact of carnivores on faunal remains is not important (< 1% layers I–V, 13% layer VI) (See SF Table S12). Tooth marks on bones of large-, medium- and small-sized animals are observed, but the frequencies are low. Carnivores have affected all skeleton sections with the axial sections and epiphyses of limb bones the most affected ones (See SF Table S12). The actions of carnivores may explain the loss of some specimens, but the few presence of tooth marks indicates that carnivores were not the major agents responsible for the carcasses contribution to the site, but they seem rather to have acted as secondary agents, altering previously introduced bones.

The high frequency of cut marks (Table 3) and percussion marks (Fig. 4) and the high fragmentation index suggest that

**Table 3** Frequencies of cut marks (CM) and percussion marks (PM) of La Peña de Estebanvela. Bones < 2 cm, teeth and sesamoid bones are excluded. Horse include *Equus ferus*, *Equus sp.* and *Equus hydruntinus*

	I		II		III		IV		V		VI	
	CM	PM	CM	PM	CM	PM	CM	PM	CM	PM	CM	PM
Horse	37.3	16.7	12.1	15.0	50	13.2	0	0.0	0		0	0.0
Deer	10.7	28.6	3.6	9.1	13.3	3.3	40	20.0	0	0.0	0	200.0
Iberian ibex	28	19.6	11	10.3	22.6	1.7	8.6	2.9	33.3	11.1	85.7	0.0
Lynx	10.3		33.3	33.3			0					
Indet large size	26	14.6	10.8	15.9	10.8	8.6	20	0.0	12.5	12.5	53	0.0
Indet median size	35.6	8.9	7.9	17.5	40	26.7	0	0.0	0	0.0	0	0.0
Indet small size	9	6.5	14.5	13.5	18.5	8.1	7.7	4.4	7.7	0.0	15	0.0
Indet.	1.7	0.8	0.5	0.4	0.8	0.5	0.2	0.0	5.6	0.0	4.5	0.0
Total	7.3	4.5	1.4	1.4	2.6	1.2	2.6	1.0	10.6	2.7	18.5	1.6

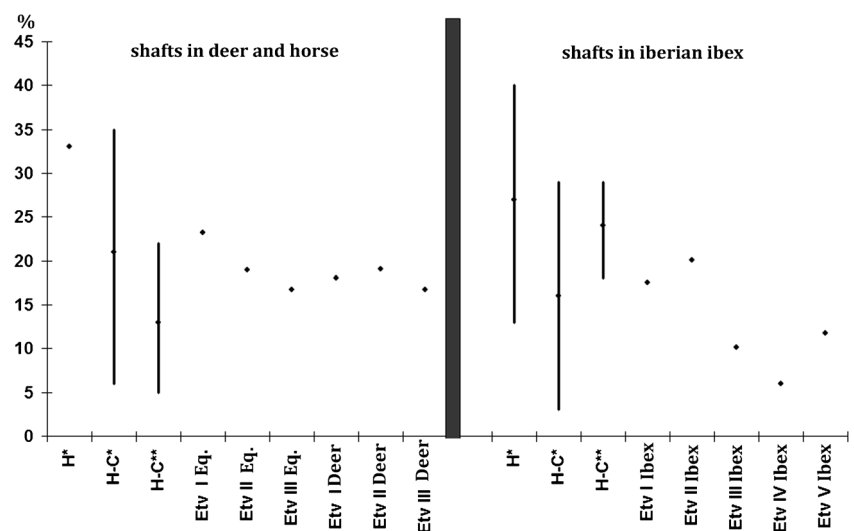
human groups were a major driver of bone assemblages (Table 3). The anatomical distribution of cut marks and their high frequencies indicate an anthropogenic early access to meat resources (SF Table S13, S14, S15). The frequencies of cut marks obtained from La Peña de Estebanvela samples fit the experimental results showing human primary access to meat on horses, deer and Iberian ibex (Domínguez-Rodrigo 1997; Lupo and O’Connell 2002; Domínguez-Rodrigo and Barba 2005) (Figs. 5 and 6). Although the abundance of cut marks on upper appendicular bones from deer are lower than 20%, the few observations of tooth marks (Table 4), the numerous percussion marks (Fig. 4) and the low percentage of cut marks in metapodial further support the human primary agency hypothesis. Among large carcasses, the cut marks on axial bones and upper limbs show similar patterns (Fig. 5). Iberian ibex assemblages are characterised by lower than 20% of cut marks in upper limbs in layers II, III, IV and VI; however, in these layers low percentages of cut marks on metapodials, large frequencies of cut marks on axial bones

(layers II–IV), and high frequencies of percussion marks are observed (Figs. 4 and 6).

The distribution of the cut marks shows various types of activities such as skinning (inferred from cut marks on phalanges and cranial elements in all species), evisceration (marks on the medial side of ribs), fleshing (traces on axial and appendicular elements), and disarticulation (marks on various articular elements, metadiaphysis and condyles, such as the mandible condyle). The *Lynx* is included in the group of species with anthropogenic defleshing and disarticulation (Yravedra 2005). The presence of percussion marks reveals that after meat consumption the exploitation of the carcasses continued with the acquisition of bone marrow. This intensive use of carcasses might explain the high fragmentation of the faunal assemblages at La Peña de Estebanvela.

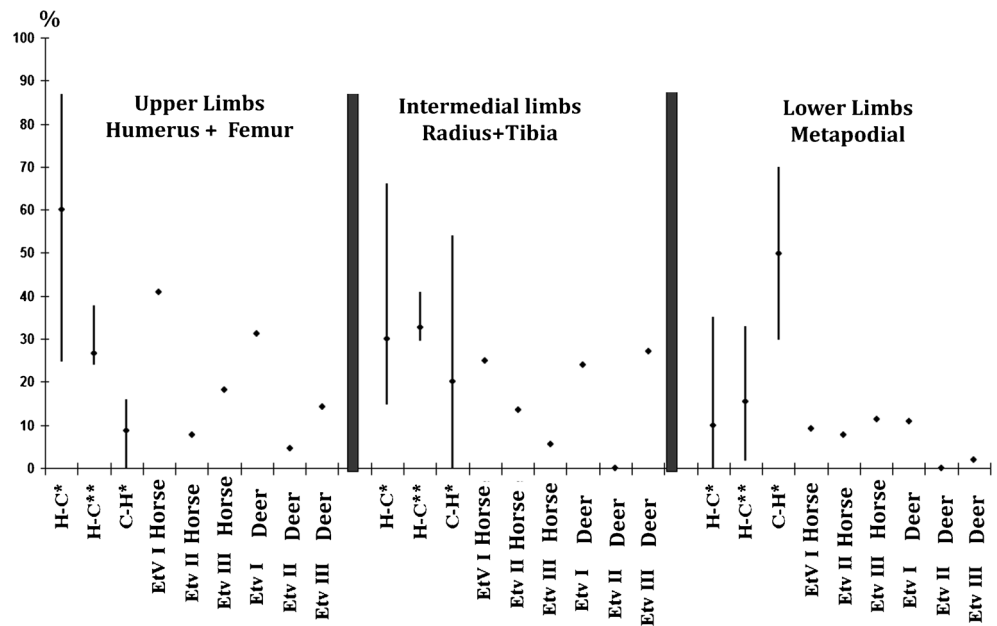
The results of taphonomic analysis on rabbit bones in layers I–III (Table 4) show a palimpsest with marks and traces associated to humans, carnivores and birds. However, according to several taphonomic evidences, see hereafter, we suggest

**Fig. 4** Frequencies of percussion marks on appendicular bones of Iberian ibex, deer and horse carcasses in La Peña de Estebanvela compared to the models of Blumenschine (1995) (one asterisk) and Capaldo (1997) (two asterisks) with primary human access -H, H-C- and primary carnivore access previous to human intervention -C-H





**Fig. 5** Frequencies of cut marks on appendicular bones of horse and deer carcasses in La Peña de Estebanvela compared to the models for early human access to large-sized carcasses before carnivores of Domínguez-Rodrigo (1997) (H-C\*); the same pattern for Hadza by Lupo and O’connell 2002 (H-C\*\*) and models for secondary human access by Domínguez-Rodrigo (1997) (C-H\*)

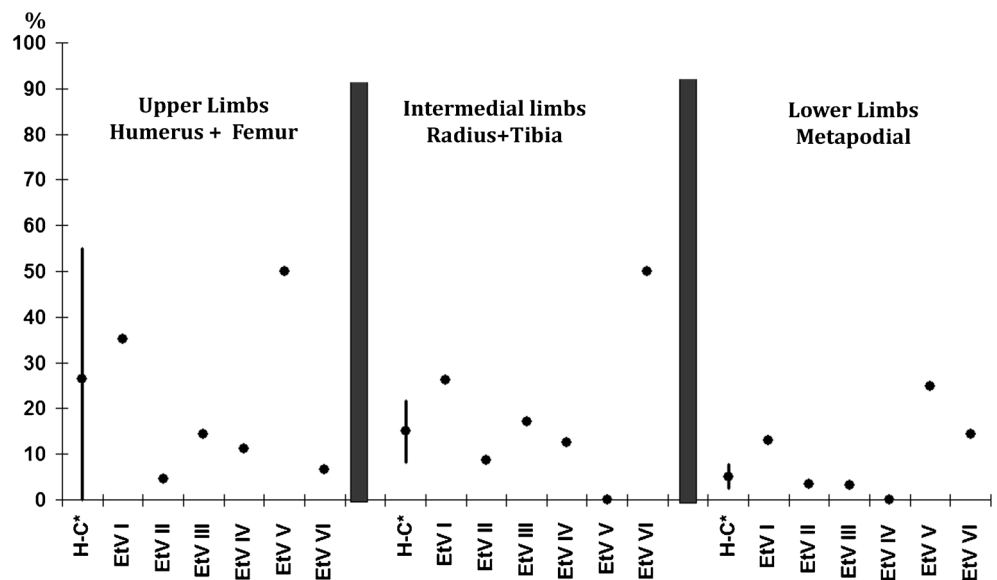


that humans are the main driver of rabbit assemblages. Indeed, following several studies (e.g. Denys et al. 1987; Pérez Ripoll 1992; Sanchís 2000; Davis 2002; Yravedra 2002, 2008; Hockett and Haws 2002; Cochard 2004; Lloveras et al. 2008, 2010), natural assemblages of leporid are characterised by anatomical connexions, the predominance of infants, complete skeletal profiles and low fragmentation. The leporid assemblages resulting from avian activities correspond to abundance of young individuals, predominance of appendicular and cranial sections, moderate fracturation that is species dependent (e.g. eagle and owl), and puncture marks, holes, polishing and digestive corrosion marks. The leporid assemblages resulting from carnivore activities are usually not preserved in anatomical connexion, adult and young individuals have similar patterns, the appendicular section is abundant,

axial bones are not preserved, epiphysis are few, the fragmentation index is high, and corrosion and digestive modifications, as well as tooth marks, are observed. The leporid assemblages resulting from human activities correspond to all anatomical sections, similar percentages of shafts and epiphysis, abundance of cylinders, similar distribution of the anterior and posterior appendicular bones, abundance of adults in the age profiles, and presence of cut marks.

The leporid assemblages from La Peña de Estebanvela are characterised by the predominance of adults (Table 2), observation of all anatomical sections (SF Table S2), low percentage of bone with tooth marks or perforations and presence of cut marks (SF Table S16). Rabbit bones are also highly fragmented in layers I–III (SF Tables S17 and S18), which results in small lengths of identifiable bones (i.e.86–92% of

**Fig. 6** Frequencies of cut marks on appendicular bones of Iberian ibex carcasses in La Peña de Estebanvela compared to the models for early human access to small-sized carcasses by Domínguez-Rodrigo and Barba (2005) (H-C\*)



**Table 4** Taphonomic modifications among rabbits

Rabbits	I	II	III	IV	V	VI	Total
NISP	3651	910	128	28	7	15	4739
NISP with cut marks	191	39	1	1			232
% bones with cut marks	5.2	4.3	0.8	3.6			4.9
NISP with tooth marks	57	11	2	0			70
% bones with tooth marks	1.6	1.2	1.6	0.0			1.5
NISP with digestive corrosion	268	213	58	1		1	541
% bones with digestive corrosion	7.3	23.4	45.3	3.6		6.7	11.4
NISP with perforation	21	2	1				
% bones with perforations	0.6	0.2	0.8				

fragments are lower than 3 cm). Cylinders, some radius, and metapodials are completes (SF Table S19 and S20). The presence of cut marks on mandibles, cranial bones and metapodials suggest skinning. Defleshing traces are also observed on shafts of limb bones and vertebrates. Then, disarticulation marks are present on articular elements, pelvis and scapulae (SF Table S16). One can easily concludes that human was the major causes of leporid assemblages at La Peña de Estebanvela in layers I–III. Few actions of carnivores and/or birds have also been observed in layers I–III, i.e. tooth and puncture marks and digestive corrosion (SF Table S16). This implies that, occasionally, birds and carnivores could have carried some rabbits in the settlements; however, the actions of carnivores as secondary agent altering previously introduced bones are the most probable if we refer to the presence of tooth marks and the loss of some sections such as ribs and vertebrae (<10%), as well as the disproportion between diaphysis and epiphysis (SF Table S19).

## Discussion and conclusion

The interior of the Iberian Peninsula was supposed to be a totally or partially depopulated area during the Upper Palaeolithic (Breuil and Obermaier 1913; Sauvet and Sauvet 1983; Davidson 1986; Straus 1991; Corchón 1997; Vaquero 2006). Recent studies have shown that several settlements were present from the end of the MIS 3, e.g. El Palomar (Vega and Martín 2006), Portalon 10 (Ortega et al. 2008), Valle de las Orquideas (Mosquera et al. 2007), Peña Capón (Alcaraz et al. 2013; Yravedra et al. 2016), Delicias (Alcaraz et al. 2015), and the sites located in the Manzanares valley (Sesé and Soto 2002). This suggests that human groups have occupied the inner part of the Peninsula already at the beginning of the Upper Palaeolithic. The faunal assemblages of these sites reveal enough hunting resources for the groups that might explain the presence of sustainable settlements in that region. Subsistence strategies (i.e. management of hunting resources) can be assessed in some sites, although the taphonomical evidences are scarce. For example, cut marks

in shafts of large bovid and horses have been observed in the Solutrean sites of el Sotillo (Madrid) (personal observation, unpublished). Deer, horses, ibex and large bovid also show traces of human activities in the Solutrean and Proto-Solutrean levels of Peña Capón (Yravedra et al. 2016). The presence of faunal resources certainly favour the human settlements in the interior of Iberian Peninsula during the Upper Palaeolithic.

From the Magdalenian, recent studies have shown higher presence of human settlements than in the previous period (Neira et al. 2006; Utrilla et al. 2006, 2011; Cacho et al. 2007, 2012; Vega et al. 2008). If it is still unknown whether such settlements were as many as the ones seen on the Cantabrian (Straus 1992) and Mediterranean coastal regions (Davidson 1989; Villaverde et al. 2012), it seems clear that the interior region of the Peninsula has been occupied throughout the Magdalenian, even during the harshest climate events (Cacho et al. 2012; De la Torre et al. 2015). La Peña de Estebanvela (Cacho et al. 2012), the sites Alejandro and Vergara rock shelters in Soria (Utrilla et al. 2006), el Monte in Madrid (Vega et al. 2008) and the rock shelter of Buendia in Cuenca (De la Torre et al. 2015) are incontestable proofs of the human settlements in that region during the cold and dry period of the Dryas at the end of MIS 2.

Subsistence strategies during the Magdalenian period are keys to increase the understanding of the adaptations of human groups to their relative environments and climates resulting in sustainable settlements. La Peña de Estebanvela is a great example that shows the variety of hunting resources available for the populations, e.g. deer, horses and ibex. Our results demonstrate that the variety of animals of the interior region of the Peninsula was wide enough to ensure the survival of human groups. Further plant resources (e.g. pine, willow, alder and hazel) might also have been enough to insure viable occupations of the site during the Middle and Upper Magdalenian periods (Ruiz et al. 2013). Plant resources increase a lot during the Late Magdalenian. Additional resources might have been fish according to Cacho et al. (2012, 2015).

Taphonomic evidences show that the bone assemblages were human induced. These assemblages include ungulates,

carnivores such as the lynx, and lagomorphs. The hunting behaviour observed at La Peña de Estebanvela clearly indicates recurrent occupations of the site throughout the Magdalenian. The high MNI values (in particular for layers I–III) confirm these intense and recurring occupations. Evidences of Magdalenian settlements are also observed in other sites, e.g. Jarama VI (Adan et al. 1995), Verdelpino (Rubio and Valiente 1985), el Monte (Vega et al. 2008) and Buendía (De la Torre et al. 2015). These sites are characterised by similar mammal assemblages than La Peña de Estebanvela, but none taphonomic studies have been done. The knowledge of the animal resources that were exploited by the human groups cannot be assessed and thereby no comparisons can be realised with our outcomes from La Peña de Estebanvela. Other Magdalenian sites might contain additional hunting evidences, but the small sizes of excavation areas (Neira et al. 2006; Utrilla et al. 2006, 2011), small sizes of zooarchaeological samples (Rubio and Valiente 1985; Neira et al. 2006; Utrilla et al. 2006; De la Torre et al. 2015), and taphonomic and sampling losses of faunal remains caused by deficient methodology used at the beginning of twentieth century (Panera and Rubio 2002) make difficult to assess the subsistence strategies of the Magdalenian groups. La Peña de Estebanvela is therefore the unique site that provides information on subsistence strategies in this region, up to now.

Our studies at La Peña de Estebanvela reveal the wide variety of hunting resources which indicates the exploitation of various ecosystems. Horses were probably found in open areas, whereas ibex belong to rocky environments and deer as well as other forest species are characteristics of wooded environments. Hunting resources are characterised by short-distance transportations (see results about the Shannon's evenness index in Yravedra and Domínguez-Rodrigo 2009). These short distances might be around 20 km, if we refer to the use of space at La Peña de Estebanvela that suggests the exploitation of raw material from nearby outcrop and resources obtained to 20 km away (Cacho et al. 2015). Charcoal analysis also confirms the local area of resource managements with the major wood species coming from the river bank located few hundred meters from the settlement (Ruiz et al. 2013).

The Magdalenian sites of the Ebro valley (El Gato II, Peña Diablo Peña, Alejandro, Vergara and Legunova (Utrilla et al. 2006)), Burgos (La Paloma and el Caballón o Penches, Leon - Uña), Madrid (La Ventana and El Monte), Cuenca (Verdelpino y Buendía), Soria (Villaba), and Guadalajara (Jarama) also underline the variety of ecosystems used as fauna resources during the Magdalenian (Rubio and Valiente 1985; Adan et al. 1995; Corchón 2002; Neira et al. 2006; Utrilla et al. 2006; Vega et al. 2008; De la Torre et al. 2015). These sites show the presence of horses, large bovid, Iberian ibex, chamois and deer, and sometimes extreme cold species such as antelope saiga (e.g. Abautz cave in Navarra; Altuna et al. (2002)). The presence of these species in the inner

regions of the Peninsula supports our thoughts about the exploitation of various ecosystems by Magdalenian groups which can favour the sustainable settlements in that region. Further investigations are still needed, in particular to assess the seasonality of the settlements. Upper Palaeolithic sites like La Peña de Estebanvela indicate recurrent occupations of the same place for thousands of years in different climate episodes. If the Magdalenian groups at La Peña de Estebanvela had quite local resource areas, the discovery of portable art and marine gastropod shells at La Peña de Estebanvela and Buendía implies the movement of human groups from the interior Peninsula to the Atlantic, Mediterranean and Pyrenean regions. The decorative motifs observed at La Peña de Estebanvela are similar to the portable art found in Europe (Cacho et al. 2012), and the marine gastropod species include shells of Atlantic and Mediterranean origins (Cacho et al. 2007, 2012, 2015; De la Torre et al. 2015). The interior of the Iberian Peninsula was not an isolated region, but it was rather a region of cultural exchanges between the Mediterranean and the Cantabric areas. The present study open new lines of research related to the links of human groups between Inner region of the Peninsula and the Mediterranean and Cantabrian regions.

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