Journal of Archaeological Science: Reports 68 (2025) 105486

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Zooarchaeological study of the Magdalenian sequence of the Valdavara 1 site (Becerreá, Lugo, NW Iberia)☆

Hugo Bal-García [a,b,*], Carlos Fernández-Rodríguez [c], Manuel Vaquero [d,e], Elvira Susana Alonso-Fernández [d,e], Ramón Fábregas Valcarce [a,b]

[a] Grupo de Estudos para a Prehistoria do Noroeste Ibérico – Arqueoloxía, Antigüidade e Territorio (GEPN-AAT). Dpto. de Historia, Universidade de Santiago de Compostela. Praza da Universidade 1, 15782 Santiago de Compostela, Spain
[b] Centro de Investigación Interuniversitario das Paisaxes Atlánticas Culturais (CISPAC), Cidade da Cultura S/N, Santiago de Compostela, Spain
[c] Universidad de León, Departamento de Historia, Campus de Vegazana S/N, 24071 León, Spain
[d] Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Zona Educacional 4, Campus Sescelades URV (Edifici W3), 43007 Tarragona, Spain
[e] Àrea de Prehistòria, Universitat Rovira i Virgili (URV), Avinguda de Catalunya 35, 43002 Tarragona, Spain

ARTICLE INFO

Keywords:
Lower-Middle Magdalenian
Northwestern Iberian Peninsula
Zooarchaeology
Taphonomy
Mixed-sites

ABSTRACT

Valdavara 1 (Becerreá, Lugo) is an archaeopalaeontological cave site located in the NW of the Iberian Peninsula, in the western limit –both geographically and culturally- of the Cantabrian area of influence. The stratigraphic sequence includes levels chronoculturally framed in the Lower-Middle Magdalenian and dated between 18,720 and 16,680 cal BP. The faunal assemblage, dominated by chamois (*Rupicapra pyrenaica*), shows a great diversity in ungulate, carnivore and leporid remains. Zooarchaeological and taphonomic analyses reveal a complex accumulation history, shaped by both anthropogenic and carnivore presence at the cave. Despite a low percentage of remains with direct evidence of human modification (5.92 %), the lithic and bone artifacts and the personal ornaments retrieved suggest repeated human occupations alternating with the use of the cavity as a den by a variety of carnivores, mainly wolves (*Canis lupus*) and foxes (*Vulpes vulpes*), as 13.59 % of the bones exhibit toothmarks and digestion traces. Anatomical representation patterns, bone mineral density (BMD) correlations, and the taphonomic study suggest selective transport, exploitation by both human and non-human predators, and differential preservation processes played a big role on the conservation of the assemblage. Overall, the study positions Valdavara 1 as a unique site within the Magdalenian record of the Iberian Peninsula, illustrating a dynamic interplay of ecological and cultural factors that shaped the presence of hunter-gatherers in the Eastern Mountains of Galicia during the Late Glacial.

1. Introduction

The archaeological record of the Upper Palaeolithic in Galicia (NW Iberian Peninsula) remains notably limited and fragmentary when compared to other parts of the Iberian Peninsula that have undergone more extensive archaeological investigation in the past decades, such as the Cantabrian and Mediterranean regions. However, within this general lack of information, there is one period for which a relatively broad number of sites are known: the post-LGM Upper Pleistocene (ca. 19–11.7 kyr cal BP) (Rasmussen et al., 2014). Evidence of Palaeolithic occupation during this period stretches from the Lower-Middle Magdalenian (Dos Niñas, Férvedes II, and the site discussed here, Valdavara 1) to the Final Upper Magdalenian (Cova Eirós Level B), and the Azilian (Pena Grande, Pena Xiboi, and Prado do Inferno). These sites are clustered into so-called *Serras Septentrionais* (Northern Mountain Ranges), except for Cova Eirós and Valdavara 1, which are located in the *Serras Orientais* (Eastern Mountain Ranges). In both cases, the location of the sites indicates a significant proximity to the Cantabrian region, as both areas are situated along the two natural entry routes into the interior of Galicia from northern Iberia.

The Late Glacial occupation of NW Iberia begins with Dos Niñas (Vilalba, Lugo) (Vázquez Varela, 2000; Villar Quinteiro, 1997) and

---

☆ This article is part of a special issue entitled: ‘Iberian Zooarchaeology’ published in Journal of Archaeological Science: Reports.

* Corresponding author at: Grupo de Estudos para a Prehistoria do Noroeste Ibérico – Arqueoloxía, Antigüidade e Territorio (GEPN-AAT). Dpto. de Historia, Universidade de Santiago de Compostela. Praza da Universidade 1, 15782 Santiago de Compostela, Spain.

E-mail address: hugo.bal.garcia@usc.es (H. Bal-García).

https://doi.org/10.1016/j.jasrep.2025.105486
Received 16 August 2025; Received in revised form 7 November 2025; Accepted 10 November 2025
Available online 12 November 2025
2352-409X/© 2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Férvedes II (Xermade, Lugo) (Llana Rodríguez, 1993; Ramil Soneira and Vázquez Varela, 1983; Ramil Soneira et al., 1994), for which there are no absolute dates. However, based on technological and geo-stratigraphic context, both have been placed in the Oldest Dryas phase (ca. 19–14,6 kyr cal BP) (Stanford et al., 2011); thus in the early stages of the Magdalenian period, in line with Straus and González Morales (2012) periodization that places the Early Magdalenian in northern Spain at ca. 19–18 kyr cal BP, the Middle Magdalenian at ca. 18 – 16 kyr cal BP and the Upper Magdalenian at ca. 16 – 14 kyr cal BP. Only lithic remains have been recovered from both sites, which is common in open-air or rock-shelter sites in Galicia, where highly acidic soils prevent the preservation of organic material (De Lombera-Hermida, 2011). These assemblages are dominated by locally sourced, low-quality flint, in contrast to other Upper and Middle Palaeolithic phases in the region, where quartz and quartzite dominate and flint appears only in minimal proportions (de Lombera-Hermida et al., 2016; Ramil Rego, 2014). At Férvedes II, the lithic assemblage is accompanied by what was then the first evidence of Palaeolithic art in the NW Iberian Peninsula: a stone pendant with a perforation for suspension and notched decoration along its edge (Ramil Soneira and Vázquez Varela, 1983). This artifact places the group of hunter-gatherers within the Cantabrian cultural sphere, with parallels at La Paloma, Altamira, Balmori, El Castillo, Lumentxa, Morín among others (Villar Quinteiro, 1997). However, the attribution of Férvedes II to the Lower-Middle Magdalenian (ca. 19–16 kyr cal BP) has been questioned by some researchers who argue for a better fit within the Upper Magdalenian (ca. 16 – 14 kyr cal BP) (Ramil Rego and Ramil Soneira, 1996).

The final stretch of the Magdalenian is represented exclusively by Level B of the Cova Eirós site (Triacastela, Lugo), dated to 14,045–13,755 cal BP (Fábregas Valcarce et al., 2012). Despite the small volume of remains, this level includes a lithic assemblage made mainly of quartz and rock crystal, with a clear specialization in bladelet production and backed elements on the latter material (De Lombera-Hermida et al., 2014), connecting this episode to Azilian sites in the northern region (Vázquez Varela, 2000; Villar Quinteiro, 1997). Although faunal remains were recovered, the small sample size (NISP = 33) prevents any solid conclusions about subsistence strategies. Only red deer (*Cervus elaphus*) has been confirmed, without associated exploitation evidence. In any case, it is worth mentioning –despite the scarcity of the faunal record- the presence of two cultural elements: a medium-sized carnivore canine tooth that has been modified and used as a hanging ornament, and a finely decorated bone spear-point recovered from a disturbed area adjacent to this level.

In the final phase of the period, the Azilian, roughly dating to 13–10 kyr cal BP (Straus and González Morales, 2012), archaeological traces of hunter-gatherer groups in the region come from Pena Grande (Vilalba, Lugo) (Vázquez Varela, 2000; Villar Quinteiro, 1997), Pena Xiboi (Guitiriz, Lugo) (López-Felpeto and Llana, 1997), and Prado do Inferno (Muras, Lugo) (Villar Quinteiro, 1997, 2011). These sites, again representing open-air or rock-shelter occupations, share the same preservation challenges as the previously mentioned early Magdalenian contexts, with only lithic remains recovered. The lithic industry of these sites shows the disappearance of flint as a dominant raw material, replaced by rock crystal in Pena Grande and Prado do Inferno, and by quartz in Pena Xiboi. All of this highlights the importance of Valdavara 1 as a pivotal site in the Palaeolithic investigation of the region. By having well-preserved lithic and faunal records, it stands as the most informative site for understanding the development of Late Glacial hunter-gatherer groups in the northwestern Iberian Peninsula.

2. Site description and archaeological background

The Valdavara 1 site (Fig. 1) is located in the municipality of Becerreá (Lugo, Galicia, NW Iberia) (UTM X: 5241085; UTM Y: 474533126). It consists of a small karstic cavity with its opening at the NE slope of a small hill in the easternmost foothills of the Serra dos Ancares. The cave is accessed through a small entrance 1.6 m high and 1.2 m wide, which leads to the main chamber, measuring a maximum of

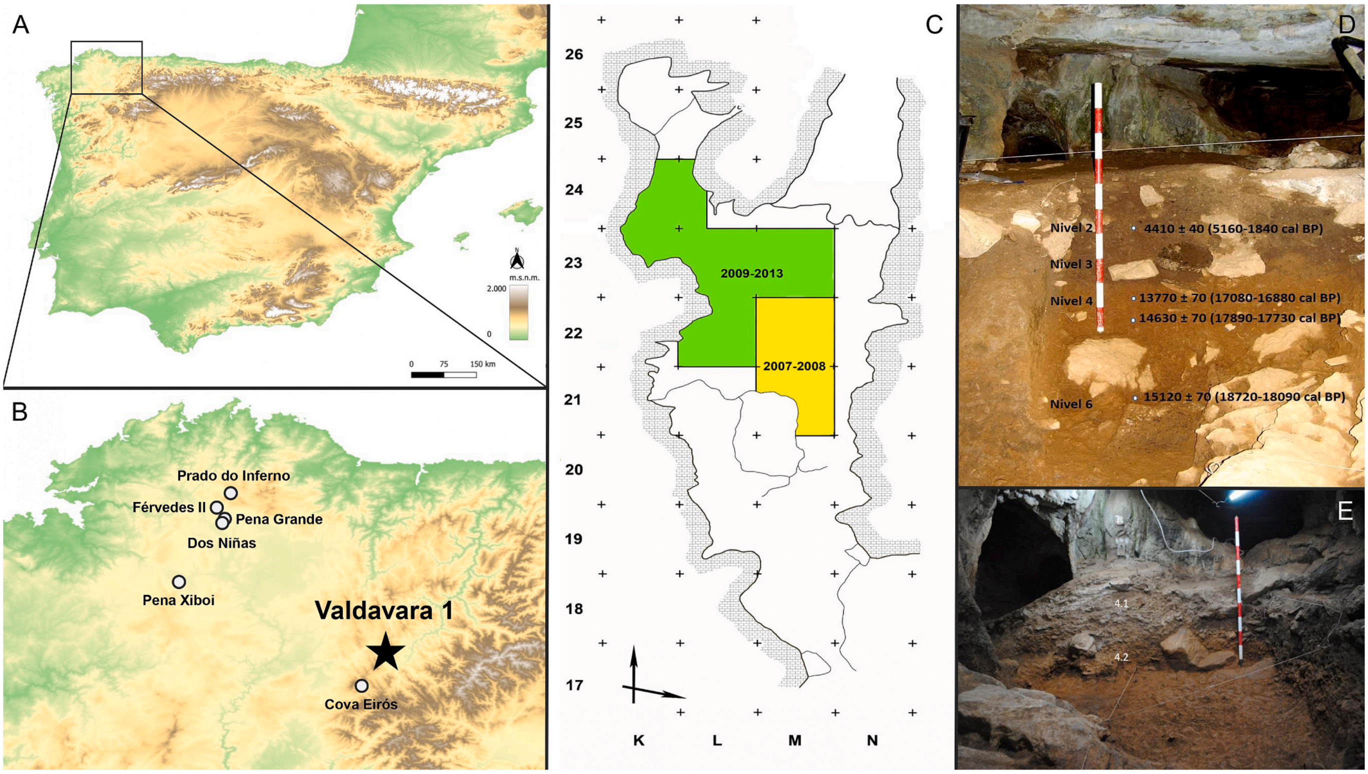

Fig. 1. Valdavara 1 site. A-B) Location of the cave, highlighting other Late Upper Palaeolithic sites in NW Iberia mentioned in the text. C) Plan of the site. D) Archaeostratigraphic division of the sequence. E) Archaeostratigraphic subdivision of the Level 4.

5 x 3 m. From this chamber, two small galleries extend towards the back of the cave, both very short in length. Overall, the cave has a maximum length of just 7 m. It is situated at an elevation of ∼ 600 m.a.s.l. and ∼ 120 m above the Cruzul river. which is a tributary of the Navia River, one of the main natural communication routes between the interior of the Galician region and the Cantabrian coast. In the immediate surroundings of Valdavara 1 there are additional karstic formations that reflect a broad chronology of occupations. Particularly noteworthy is Valdavara 2, a small opening located just 6 m downhill from the entrance of Valdavara 1. This site contains a small archaeological assemblage from the Middle Bronze Age with the inhumated remains of at least 3 individuals (Hernando et al., 2019; Vaquero et al., 2009). The slope connecting Valdavara 1 and Valdavara 2 also contains an archaeological sequence, with evidence of occupation from the Late Prehistory (Level B), the Mesolithic (Level C), and the Upper Palaeolithic —a transitional moment between the Gravettian and Solutrean- (Level D), with a range of dates between 27,4 – 24 kyr cal BP (Vaquero and Alonso-Fernández, 2020). Lastly, Valdavara 3, located approximately 400 m from the main cluster of karstic formations, was identified as an archaeopalaeontological site that was almost entirely destroyed due to quarrying activities in the area. Nevertheless, faunal remains and lithic tools were recovered from it, dating to the Eemian interstadial (MAD-5948BIN: 103,414 ± 6,956 BP; MAD-6025rBIN: 112,837 – 8,903 BP) (Vaquero et al., 2018).

From an archaeological and stratigraphic perspective, the site contains two clearly differentiated sedimentary units. The Holocene unit (Levels 1–3), which will not be discussed here, and the Pleistocene unit (Levels 4–6), consisting of two main levels: Levels 4, and 6. Level 4 was subdivided during the excavation into three units. Sublevel 4.1, a highly cemented deposit which appears only in the parts of the cave where the stalagmitic floor that separates Level 4 from Level 3 is preserved. This sublevel has yielded few archaeological remains. Sublevel 4.2, which is preserved across the entire excavated surface and has a lower degree of cementation. Most of the archaeological remains come from this level. Sublevel 4.3, at the base of the level, shows an increase in the presence of rounded gravels, and the archaeological finds decrease again. Level 6 differs from Level 4 in that, instead of being mainly composed of silts, the primary substrate is fine gravel within a sandy matrix, a dynamic that begins in sublevel 4.3. However, this level has very little vertical development, as it is limited to fillings in the cavities left in the rocky substrate of the cave. Level 5, which was differentiated in the first test pit made in the cave (Vaquero et al., 2009), was later integrated into sublevel 4.2. Radiocarbon dating conducted across this sequence shows an age of 17,890 – 16,680 cal BP (Beta-235728: 13,770 ± 70 BP; Beta-235726: 14,630 ± 70 BP) for Level 4.2 and 18,720 – 18,090 cal BP (Beta-257849: 15,120 ± 70 BP) for Level 6 (Vaquero et al., 2009), placing this sequence within the Lower – Middle Magdalenian, and reveals approximately 2,000 years of successive occupations of the cave.

This Magdalenian sequence has yielded a substantial archaeological assemblage, especially considering the small size of the cavity. In addition to the faunal assemblage reported here, the remains of a dismantled hearth, a decidual tooth of a child, and abundant (ca. 1,600) lithic artifacts and several bone/antler tools and pendants were recovered (Alonso-Fernández & Vaquero, 2024; Vaquero et al., 2009). This assemblage (Fig. 2), still under study, includes 18 shells of *Antalis novemcostata*, a perforated upper canine from a deer, a quadrangular-sectioned spear-point, and a semi-cylindrical rod with “clover” or “chicken feet” decoration on its dorsal face; both pieces are made from deer antler. Finally, an undetermined bone fragment has been engraved with a step-like (escaleriforme) motif.

The lithic assemblage, described by Alonso-Fernández & Vaquero (2024), is dominated by flint as the primary raw material, with limited quartz use. Knapping debris, cores, and core-preparation pieces indicate on-site reduction of both materials. Core analysis reveals a broad range from expedient cores producing short flake series or abandoned early, to more complex strategies aimed at elongated products, especially bladelets. Seventy-one retouched pieces were identified: burins (38 %) and endscrapers (31 %) dominate, with denticulates, sidescrapers, and

Fig. 2. Tools and ornaments made from animal raw materials. A) Square-sectioned spear point made from deer antler. B) Plano-convex rod made from deer antler. C) Bone fragment with step-like decoration. D) Perforated deer canine. E-Q) Set of *Antalis novemcostata* beads.

retouched flakes also present. Backed artifacts are notably scarce (4.2 %). Burins show considerable variability, though dihedral forms prevail. Overall technological and typological patterns accord with Early-Middle Magdalenian assemblages in the Cantabrian region, with the principal divergence being the rarity of backed tools at Valdavara 1 –common and often dominant elsewhere- suggesting an emphasis on domestic tasks and an underrepresentation of hunting-related activities.

3. Methods

Faunal remains analysed in this study were obtained from archaeological excavations conducted at Valdavara 1 between 2007 and 2013. This study presents for the first time the results of the zooarchaeological analysis of the Palaeolithic sequence from the site (Levels 4–6), updating the preliminary information provided in previous studies (Fábregas Valcarce et al., 2012; Valverde Tejedor, 2012; Vaquero et al., 2009).

The excavation followed a traditional methodology, using 1 square metre grids. All bone fragments larger than 20 mm were recorded at the site, and all the extracted sediment was wet-sieved using mesh screens of 5 mm, 2 mm and 0.5 mm respectively in order to retrieve the smaller fragments.

For the study of the macrofaunal assemblage, the anatomical and taxonomical identifications were carried out using animal anatomy and zooarchaeology manuals (Davis, 1987; Hillson, 2005, 1992; Pales and Lambert, 1971, 1981; Schmid, 1972; Varela and Rodríguez, 2004) and the reference collections from the Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), in Tarragona, Spain. The remains were identified to the closest possible taxonomic unit, whether species, genus, family, or size group. For each specimen, the laterality, bone portion, and degree of fusion for the bone remains were recorded. Dental age estimation was done using the Individual Dental Age Stages (IDAS) system proposed by Anders et al. (2011). To obtain greater accuracy in age estimations based on tooth eruption, wear sequences and patterns of bone fusion, specialized literature has been used for the main taxa at the site: *Rupicapra pyrenaica* (Domínguez Sanjurjo et al., 2009; Pérez-Barbería, 1994; Pérez-Barbería and Mutuberría, 1996), *Cervus elaphus* (Azorit et al., 2002; Azorit, 2011; Marín et al., 2024), *Ursus arctos* (Andrews and Turner, 1992; de Torres Pérez Hidalgo, 1988; Debeljak, 1996; Koby, 1952), *Vulpes vulpes* (Harris, 1978; Roulichová and Anděra, 2007a, 2007b; Van Bree et al., 1974), *Canis lupus* (Ballard et al., 1995; Döring et al., 2018; Gipson et al., 2000; Landon et al., 1998; Romairone Duarte, 2015; Williams and Evans, 1978). For specimens that could not be assigned to a taxon or family, weight groups were used following Brain (1981) model, modified by Marean et al. (2000): Size 1 (<20 kg), Size 2 (18–100 kg), Size 3 (70–300 kg), Size 4 (300–1,000 kg) and Size 5 (>1,000 kg), distinguishing between orders (i.e. ungulates, carnivores, lagomorphs, etc.) when possible.

To quantify the assemblage, the Number of Identified Specimens (NISP), Minimum Number of Elements (MNE), Minimum Number of Individuals (MNI), and Minimal Animal Units (MAU) were used (Binford, 1981; Lyman, 2008). For MNE we adopted an approach focused on the identification of diagnostic features (Dobney & Rielly, 1988; Gifford & Crader, 1977), whereas MNI counts were derived from the maximum MNE for the same element within each species, considering laterality and the individuals ontogenetic age. Additionally, the anatomical pattern (expressed in %MAU) of the main taxa were compared with current data on Bone Mineral Density (BMD) (Kreutzer, 1992; Lam et al., 1999; Lyman, 1984; Novecosky and Popkin, 2005; Pavao and Stahl, 1999) and a Pearson correlation coefficient was calculated for each taxon to analyse the extent to which the density of the remains may have influenced their survival or loss.

The taphonomic study of these remains has been carried out using an Olympus SD-51 stereomicroscope with up to 40X magnification. All identifiable skeletal remains and indeterminate remains larger than 20 mm have been analysed. The surface of these remains was examined and specimens were classified by preservation state as well preserved (retaining external cortical surface and not being extensively affected by taphonomic processes capable of erasing superficial marks), partially preserved (retaining external cortical surface, but being substantially altered by diagenetic processes) and poorly preserved (lacking external cortical surface and therefore unable to preserve superficial modifications such as cutmarks or tooth marks). Criteria for classifying alterations were established based on taphonomy manuals (Fernández-Jalvo & Andrews, 2016; Fisher, 1995; Gifford-Gonzalez, 2018), with specialized literature consulted for certain topics.

In terms of anthropic exploitation, the identification of cutmarks followed the criteria of Domínguez-Rodrigo et al. (2009). In addition, the location of marks on each element was recorded to infer the activities undertaken (Binford, 1981; Soulier & Costamagno, 2017; Trolle-Lassen, 1990). Regarding fragmentation, fracture patterns were assessed for all large bone remains following the model of Villa & Mahieu (1991), recording the percentage of surviving circumference for each specimen and the morphology of fracture surfaces (orientation, angle and texture). Likewise, features indicative of green-bone breakage were recorded, such as impact platforms, impact points, hackle marks, flake scars, adhering flakes, presence of cortical flakes and peeling (Blumenschine & Selvaggio, 1988; Capaldo & Blumenschine, 1994; Coil et al., 2020; Moclán et al., 2019; Pickering and Egeland, 2006; Vettese et al., 2020). Thermal alteration was evaluated by colour changes and classified into five stages: S0 (unburned), S1 (brown), S2 (black), S3 (grey/blue) and 4 (white) (Etxebarría, 1994; Shipman et al., 1984; Stiner et al., 1995).

A wide range of carnivore-induced modifications were recorded, such as scores, pits and punctures, crenulated edges, thinning, digestion traces, furrowing and scooping out (Brugal & Fourvel, 2024; Domínguez-Rodrigo et al., 2012; Esteban-Nadal et al., 2010; Haynes, 1980, 1983; Kuhn et al., 2010; Selvaggio & Wilder, 2001). Special attention has been paid to pits, owing to their capacity to discriminate among carnivore taxa; all pits whose morphology had not been altered my other modifications were recorded and the metric results were compared with those reported in neotaphonomic studies of different carnivore species (Andrés et al., 2012; Arilla et al., 2019b; Delaney-Rivera et al., 2009; Domínguez-Rodrigo & Piqueras, 2003).

Finally, the extent of fossil-diagenetic alterations was recorded, such as trampling, weathering, carbonate-encrusted surfaces, chemical dissolution, abrasion, rounding, polishing, root etching, manganese and iron coatings (Andrews & Cook, 1985; Behrensmeyer, 1978; Courtenay et al., 2020; Gümrükçü & Pante, 2018; Kos, 2003; López-González et al., 2006; Pineda et al., 2019; Shipman et al., 1984; Thompson et al., 2011).

4. Results

4.1. Taxonomic and anatomical analysis

A total of 2,180 faunal remains have been identified throughout the Palaeolithic sequence of the Valdavara 1 site. Most of the material comes from Level 4 (NISP = 2,077), especially from sublevel 4.2 (NISP = 1,872), while sublevels 4.1 and 4.3 have yielded much discrete quantities (47 and 158 identified specimens, respectively). Lastly, Level 6 has only produced a modest assemblage consisting of 103 specimens. From a zooarchaeological perspective, the material from the different units is identical in terms of type of remains, represented taxa, proportions in which they are present at the site, and they show a great degree of homogeneity in their taphonomic signatures. This, together with the evidence that the site has been affected by post-depositional processes that have diminished the temporal resolution of each archaeostratigraphic unit, leads us to propose a global analysis of the site, understood as an accumulation resulting from multiple brief episodes of occupation.

Of the total 2,180 specimens recovered, only 354 (16.26 %) could be fully identified anatomically and taxonomically (Table 1). The remaining specimens were either attributed to a size class (24.58 %) or classified as indeterminate remains (59.16 %). Among the identified taxa

Table 1
Valdavara 1 Levels 4-6 macrofaunal representation of the Number of Identified Specimens (NISP, %NISP), Minimum Number of Elements (MNE) and Minimum Number of Individuals (MNI), dividing between immature individuals on the left and adults on the right. %NISP and %MNE reflect the percentage within the identification group to which they belong (i.e. Total identified remains).

Taxa	NISP	%NISP	MNE	%MNE	MNI (IMM/AD)
Bos/Bison	2	0.56	2	0.63	1
Cervus elaphus	31	8.76	26	8.13	4 (3/1)
Rupicapra pyrenaica	143	40.40	116	36.25	8 (3/5)
Equus ferus	8	2.26	8	2.50	2 (1/1)
Sus scrofa	2	0.56	2	0.63	1 (0/1)
Canis lupus	31	8.76	31	9.69	3 (2/1)
Mustelidae	5	1.41	5	1.56	2 (1/1)
Ursus arctos	23	6.50	23	7.19	7 (5/2)
Vulpes vulpes	60	16.95	59	18.44	5 (2/3)
Oryctolagus cuniculus	32	9.04	32	10.00	3 (1/2)
Lepus sp	17	4.80	16	5.00	3 (1/2)
Total identified remains	**354**	**100.00**	**320**	**100.00**	**39 (19/19)**
Size 3 ungulate	2	2.13	1	1.79	-
Size 2 ungulate	51	54.26	23	41.07	-
Size 4 carnivore	2	2.13	1	1.79	-
Size 1 carnivore	6	6.38	5	8.93	-
Size 1 leporid	13	13.83	11	19.64	-
Bird remains	19	20.21	14	25.00	-
Fish remains	1	1.06	1	1.79	-
Total partially identified remains	**94**	**100.00**	**56**	**100.00**	**-**
Size 4 indeterminate	6	0.35	-	-	-
Size 3 indeterminate	20	1.15	-	-	-
Size 2 indeterminate	324	18.71	-	-	-
Size 1 indeterminate	1291	5.25	-	-	-
Indeterminate	1291	74.54	-	-	-
Total indeterminate remains	**1732**	**100**	**-**	**-**	**-**
TOTAL	**2180**	**100.00**	**376**	**100.00**	**39 (19/19)**

(Fig. 3), the species with the highest number of remains is the chamois (*Rupicapra pyrenaica*), with 143 identified specimens (40.4 %). This species, along with *Cervus elaphus* (NISP = 8.76 %), is the only well-represented ungulate species at the site, as *Equus ferus* (NISP = 2.26 %), *Bos/Bison* (NISP = 0.56 %), and *Sus scrofa* (NISP = 0.56 %) are present in much lower numbers. Carnivores are well represented at the site, led by the red fox (*Vulpes vulpes*) with 60 specimens (NISP = 16.95 %), along with the presence of *Canis lupus* (NISP = 8.76 %), *Ursus arctos* (NISP = 6.5 %), and unidentified small mustelids (NISP = 1.41 %). Lastly, it is worth noting the relatively significant presence of leporids at the site, including both rabbits –*Oryctolagus cuniculus*- (NISP = 9.04 %) and hares –*Lepus* sp.- (NISP = 4.8 %). The latter could not be identified at the species level due to the taxonomic diversity within the genus Lepus in northern Iberia, where three species with minimal skeletal differences coexist: *Lepus europaeus, Lepus granatensis*, and *Lepus castroviejoi* (Palomo et al., 2007).

If we consider the Minimum Number of Individuals (MNI) the situation changes slightly. The chamois remains the dominant taxon with at least 8 individuals, but its relative abundance decreases compared to other ungulates, particularly *C. elaphus* (MNI = 4). Among the carnivores *V. vulpes* is no longer the most abundant taxon (MNI = 5), as it is surpassed by *U. arctos* (MNI = 7). *C. lupus* importance also decreases, with only 3 individuals identified. Leporids show a clear balance, with 3 individuals each for both rabbits and hares.

Among the partially identified remains, there is a certain degree of correlation with the identified taxonomic spectrum. Size 2 ungulates are the dominant group (54.26 %), while larger ungulates (sizes 3 and 4) are very rare. No evidence of any Size 5 remains was found. Given that the chamois is the only small-sized ungulate identified at the site, it is quite likely that much of this material belongs to that taxon. However, the potential presence of *Capreolus capreolus* at the site cannot be ruled out, as this species is commonly found in Palaeolithic archaeological sites in NW Iberia (Bal-García et al., 2025; De Lombera-Hermida et al., 2021; Fernández Rodríguez et al., 2018; Vaquero et al., 2018). Therefore, we have opted not to attribute these remains to any specific taxon. In the case of carnivores, the number of partially identified specimens is not high, but similar patterns are observed, with Size 1 carnivores being the dominant group (6.38 %). Finally, the faunal assemblage at the site is completed with a few small-sized bird remains (NISP = 19) and a single

Fig. 3. Macrofaunal remains identified in Valdavara 1 Levels 4-6. A) *Rupicapra pyrenaica* mandible (*sin*). B) *Rupicapra pyrenaica* metapodial. C) *Rupicapra pyrenaica* femur (*dex*). D) *Rupicapra pyrenaica* humerus (*sin*). E) *Rupicapra pyrenaica* patella (*sin*). F) *Rupicapra pyrenaica* astragalus (*dex*). G) *Cervus elaphus* mandible (*dex*). H) *Cervus elaphus* metatarsal. I) *Equus ferus* scaphoides (*sin*). J) *Equus ferus* I^2 (*sin*). K) *Sus scrofa* I_2 (*dex*). L) *Sus scrofa* medial phalanx. M) *Vulpes vulpes* mandible (*sin*). N) *Vulpes vulpes* radius (*sin*). O) *Canis lupus* maxilar (*sin*). P) *Canis lupus* lower canine (*sin*). Q) *Canis lupus* metacarpal II (*dex*). R) *Ursus arctos* M^1 (*dex*). S) *Ursus arctos* M_1 (*dex*). T) *Ursus arctos* M_3 (*sin*). U) *Oryctolagus cuniculus* mandible (*sin*). V) *Oryctolagus cuniculus* femur (*sin*). W) *Lepus* sp. tibia (*sin*).

fish vertebra.

Regarding the anatomical representation of the assemblage (Fig. 4), there is generally a dominance of cranial and lower appendicular elements, both in terms of NISP and MNE, with isolated teeth (NISP = 145) and phalanges (NISP = 81) being notably overrepresented. These two elements make up to 45.66 % of all anatomically identified remains in the site, regardless of the degree of anatomical identification, while the upper appendicular and specially the axial skeleton are very poorly represented. However, despite this general pattern, there are differences between the various taxa at the site. For instance, in *C. elaphus* and *U. arctos,* almost the entire record consists of dental remains, particularly significant in the case of the bear, with only one postcranial element identified: a sesamoid bone. On the other hand, in the case of leporids, the cranial record is virtually non-existent, representing less than 5 % of the remains, having a much greater representation of the lower appendicular skeleton and, to a lesser extent, the upper appendicular skeleton. In terms of %MAU, the situation changes: upper appendicular elements gain more relative importance, mainly at the expense of the lower appendicular skeleton. The representation of the cranial skeleton remains high, especially in *C. elaphus* and *U. arctos*, while the axial skeleton improves slightly, although it remains the least represented.

In general, there is a significant loss of bone remains at the site, with most elements representing less than 60 % of the %MAU for each taxon. Comparison between %MAU and BMD of the closest species show a positive and statistically significant correlation between the two variables for *R. pyrenaica* (r = 0.24; p-value = 0.0006), *C. elaphus* (r = 0.21; p-value = 0.0006), *V. vulpes* (r = 0.23; p-value = 0.0004), and both leporids (r = 0.21; p-value = 0.0019). However, in the case of *C. lupus*, there is no relationship between the recovered remains and BMD (r = 0.01; p-value = 0.0005).

Regarding the age pattern of the remains recovered at the site

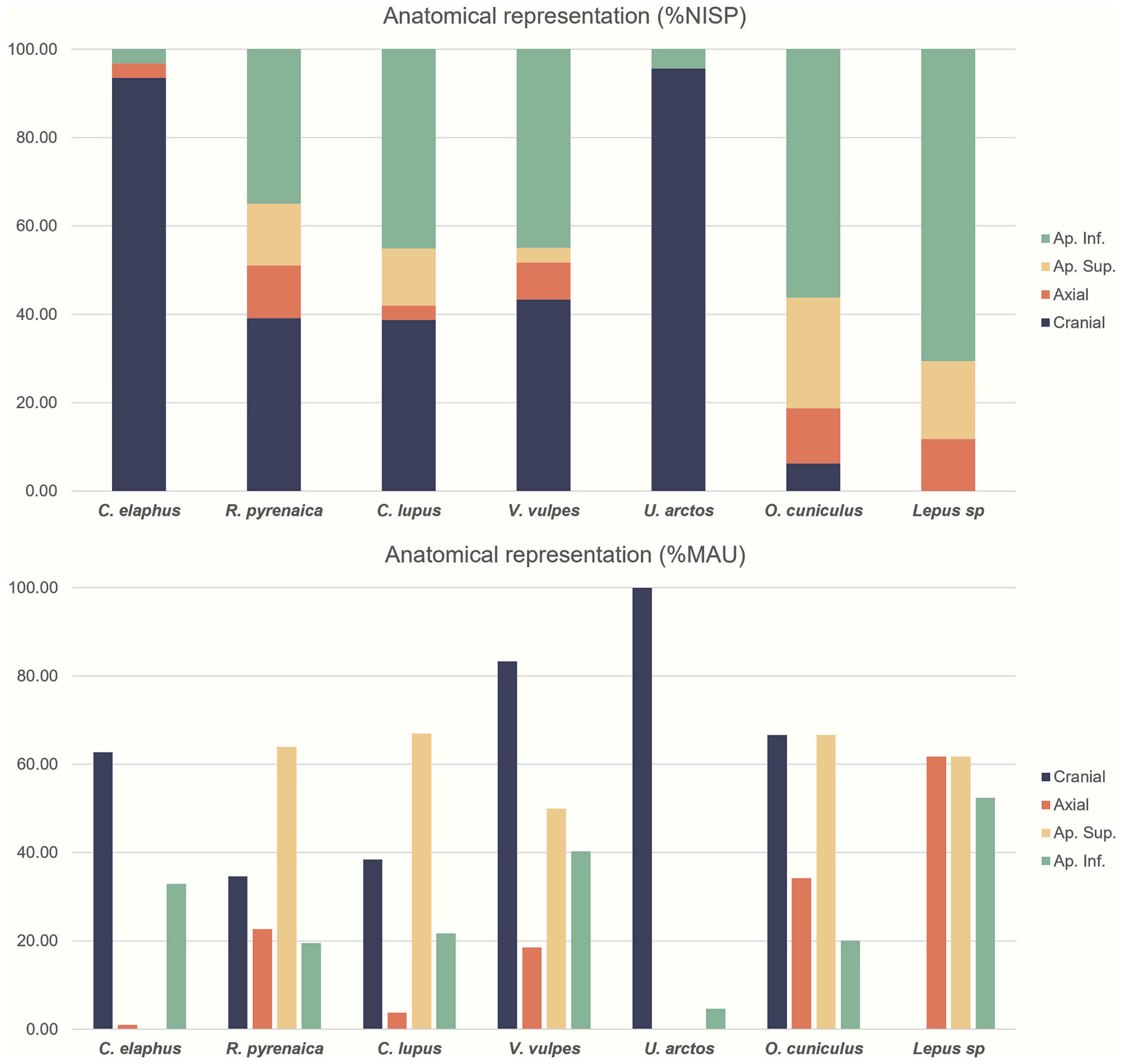

Fig. 4. Percentual representation of each anatomical unit among the main taxa from the site, expressed as %NISP and %MAU.

(Fig. 5), there is a balance between adult and immature individuals, with 19 individuals in each group. Based on age cohort classification of the dental record, this balance remains consistent: 8 infant individuals, 8 juveniles, 7 prime-age adults, and 5 older adults. No skeletal or dental remains attributable to senile animals have been identified.

In the case of the chamois, there is a greater representation of adult individuals (62.5 %) compared to immature ones, although the different age cohorts are relatively well distributed. It is possible to estimate the age of individuals from this taxon using dental wear criteria (Domínguez Sanjurjo et al., 2009; Pérez-Barbería, 1994; Pérez-Barbería and Mutuberría, 1996); however, these provide very low resolution, making it difficult to establish a clear seasonality profile. The only remains that offer a relatively precise timeframe are the deciduous premolars showing very early wear but remaining sharp. These clearly indicate individuals that had not yet reached one year of age but had already begun to feed independently –therefore starting to wear down their teeth- which would place their death between late summer and early autumn. For the remaining individuals whose age could be estimated, the ranges are too broad to determine specific periods. Adult individuals are mainly divided into two groups, the first one being chamois with limited wear on their molars, corresponding to IDAS 3 (prime-age adults), individuals between 3 – 8 years old at the time of their death. The second group includes chamois with very advanced molar wear, particularly noticeable on the lower M3, corresponding to IDAS 4 (older adults), individuals older than 8 years. This age pattern aligns with the expected natural structure (Deevery, 1947; Kurtén, 1954): no senile individuals are present and all other age groups are represented, mortality is higher among infants and older adults than among juveniles and prime-age adults. When comparing the age structure of these chamois with that observed in modern populations (García-González, 1985), the proportions across age groups are identical. In the cited study, all adults are grouped together regardless of age, but other studies on the same populations offer a more detailed analysis and show that adult mortality increases significantly after the age of 10 (Gonzalez and Crampe, 2001), once again matching the higher mortality observed at the site among IDAS 4 individuals.

For the red deer, the predominance of infant individuals (75 %) allows for greater temporal resolution regarding the moment of accumulation. All three infant specimens fall within the 0 – 5-month age range, as indicated by the absence of wear on their deciduous dentitions (Azorit et al., 2002; Azorit, 2011; Marín et al., 2024). Specifically, one mandible preserved a deciduous fourth premolar that, although advanced in eruption, has not yet fully emerged, suggesting that this individual is likely perinatal. This would place the death of these animals between late spring and early summer, as births take place during April–May. The rest of the ungulates, with a MNI of 1–2 individuals, are not statistically significant and include both immature and adult animals.

Regarding carnivores, *U. arctos* provides the most information. The bear dental record at the site is primarily composed of juvenile individuals, represented by a substantial number of deciduous canines with advanced wear and roots either in the process of reabsorption or already reabsorbed, along with the presence of two first incisors with very slight wear. These would represent a group of at least 3 ursids approximately 12–15 months old. However, it is important to note that the presence of shed canines indicated that bear cubs were present at the site during winter but does not necessarily imply their death at the site, which could explain why postcranial remains are so rare. The age of an infant individual has also been determined, represented by a canine and two deciduous incisors with little to no wear, indicating a cub that likely died just a few months after birth. In both this case and the previous ones, the time of death coincides with the hibernation period, roughly between January and April, a period which is especially critical for immature bears that still rely on their mothers to survive. Additionally, the age of the older individuals has been determined from the permanent dentition recovered, but these show broader margins that do not allow for a precise time of death. Specimens have been identified in their third, sixth and tenth years of life, based on various stages of dental wear (Andrews and Turner, 1992).

For *C. lupus* the time of death was reconstructed from various elements. Unfused phalanx and metapodials, and a recently fused lateral phalanx could point towards a 6-month-old or younger individual. Additionally, a deciduous canine with advanced wear indicated an individual around 4 – 5 months old, likely deceased between late summer and early autumn. Another younger individual, marked by a maxilla fragment with minimal wear on the deciduous third premolar, suggests a death around the summer months. For *V. vulpes*, multiple elements point towards a 4 – 6-month-old individual, showing again a summer or early autumn death.

For the leporids, only the presence of both immature and adult individuals from both species has been confirmed, with a better representation of the latter. In the case of *O. cuniculus*, there is at least one individual under 4 months old, and another around 8 months, indicated by a recently fused phalanx. For the other elements, only the presence of immature or adult individuals is confirmed, with no further precision. Given these animals' ability to produce multiple litters throughout the year, it is not possible to estimate the time of death.

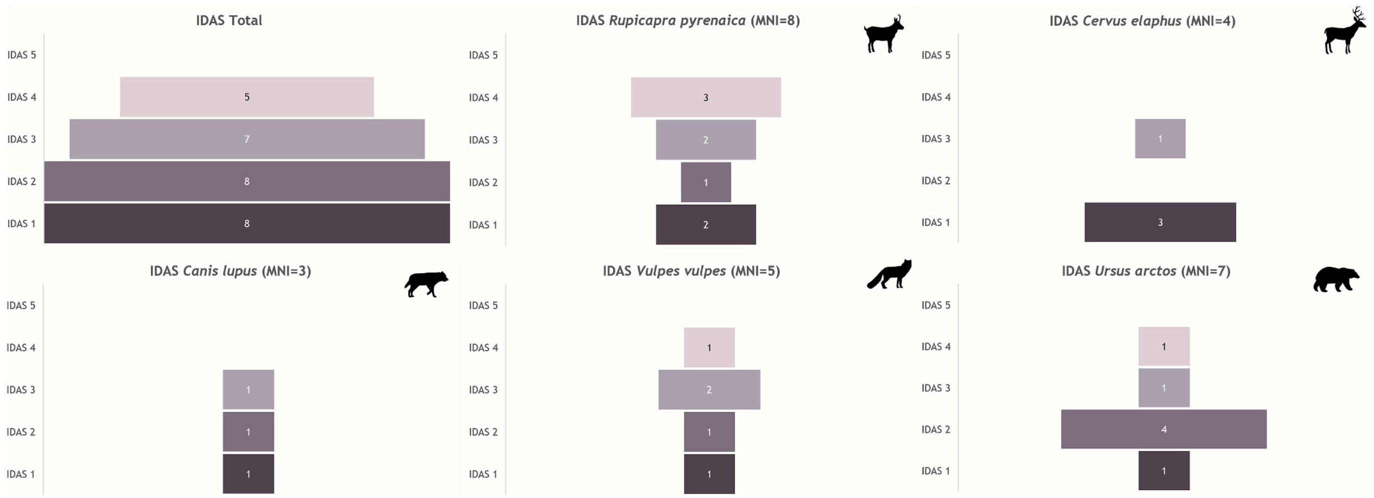

Fig. 5. Representation of the different age cohorts among the main taxa from the site, based on the Individual Dental Age System (IDAS) (Anders et al., 2011). IDAS 1 = Infant. IDAS 2 = Juvenile. IDAS 3 = Prime-age adults. IDAS 4 = Older adults. IDAS 5 = Senile.

4.2. Taphonomic analysis

Starting with the integrity of the remains, only 132 specimens (6.05 %) have been preserved whole, but more than a third of these are isolated teeth (36.36 %). As for the postcranial material, in Size $\geq$ 2 animals, only phalanges and small and dense articular elements –such as patellae or astragali- are preserved whole. A small portion also corresponds to long bones from Size 1 animals, mainly leporids, but no long bone or axial element from any animal over 5 kg in weight has been preserved, reflecting the intense fragmentation of the remains at the site. This is also reflected in the small size of the recovered pieces, with an average size of 24 x 10 x 4 mm. Only 8 specimens (0.37 %) exceed 100 mm in length, and only 76 more (3.39 %) exceed 50 mm.

Most of the analysed specimens (n = 905) showed a good preservation of the cortical surface (n = 654; 72.27 %). The remaining material either had only partial preservation of the surface (n = 99; 10.94 %) or was significantly altered (n = 152; 16.79 %). This affects the possible preservation of superficial marks, such as cutmarks. Of the post-depositional processes (Table 2) one of the main factors affecting the preservation of the remains is the presence of cemented calcium carbonates on the bone surface, being present on 9.28 % (n = 84) of the studied bones. Weathering is more widespread, affecting 34.03 % (n = 308) of the remains, although in most cases the degree of deterioration is very incipient. For example, 75 % of the weathered specimens are at a Grade 1 – 2 according to Behrensmeyer (1978) classification, meaning they only show superficial cracking or slight flaking. Only a single piece falls within a Grade 4 weathering, and no pieces reached Grade 5. Additionally, 35.69 % (n = 323) of the analysed material shows striae on the surface caused by trampling and the dragging of small sediment particles, and an additional 16.13 % (n = 146) also displays small pits. Chemical dissolution is present on 24.42 % (n = 221) of the specimens, related to the erosive action of the sediment and the presence of water at the site. Roughly a third of the remains (n = 310; 34.33 %) are rounded –59.35 % of these are entirely rounded, while the remaining 41.65 % only have rounded edges- and 74.81 % (n = 677) are polished. However, the most common alteration is the manganese staining of the bone surfaces, affecting 90.57 % (n = 816) of the remains analysed. The intensity with which the manganese oxides affect the pieces is especially significant, as in 43.63 % of the specimens it covers more than 90 % of the surface; and in 83.82 % of the specimens the coloration is an intense black coating. Lastly, no pieces were found to be stained by iron oxides or other pigmentating materials, such as ochre.

Regarding the fragmentation of the material (Table 3), fracture surfaces of long bones were analysed to determine whether the fragmentation occurred while the bone was fresh –and therefore perimortem- or when it was dry. A total of 236 long bones were analysed, with 661 fracture surfaces counted and a predominance of fresh fractures (n = 252; 38.12 %), with an oblique orientation, oblique fracture angle, and smooth texture; while only 7 % (n = 46) display dry fractures (transversal/longitudinal orientation, straight fracture angle, and irregular texture). The rest of the material is more ambiguous, but oblique fracture surfaces predominate. Looking at the degree of circumference loss, it is observed that most bones have lost more than 75 % of their perimeter (n = 138; 60.53 %), 29.5 % (n = 68) lost 75–50 % of the circumference, 0.9 % (n = 2) lost 50–25 % and 8.8 % (n = 20) lost less than 25 %. The epiphysis:diaphysis ratio shows a value of 0.27, indicating strong preferential destruction of the bone ends. Moreover, although refits of fragmented pieces are present (all with recent fractures), no anatomical connections were observed.

Finally, regarding the organic activity on the remains, root action has been identified on a small number of remains, just 1.22 % (n = 11), and no striations associated with gnawing activity of small-sized rodents have been identified.

Regarding the anthropic activity at the site, only 31 specimens with clear evidence of direct exploitation by hunter-gatherers have been identified (3.42 %) (Fig. 6; Table 4). Most of the marks linked to human exploitation appear on remains of indeterminate Size 2 animals, which can be attributed with considerable confidence to *R. pyrenaica*, given the abundance of this taxon at the site and the absence of other species that could morphometrically match the analysed remains. In this weight category, marks affect the axial (ribs) and upper appendicular skeleton (humerus and indeterminate long bones). Additionally, anthropic activity has been identified in other two taxa: *C. elaphus* and *Lepus* sp. The rest of the marks are found on indeterminate or only partially identified remains, although it should be noted that all size groups present at the site show exploitation evidence, and it affects ungulates, carnivores, and leporids. If industrial elements and ornaments are also considered, the number of specimens attributable to anthropic exploitation rises to 55 specimens (5.92 %).

Within the human-exploited assemblage, the most frequent marks recorded are cutmarks (n = 16; 51.61 %). Both incisions (n = 11; 68.75 %) and scraping marks (n = 5; 31.25 %) are present, but no sawing or chop marks were identified. Since most of the cutmarks are located on indeterminate remains, it is difficult to reconstruct a possible exploitation strategy. Only a series of general approximations can be made. Firstly, most of the cutmarks consist of short, transversal incisions, which could be related to disarticulation or the removal of meat packages. For example, a calcaneus from a hare shows two short incisions on the anterior side of the body, which points towards the disarticulation of the tibia from the tarsus. Other groups of cutmarks correspond to very fine, longitudinal incisions with long runs, which are associated with the removal of strips of meat from the animals' limbs. Lastly, on a deer metatarsal, the presence of longitudinal scraping marks covering almost the entire anterior side could reflect cleaning of the bone surface to remove the periosteum.

Intentional fracturing (n = 15; 48.39 %) mainly affects long bones, indicating the extraction and consumption of marrow from these elements. Among these pieces, the most common alterations associated with fracturing are flake scars (n = 12; 80 %), hackle marks (n = 9; 60 %), and impact platforms (n = 5; 33.3 %). Evidence of intentional fracturing is only recorded on Size 2 and Size 3 animals.

Finally, there is a single piece with evidence of having been exposed

Table 2
Post-depositional taphonomic alterations identified in the analysed assemblage, with faunal remains grouped by size categories.

	Size 4		Size 3		Size 2		Size 1		Indet		total	
Alterations	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP
Concretions	2	20.00	1	4.35	30	8.29	7	5.65	44	11.40	84	9.28
Weathering	6	60.00	6	26.09	100	27.62	19	15.32	177	45.85	308	34.03
Trampling	6	60.00	14	60.87	195	53.87	44	35.48	220	57.00	469	51.82
Vermiculations	0	20.00	0	17.39	5	16.57	4	12.10	2	16.84	11	16.13
Disolution	3	30.00	6	26.09	95	26.24	19	15.32	98	25.39	221	24.42
Cracking	5	50.00	8	34.78	67	18.51	23	18.55	77	19.95	180	19.89
Flaking	2	20.00	2	8.70	53	14.64	12	9.68	110	28.50	179	19.78
Rounding	5	50.00	7	30.43	129	35.64	18	14.52	151	39.12	310	34.25
Polishing	7	70.00	17	73.91	286	79.01	99	79.84	268	69.43	677	74.81
Manganese	9	90.00	21	91.30	315	87.26	115	93.50	356	92.71	816	90.57

Table 3
Results of the analysis of the fracture surfaces, with faunal remains grouped by size categories. OB=Oblique; LG=Longitudinal; TR=Transversal; ST=Straight; SM=Smooth; JG=Jagged; MX=Mixed; FR=Fresh fracture; DR=Dry fracture.

Size	Fractures	Orientation			Angle		Texture			Diagnosis		
		OB	LG	TR	OB	ST	SM	JG	MX	FR	DR	MX
Size 3 (n=9)	29	78.57	0.00	3.57	82.14	17.86	78.57	14.29	7.14	58.62	3.45	37.93
Size 2 (n=189)	542	61.10	0.18	7.34	55.96	44.04	84.40	10.64	4.95	38.56	7.20	54.24
Size 1 (n=27)	58	65.52	0.00	5.17	36.21	63.79	82.76	13.79	3.45	31.03	5.17	63.79
Indet. (n=11)	32	53.13	0.00	6.25	46.88	53.13	78.13	21.88	0.00	25.00	9.38	65.63
TOTAL (n=236)	661	61.84	0.15	6.94	54.90	45.10	83.71	11.61	4.68	38.12	6.96	54.92

to fire, a Size 2 rib that is completely carbonized, which could be related to the presence of the dismantled hearth in Level 4 previously mentioned. It should be noted that the abundant amount of remains affected by manganese oxides makes it difficult to identify other colorations on the surface of the bone, especially if the thermal alteration is incipient and the material is not fully carbonized or calcined.

A total of 123 remains (13.59 %) show evidence of carnivore activity (Fig. 7; Table 4). These marks are found on nearly all the taxa present at the site and across all weight groups. *R. pyrenaica* shows the highest concentration, representing 30.89 % of the tooth-marked and digested remains, and almost half of the species remains (44.71 %) show any degree of carnivore action. Leporids also show significant damage, *Lepus* sp. and *O. cuniculus* only account for 7.69 % of the modified remains by carnivores, but 47.06 % and 26.92 % of the elements of these species were altered, respectively. Other taxa show very high percentages, up to 100 %, but due to the very low number of remains, they are not considered representative (i.e. *C. elaphus, E. ferus, V. vulpes*). Grouping the fauna of the site by weight categories reveals that more than half of the marks (57.72 %) are located on remains of Size 2 animals. This percentage is mainly represented by *R. pyrenaica*, but not exclusively, as there are also gnawed remains of *C. lupus*. In any case, it should be noted that this size group is also the most represented on the site (40 %). By comparing the %NISP of each weight group with the percentage of modifications caused by carnivores within each of these groups, a strong and statistically significant positive correlation is observed ($r = 0.9998$; p-value $= 0.0002$). Therefore, it can be stated that all the taxa present at the site have been altered by carnivores, and there is no size preference. When calculating the percentage of remains from each weight group affected by this agent, all show a percentage around 10–12 %.

The most abundant marks left by carnivores consist of scores ($n = 69$; 56.01 %), pits/punctures ($n = 50$; 40.65 %), crenulated edges ($n = 44$; 35.78 %), and digested remains ($n = 40$; 32.52 %). Some specimens also show thinning ($n = 7$; 5.69 %), furrowing ($n = 12$; 9.76 %), and scooping out ($n = 12$; 9.76 %). Bones fragmented by carnivores mainly correspond to Size 1 or Size 2 animals, although there are also some tooth-marked Size 3 remains that were likely fragmented during consumption (6.81 %). Similarly, all the pieces that show evidence of having been digested and/or regurgitated correspond to phalanges, small joint elements, or very small bones, such as those from leporids. These pieces range in size from 9 to 48 mm in maximum length, although the average is around 23 mm. In general terms, the skeletal region most affected by carnivore activity is the lower appendicular skeleton (34.15 %), followed by the upper appendicular (19.51 %), axial (9.76 %), and cranial skeleton (7.32 %), though with a relatively high percentage of indeterminate remains (28.27 %). Nevertheless, just over half of these indeterminate remains (52.78 %) correspond to long bones, indicating that the limbs remain the dominant part affected.

Measurements were taken of all the pits identified and considered representative, excluding those that are only partially preserved or where part of their area is affected by other alterations (Supplementary file 1). Average dimensions obtained are 1.43 mm in length, with a range from 1.09 to 1.77 mm within a 95 % confidence interval, and 1.26 mm (0.94 – 1.57 mm) in width for marks on dense cortical tissue; 1.03 mm (0.44 – 1.62 mm) in length and 0.85 mm (0.38 – 1.31 mm) in width for marks on fine cortical tissue; and 1.32 mm (1.05 – 1.58 mm) in length and 1.16 mm (0.87 – 1.44 mm) in width for marks made on epiphyses. When comparing the marks on dense cortical tissue –the most numerous and statistically significant- with those made by potential carnivores responsible for the accumulation based on available neotaphonomic data (*Crocuta crocuta, Canis lupus, Canis familiaris, Vulpes vulpes, Meles meles, Panthera leo*, and *Ursus arctos*) (Andrés et al., 2012; Arilla et al., 2019b; Domínguez-Rodrigo and Piqueras, 2003), the marks produced at the site correspond to a very small-sized carnivore (Size 1), which could align with the values for *Vulpes vulpes* or *Meles meles*.

There are two specimens in which both anthropic marks and carnivore marks are present, although in neither case do the marks directly overlap, so it is not possible to know with certainty which agent acted first. In any case, in both pieces, the anthropic activity consists of incisions, and the carnivore activity results in the fragmentation of the piece. It is reasonable to think that the primary access was made by the hunter-gatherers, who would have disarticulated or extracted the meat from that part of the animal and then abandoned the bones, which would later have been acted upon by a carnivore scavenging any remaining flesh or marrow in the piece.

5. Discussion

5.1. Human and non-human subsistence at Valdavara 1

From a taxonomic and taphonomic perspective, the assemblage from Valdavara 1 presents a complex history that characterizes it as a palimpsest. The formation of the archaeological record involved both hunter-gatherer groups and several carnivore taxa, with interventions taking place on the same species and, at times, even on the same specimens. As a result, distinguishing between these episodes of occupation –likely interspersed over short periods- is far from straightforward.

Human presence at the site is evidenced by the substantial assemblage of lithic tools recovered, as well as by the worked bone and ornamental elements made from animal materials, which is the richest such assemblage in the Galician Palaeolithic record. However, despite the abundance of these elements, the faunal analysis has yielded only a limited number of clear indicators of human activity, with just 5.92 % of the remains showing unequivocal signs of anthropogenic modification. Several factors may explain this discrepancy. The small size of the cave could have posed a limitation on the introduction of entire carcasses for processing, especially if other activities –as suggested by the presence of knapping evidence and at least one hearth- were taking place concurrently. Another important aspect is the functional interpretation of the lithic assemblage, which appears to be more oriented toward domestic activities and shows an underrepresentation of hunting-related tools. This might suggest that the groups of hunter-gatherers that occupied Valdavara 1 did not conceive the cave as a hunting post and that the faunal remains represent more of a daily subsistence strategy rather than a concerted effort to procure food resources.

This site presents several characteristics that define Magdalenian accumulations in the region, such as diet diversification through the incorporation of "secondary" resources, like marine and freshwater resources (Fuente Fernández et al., 2018; Yravedra, 2002a), or in this case,

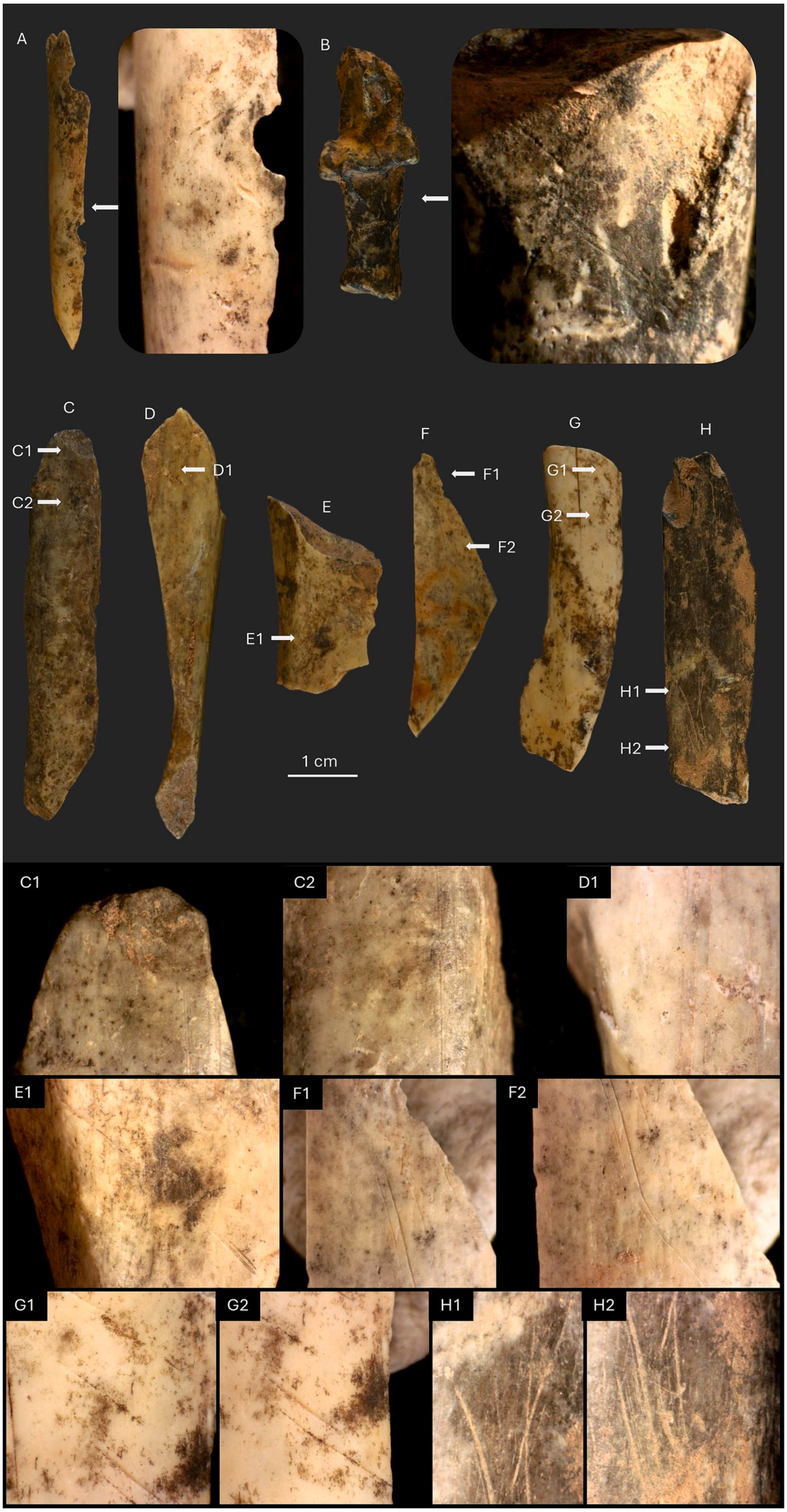

Fig. 6. Selection of cutmarked remains from Valdavara 1 Levels 4-6. A) Size 1 animal with incisions. B) *Lepus* sp. calcaneus (*sin*) with incisions. C-H) Size 2 animal long bones with incisions and scraping marks. Magnified images are shown at 10X.

Table 4
Taphonomic evidence associated with anthropic and carnivore activity on the analysed bone assemblage, expressed in terms of number of identified specimens (NISP). The size categories included in this table comprise remains from both partially identified remains (i.e. Size 2 ungulate), as well as indeterminate remains. CE=*Cervus elaphus*; RU=*Rupicapra pyrenaica*; EF=*Equus ferus*; CL=*Canis lupus*; VV=*Vulpes vulpes*; MU=Mustelidae; OC=*Oryctolagus cuniculus*; LE=*Lepus* sp.

	CE		**RP**		**EF**		**CL**		**VV**		**MU**		**OC**		**LE**		**Size 4**		**Size 3**		**Size 2**		**Size 1**		**Indet.**	
	AN	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**	**AN**	**CV**
Cranial	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Mandible	-	2	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Vertebrae	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ribs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	2	-	-	-	-
Scapula	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	-	-
Coxal	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-
Humerus	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	-	-
Radius	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-
Ulna	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Femur	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-
Tibia	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	3	-	1	-	-
Long bone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	17	17	1	1	-	-
Patella	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Metapodium	1	-	-	5	-	-	-	-	-	2	-	-	-	2	-	3	-	-	-	-	-	-	-	2	-	-
Phalanges	-	-	-	18	-	-	-	2	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Carpal/Tarsal	-	-	-	1	-	1	-	-	-	1	-	-	-	1	1	1	-	1	-	-	-	-	-	-	-	-
Indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	16
TOTAL	1	5	0	38	0	1	0	3	0	4	0	1	0	7	1	7	1	1	2	1	20	31	1	8	5	16

lagomorphs; or low specialization, which has traditionally been interpreted as the result of the exploitation of multiple ecological niches from the site (González Sainz, 1986; González Sainz and González Urquijo, 2004). In any case, it is difficult to interpret whether the low specialization of the diet of its inhabitants at Valdavara 1 is the result of exploiting several environments with different species, or if it stems from a low-intensity occupation of the area, perhaps due to temporal and spatial constraints. Another characteristic factor of the Magdalenian period that could be present at Valdavara 1 is the notable increase in the capture of fawns observed throughout the rest of the Cantabrian region, sometimes interpreted as an episode of predation on herds of mothers with their young (Menéndez Fernández and Quesada López, 2008; Yravedra, 2002a), similar to what happens in the lower Magdalenian levels of Las Caldas (Corchón Rodríguez et al., 2015). This situation could have occurred at Valdavara 1, as indicated by the presence of traces of human activity on the deer and the predominance of infantile individuals. However, since carnivores also act on these animals and the total number of remains is low, it is difficult to discern who the main contributor to the accumulation was.

Another important factor to consider when interpreting the extent of anthropogenic intervention in the assemblage is the potential loss of information due to post-depositional processes affecting the material. It is worth reiterating not only the high degree of fragmentation observed in the assemblage (93.95 %) and the ambiguity associated with many of the specimens exhibiting fresh fractures, but also the significant proportion of bones with damaged cortical surfaces (27.43 %) and those affected by trampling (35.81 %). Moreover, most of the identified cutmarks are very superficial, making it plausible that some of the original modifications have been erased or have lost the microfeatures that allow clear differentiation from marks made by non-human agents, such as internal microstriations (Domínguez-Rodrigo et al., 2009). On this point, experimental studies have demonstrated that even brief exposure to trampling can partially or completely erase the most superficial marks (Gaudzinski-Windheuser et al., 2010; Gümrükçü and Pante, 2018; Pizarro-Monzo and Domínguez-Rodrigo, 2020). To this, we must add the likely scenario in which the same assemblage processed by hunter-gatherers was later scavenged by various carnivores, including foxes –animals known for the high number of marks they leave on consumed remains- (Arilla et al., 2019a; Krajcarz and Krajcarz, 2014; Lloveras et al., 2012). However, experimental studies on the superimposition of marks from both agents suggest that while secondary access by carnivores can alter the trajectory or morphology of a cutmark, it generally does not lead to complete erasure (Blasco and Rosell, 2009; Camarós et al., 2017). Still, these studies focus primarily on scores and pits/punctures and do not address the impact of enzymatic activity or digestion on rounding and dissolution of the bone surfaces, nor do they consider differential fragmentation before and after carnivore intervention. In any case, the overlap between human and carnivore activity in the Valdavara 1 record is clearly attested by the presence of both cut marks and carnivore tooth marks on at least two specimens, even if the sequence of access cannot be firmly established.

The pattern of carnivore activity identified at the site reflects that, while it does not affect a large number of remains (13.59 %), it does show characteristics typical of intense exploitation of carcasses or isolated parts which are consumed, aligning with secondary scavenger access patterns (Haynes, 1980a, 1980b). For example, the fact that 57.14 % of the femurs of Size 2 animals found at the site are represented only by gnawed femoral heads, some of which are also digested, or the intensity with which the elements of the acropodium –especially phalanges- are modified (41.3 % in the case of Size 2 animals). The intensity of secondary exploitation of these remains, combined with the presence of juvenile and infant individuals in both *C. lupus* and *V. vulpes*, could indicate that the cavity functioned as a den for these species. Moreover, metric analysis of pits attributes the marks to a very small carnivore (Size 1), aligning with the size ranges of *V. vulpes* and *M. meles* (Arilla et al. 2019a). Among these two taxa, the attribution to the fox is more

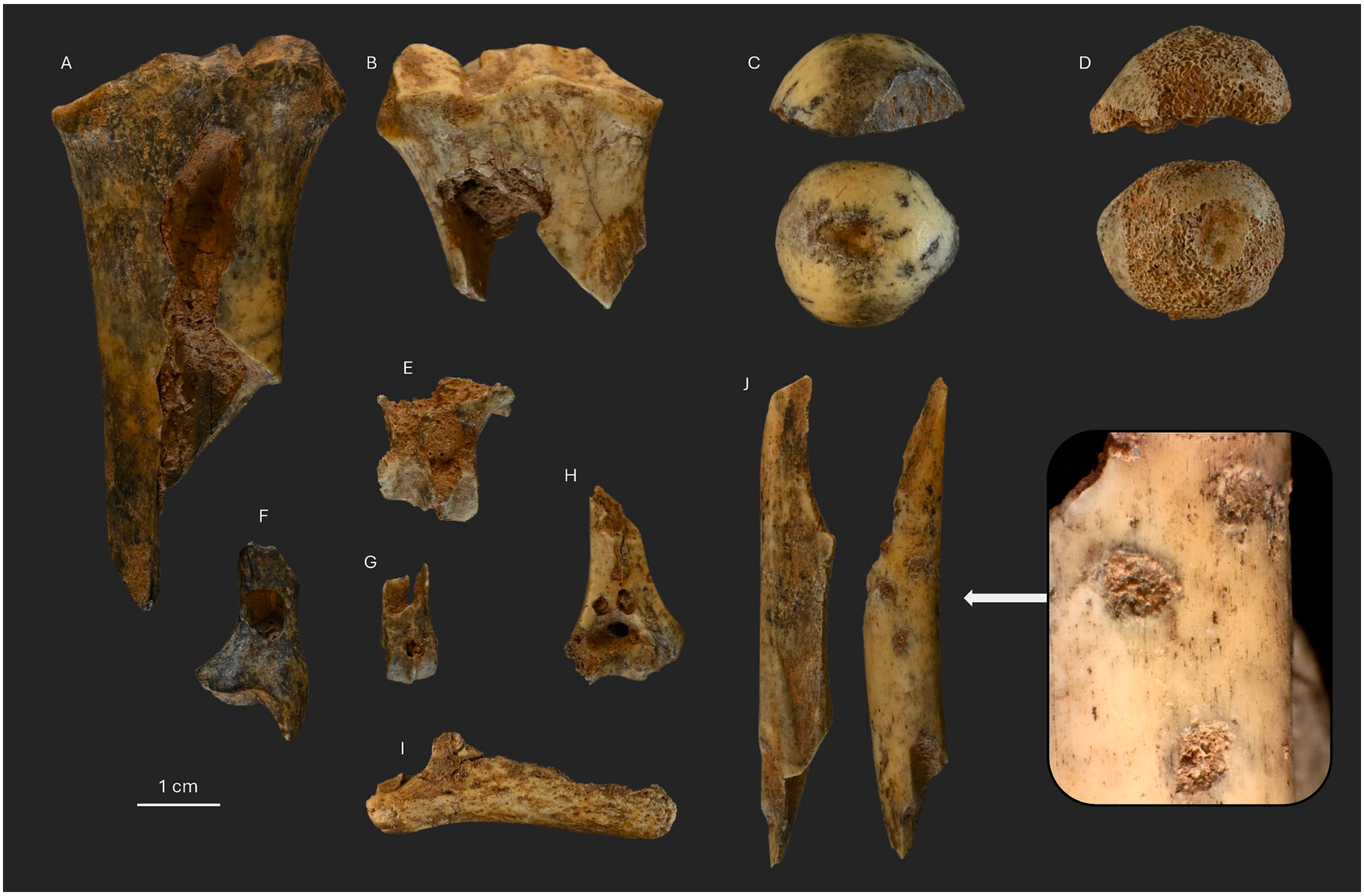

Fig. 7. Selection of bone remains with toothmarks and digestion traces. A) *Rupicapra pyrenaica* radius (*dex*). B) *Rupicapra pyrenaica* radius (*sin*). C) Size 2 ungulate femur (*dex*). D) Size 2 ungulate femur (*dex*). E) *Rupicapra pyrenaica* metapodial. F) *Lepus* sp. scapula (*dex*). G) *Vulpes vulpes* metapodial. H) *Erinaceus europaeus* humerus (*dex*). I) *Rupicapra pyrenaica* distal phalanx. J) *Rupicapra pyrenaica* radius (*dex*). Magnified images are shown at 10X.

likely. The main reason is that badgers do not digest the bone remains of the animals they consume, even when their diet consists of leporids, the percentage of remains with corroded marks is minimal (Arilla et al., 2019b). Meanwhile, for the fox –although there is debate due to some contemporary studies in which no digested remains are recovered (Krajcarz and Krajcarz, 2014)- most studies point to low or moderate percentages (≤15 %), especially when it comes to remains of leporids (Gabucio et al., 2024; Lloveras et al., 2010, 2012; Sanchis Serra, 2000). Another reason is that foxes have a more notable presence at the site, with a minimum of five individuals, at least two of which are immature, which likely indicates that the cavity served as a den for this species. The badger is not identified at the species level –although mustelid remains have been identified that would fit within its size range- but in any case, these are a much smaller group compared to other carnivores like the fox or the wolf.

However, attributing the authorship of these alterations to the fox poses some problems. Firstly, as previously mentioned, although it is an animal that digests part of the remains of its prey, the Valdavara 1 assemblage presents a much higher percentage of digested remains than what has been described in known fox accumulations (35.52 %) and is primarily composed of remains of chamois, not just leporids. This type of consumption raises doubts, as although it is well known that the fox consumes and even transports parts of small-sized ungulates (Krajcarz and Krajcarz, 2014; Mondini, 1995), none of the cases that address the fox's ability to digest bone remains report elements from such animals, only from leporids. The average size of 23 mm would not be problematic on its own, as it is a size manageable for the fox (Lloveras et al., 2012), but the pieces that exceed this size raise more doubts. This factor, combined with the fact that a taxon such as *C. lupus*, capable of digesting larger remains with no issues, is also present at the site, and that the anatomical pattern of digested remains at the site matches the one found in this animal's excrements (Barja Núñez and Corona, 2007; Esteban-Nadal et al., 2010; Fosse et al., 2012; Lloveras et al. 2020; Poulle et al., 1997), leads to the idea that both canids likely acted on the assemblage at different times. Another factor that would suggest the possible involvement of wolves as modifiers of the bone assemblage is the large number of chamois remains and similar-sized animals with fractures associated with the consumption of their remains. The wolf is an animal well-known for its bone-breaking ability, with the possibility to reach bone fracture percentages in fresh remains of up to 90 % (Domínguez-Rodrigo et al., 2012; Sala et al., 2014). In contrast, the fox's ability to break remains from such carcasses is mainly limited to axial elements (Arilla et al., 2019a), and in the analysed sample, there are appendicular elements with high resistance –such as radius or metapodial bones- broken transversely. In any case, it should be noted that all the studies used for comparison that analyse the fox's consumption pattern involve primary access to carcasses, so the intensity of exploitation is not as high as it would be in secondary exploitation, which seems to be the case in the sample presented here.

Finally, another aspect to analyse regarding the attribution of the assemblage to one predator or another is the seasonal pattern of the site. For both canids, it has been observed that the cavity was occupied during the months between the end of summer and the beginning of autumn. This period coincides with the time when wolves keep their pups at den sites (Blanco, 2011). In the case of ungulates, only one specific hunting event has been identified, also precisely between the end of summer and the beginning of autumn. Additionally, a minimum of 3 fawns has been contributed to the site between late spring and early summer, which could coincide with the period when the predators are present, as one of the jaws that provided this age shows dental imprints. This, combined with the fact that some studies have observed an increase in the proportion of chamois in the diet of wolves during the summer months (Poulle et al., 1997), and that the chamois at the site shows a pattern of live-structure, suggests that a significant portion of the remains were likely contributed to the site by this predator, either through the occasional transport of specific anatomical parts −supported by the abundance of appendicular elements-, by the possible remains indirectly provided through excrements, or by a combination of both. It is common to find acropodial elements of the chamois in the faeces, and this is precisely the anatomical group most affected by digestion at the site, which may explain why there are not as many dental marks from this animal as there are from the foxes.

From this perspective, the wolf would be both a primary and secondary consumer, possibly contributing part of the carcasses indirectly through excrements, except in rare cases that could involve occasional scavenging or the transport of specific anatomical sections. The fox's role, on the other hand, would be limited to secondary exploitation only. This animal would act as an occasional visitor, scavenging the remains abandoned by the other agents and, for this reason, being present through the intense exploitation of the carcasses. This fits with the commensal relationship that these two predators still maintain today, with it being common for foxes to exploit the same areas as wolves (Lazzeri et al., 2024), and foxes often benefiting from this relationship by scavenging carcasses abandoned by wolves (Selva et al., 2005).

The key question that remains unsolved is whether the destruction pattern of the remains of the main species −*R. pyrenaica*- resulted from exploitation by hunter-gatherers and carnivores, or rather from post-depositional processes. At first glance, the high number of green bone fractures seems to support the former hypothesis. To investigate further, the anatomical representation of chamois remains from Valdavara 1 was compared with that of ibex from the palaeontological site of Los Batanes (Huesca), a natural trap site unaffected by predator activity (Sauqué et al., 2018) (Fig. 8). When comparing the correlation indices of both assemblages against the bone density of *Ovis aries* (Lyman, 1984), both exhibit a positive correlation, though it is significantly lower for Valdavara 1 (r = 0.24; p-value = 0.0012) than for Los Batanes (r = 0.6; p-value = 0.0002). Moreover, a negative correlation is observed when comparing the values between the two sites (r = -0.19; p-value = 0.0013), suggesting that preservation at Valdavara 1 is not solely conditioned by bone survivability. When both sites are compared with the "expected" pattern of preservation based on bone density, it becomes clear that while Los Batanes closely mirrors that expectation, Valdavara 1 displays notable deviations in %MAU. In Valdavara 1, while the upper appendicular elements −except for the ulna- align with what would be expected in a natural accumulation, cranial, axial, and lower appendicular elements are underrepresented. The patella, conversely, is the only element that is overrepresented at the site despite its relatively low density (64.71 %), whereas elements with much higher density, like the metacarpal (98.53 %), are scarcely present. The overrepresentation of patellae has been noted at other sites dominated by chamois, such as Aitzbitarte III (Altuna and Mariezkurrena, 2011) and Amalda (Yravedra, 2006b, 2007, 2010b). Although these sites represent accumulations of different origins, in the case of Amalda, this overrepresentation has been attributed to carnivore activity. Carnivores tend to heavily fragment femurs and tibias due to their meat and marrow content, whereas the patella, which offers no caloric value, is often left untouched.

5.2. Occurrence and exploitation of chamois at Cantabrian archaeological sites

The Valdavara 1 faunal assemblage presents the typical characteristics of a site located in a mountainous environment, dominated by an

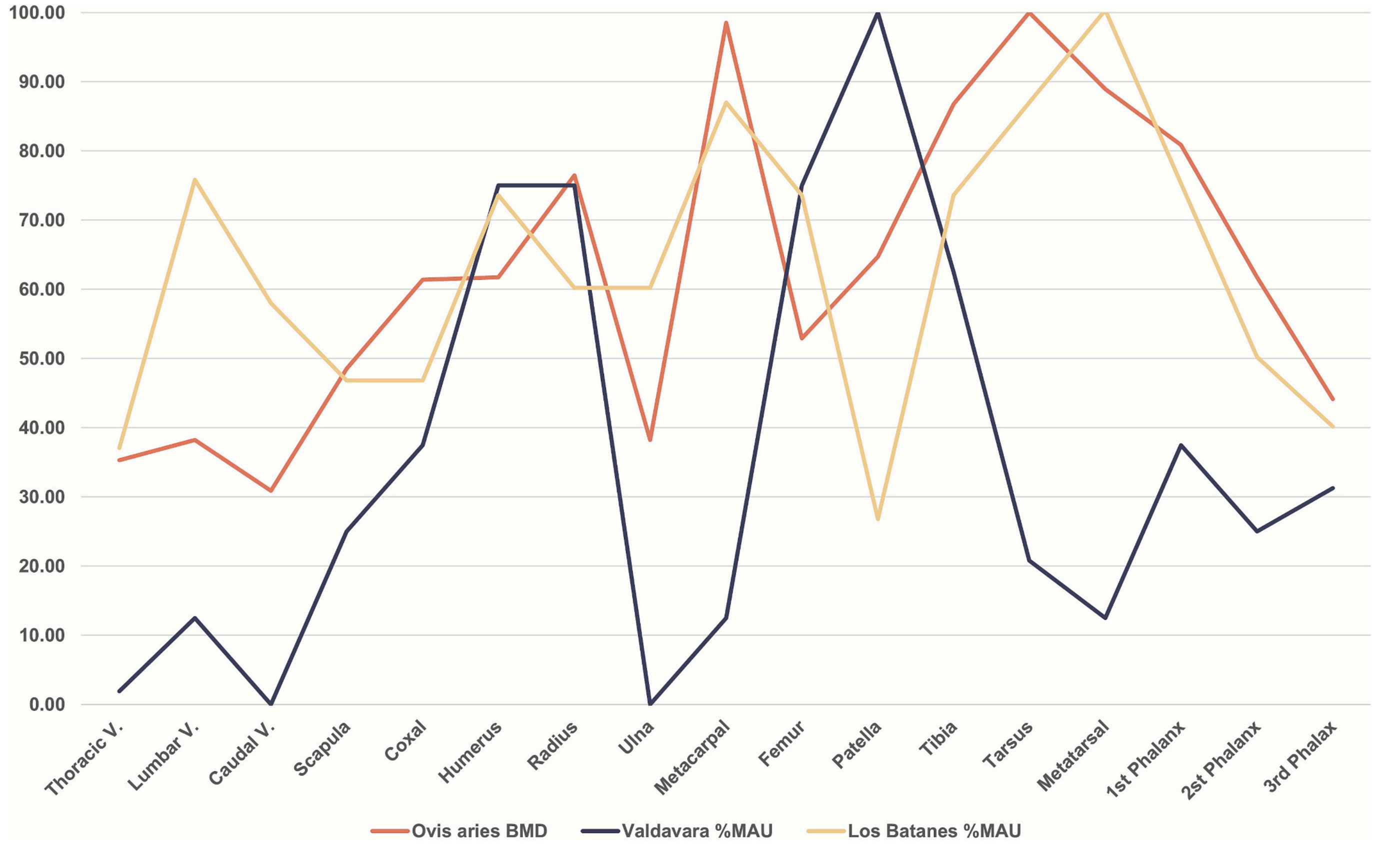

Fig. 8. Comparison of the anatomical representation in terms of %MAU of Rupicapra pyrenaica in Valdavara 1 with %MAU of Capra pyrenaica from the palaeontological site of Los Batanes (Sauqué et al., Yravedra et al., 2017) and the Bone Mineral Density (BMD) values of Ovis aries (Lyman, 1984).

alpine taxon such as *R. pyrenaica*. This, although not uncommon in the Pleistocene Cantabrian record (Fig. 9), is noteworthy because few sites in the northern peninsula have chamois as a dominant taxon. It is much more common for red deer or, less frequently, ibex to dominate (Altuna, 1992; Álvarez Lao, 2003; Castaños Ugarte, 2005; Martínez-Moreno, 2005; Quesada López, 1995; Yravedra, 2002a, 2002b). In the post-LGM western Cantabrian region, chamois only represents the main taxon at El Buxu (Rojo Hernández and Menéndez Fernández, 2012), where its presence is not attributed to hunting. There are also several sites where chamois reaches a considerable –but secondary- importance, such as Coímbre (López-Cisneros et al., 2019b), Las Caldas (Corchón Rodríguez et al., 2015; Mateos Cachorro, 2002) or La Güelga, where it is surpassed by *C. pyrenaica* (Fuente Fernández et al., 2018). In the rest of the region, its presence is also cited as a residual component of the faunal spectrum at La Lluera (López-Cisneros et al., 2019a; Mielgo et al., 2022), La Riera (Straus, 1983; Straus and Clark, 1986), La Viña (Torres-Iglesias et al., 2022), Tito Bustillo (Moure Romanillo, 1990), Cueto de la Mina (Straus, 1983), Peña de Candamo (Straus, 1983) or Les Pedroses (Martínez-Villa et al., 2022) among others. In the central and eastern part of the Cantabrian region, it is neither an abundant species, except in specific cases such as Hornos de la Peña (Yravedra, 2010a), Aitzbitarte III (Altuna and Mariezkurrena, 2011), Abauntz (Utrilla Miranda, 2004), El Esquilleu (Yravedra, 2006a; Yravedra et al., 2014), Ermittia (Altuna, 1972), or Urtiaga (Altuna, 1972), although it is again usually surpassed by ibex. In the MIS 3 chronology, large accumulations of chamois are not recorded either (Yravedra and Cobo-Sánchez, 2015). It has only a notable presence at the sites of Llonín (Sanchis et al., 2019), Amalda (Yravedra, 2010b, 2007, 2006b) and, again, La Güelga (Menéndez et al., 2018) and Aizbitarte III (Altuna and Mariezkurrena, 2011). It is also important at the Valdegoba site, located south of the Cantabrian Mountains range, where the chamois accumulation is undoubtedly attributed to hunter-gatherers (Diez Fernández-Lomana, 2006). Lastly, the *Rupicapra* archaeological record is also noteworthy in the Basque site of Axlor, though it is far behind the primary taxa of the site (*C. elaphus, E. ferus,* and *Bos/Bison*) (Altuna, 1972). In most sites, the appearance of *Rupicapra* is often linked to carnivore activity, as seen in the cases of El Buxu, Amalda, or Llonín, the latter two linked to leopard activity. Nevertheless, the exploitation of this animal has occurred in the region since the Middle Palaeolithic, evidenced in sites like Valdegoba. In other cases, such as Hornos de la Peña or El Esquilleu, depending on the level, the incorporation of chamois into the record is the result of either human or carnivore activity.

According to Yravedra and Cobo-Sánchez (2015), one of the factors limiting the presence of chamois at archaeological sites in the region is the topography, with its distribution being conditioned by the presence of rocky escarpments or significant altitudinal differences. In the case of Valdavara 1, the surrounding environment does not fully align with the type of terrain described by these authors: although the area features steep slopes and limestone formations, it is generally characterized by a relatively gentle relief. However, it is important to note that the site lies in a transitional zone between the heights of the Serra dos Ancares –which reaches elevations of up to 1800–1900 m.a.s.l.- and the valleys of the Narón and Navia rivers, situated at a more modest 300 m.a.s.l. The landscape, overall, is undulating. Nevertheless, the ecology of the chamois must be considered. This is a species that undertakes seasonal migrations, alternating between high-altitude alpine pastures in the summer and descending to lower mountain areas and surrounding valleys in the winter, in environments that ideally combine forested and subalpine pasture areas (Crampe et al., 2007; García-González, 1985; Pérez-Barbería and Pérez-Fernández, 2009). The Valdavara 1 setting seems to meet chamois climatic and topographical preferences quite well. Palaeoenvironmental reconstruction at the site based on the microfaunal assemblage (López-García et al., 2011) –although based on preliminary data- reflects a landscape dominated by forest (36–39 %) but in which rocky areas also play an important role (10–21 %), particularly due to the high abundance of *Chionomys nivalis* (MNI = 20; 15.62 %). This would place Valdavara 1 clearly within a forest-dominated environment, yet not far from the alpine zone, likely attracting chamois during their winter migrations. At the same time, it would be located within a short distance of the summer pastures, given that the species' seasonal movements typically span only a few kilometres (Crampe et al., 2007).

Aside from the chamois, the remaining taxa present at the site reflect the typical species found in Late Upper Pleistocene sites of the Cantabrian region (Altuna, 1992; Álvarez Lao, 2003; Rasilla Vives and Guy Straus, 2004; González Sainz and González Urquijo, 2004). What stands out more is the abundant presence of leporids, animals that are rarely found in the Cantabrian region both during the Pleistocene and nowadays (Palomo et al., 2007). Only at Level 1 of the Coímbre cave do they reach notable representation (Yravedra et al., 2019). Nevertheless, the Galician territory appears to show a different pattern from the rest of the Cantabrian region when it comes to these animals. To varying degrees, leporids are present at all known Palaeolithic archaeological sites in Galicia: Cova Eirós (Bal-García et al., 2025; De Lombera-Hermida et al., 2021), Valdavara 3 (Vaquero et al., 2018), and above all at A Valiña, where they are the most abundant taxon with 82.3 % of all identified remains and showing evidence of punctual human exploitation (Fernández-Rodríguez et al., 2018). This scenario is not seen at any other site in northern Iberia. For example, although numerous in Coímbre (MNI = 43), they still fall well behind the main taxon, *C. pyrenaica* (MNI = 73). In the case of Valdavara 1, with a combined MNI of 6 lagomorphs occupy the third place in abundance, closely following *R. pyrenaica* (MNI = 8) and *U. arctos* (MNI = 7).

Comparison with other sites becomes problematic since few share

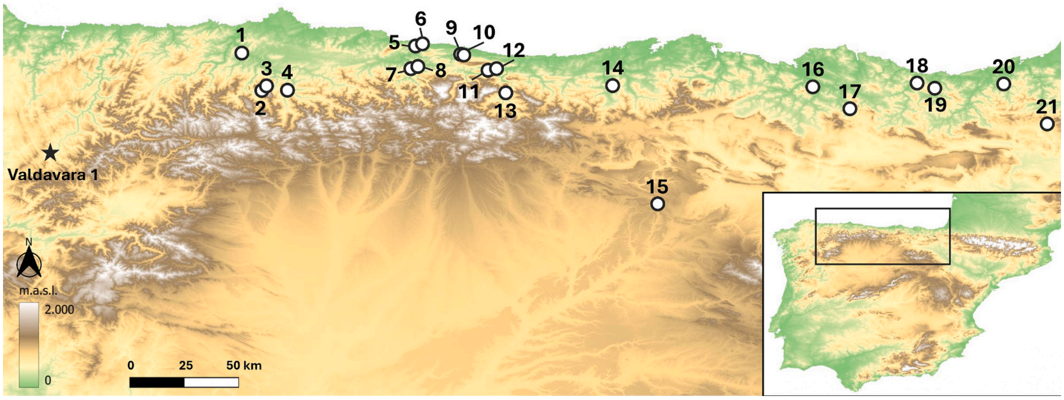

Fig. 9. Sites in northern Iberia bearing substantial accumulations of *Rupicapra pyrenaica* mentioned on the text. 1) Peña de Candamo, 2) La Lluera, 3) Las Caldas, 4) La Viña, 5) Les Pedroses, 6) Tito Bustillo, 7) La Güelga, 8) El Buxu, 9) La Riera, 10) Cueto de la Mina, 11) Coímbre, 12) Llonín, 13) El Esquilleu, 14) Hornos de la Peña, 15) Valdegoba, 16) Urtiaga, 17) Axlor, 18) Ermittia, 19) Amalda, 20) Aitzbitarte III, 21) Abauntz.

the same characteristics. Coímbre (López-Cisneros et al., 2019b; Yravedra et al., 2019, Yravedra et al., 2017) is the site with the most similarities to Valdavara 1 in terms of anthropic exploitation: a faunal spectrum dominated by an alpine bovid (*C. pyrenaica* in the case of Coímbre) and complemented by the occasional exploitation of other typical taxa (*C. elaphus, E. ferus,* etc.) and leporids. However, in the case of Coímbre the exploitation is much more intense, with around 20 % of the remains of each taxon on average, and carnivore activity is almost negligible. In the case of El Buxu (Rojo Hernández and Menéndez Fernández, 2012), the similarities between the two sites become more marked: a clear predominance of *R. pyrenaica* (although less statistically important in Valdavara 1 due to the higher number of carnivores at the site); a smaller but significant presence of *C. elaphus*, and fewer remains of other ungulate taxa, along with a few significant remains of *C. lupus* and *V. vulpes*. The age profile of the ungulates is again very similar between the two sites, characterized by a chamois population with a herd structure, with a good representation of older individuals (<96 months), and for the deer, a clear predominance of immature individuals. Lastly, there are also taphonomic similarities between the two assemblages, with evidence of exploitation by both hunter-gatherers and carnivores on the chamois (if we account for Size 2 ungulates at Valdavara 1), but with carnivore marks being much more frequent; whereas for the deer, despite some occasional intervention by carnivores, most pieces show evidence of having been brought by humans. The interpretation made by the authors of El Buxu is similar to that drawn from this study for Valdavara 1: an anthropic occupation that is partially blurred by the also significant presence of carnivores in the cavity, although in Valdavara 1, the wolf occupation would be placed between summer and autumn, while in El Buxu it is attributed to autumn and spring.

In any case, both the results of the faunal analysis presented here and those obtained by Alonso-Fernández & Vaquero (2024) for the lithic assemblage converge in indicating a low-intensity occupation model, involving one or several short-term occupations. This agrees in broad terms with the secondary-camp model proposed by Álvarez-Alonso et al. (2014) based on the record from the also Middle Magdalenian site of El Olivo and, more recently, with the protocol proposed by Lubrano et al. (2025) to distinguish sites with short-term occupations from those with a steadier presence. Regarding the faunal remains and despite observing an apparent predominance of chamois on the exploited assemblage, the fact that most of the cut-marked bones are either indeterminate or identified only to broad body-size categories hinders a detailed understanding of the exploitation strategies. However, the low number of cutmarks, along with their distribution across various taxa without clear specialization, agrees with this model of a varied hunting spectrum proposed for short-term occupations, which in this case would reflect the species available in the sités immediate surroundings, thereby accounting for the pronounced similarity between the human and non-human subsistence patterns.

5.3. Cultural links during the Early-Middle Magdalenian in northern Iberia

Apart from the ecological and ethological similarities highlighted by both the faunal spectrum of the site and the exploitation strategies of its occupants, the Valdavara 1 site shares further connections with the rest of the Cantabrian region, especially through the artistic and industrial evidence. It should be noted that most of these elements are extremely abundant in assemblages not only from the Cantabrian region but from the entire Iberian Peninsula. For example, the case of the perforated deer canines, which are present in the European record from the earliest artistic manifestations of the Upper Palaeolithic through to post-Palaeolithic chronologies (Boric and Cristiani, 2019); or the use of *Antalis* as ornaments, which −although not as common as pendants made from *Littorina obtusata* or *Littorina fabalis* shells- (Álvarez Fernández, 2006) is well-represented in contexts from both the Cantabrian and the Mediterranean areas (Álvarez-Fernández, 2014). In any case, the presence of these shell ornaments in Valdavara 1, located 60 km in a straight line from the current coastline, provides information about the movements and/or connections of the Valdavara 1 hunter-gatherers with other groups in the region.

In the case of the bone industry, the square-sectioned spear-point is considered one of the key indicators of the Lower Magdalenian in the Cantabrian region, being common in sites with levels corresponding to this period, such as La Paloma, El Cierro, La Riera, or Cueto de la Mina, in the neighbouring region of Asturias, as well as in sites from the eastern and Franco-Cantabrian sectors (Tapia et al., 2018). Regarding the plano-convex rod, which has more specific artistic implications than the spear-point, it is interesting that the same type of decoration is present in sites at the opposite end of the Iberian Peninsula −such as Isturitz and Mas d'Azil- where this motif is considered a characteristic element of the Middle Magdalenian (Lucas, 2014; Sauvet, 2019), although it is also present in closer contexts like Cueto de la Mina or Las Caldas (Corchón Rodríguez et al., 2015). Finally, the step-like motif identified on an indeterminate bone fragment also has numerous parallels throughout the entire Franco-Cantabrian region, particularly at Abauntz, where it is the most common motif during the Middle Magdalenian occupation, although it is a frequent motif in the region throughout all subphases of the Magdalenian (Duarte Matías et al., 2012). Despite the abundance of parallels, the site most closely related to this assemblage seems to be La Paloma. This site happens to be part of the group of sites in the Nalón basin, the closest to Valdavara 1 geographically. In the industrial and artistic assemblage from La Paloma (Barandiarán, 1971), several of the motifs defined at Valdavara 1 are present, such as the step-like motif from the indeterminate fragment or the decoration in the form of sharp angles on the spear-point. Both sites also share the presence of pendants made from deer canines, though less significantly due to the abundance of such items in the Palaeolithic of all Europe. Lastly, an element absent at Valdavara 1 but that again establishes connections with the Galician Magdalenian is the stone pendant recovered at La Paloma, consisting of a flattened stone cobble with incised decoration on the sides, closely resembling the specimen described from Férvedes II (Villar Quinteiro, 1997).

6. Conclusions

The zooarchaeological study of the Valdavara 1 site provides a valuable contribution to the understanding of the Late Glacial period in Northwest Iberia and has helped to offer a perspective that was still lacking in the study of this period in the region: the faunal record and subsistence strategies. The record, dominated by *R. pyrenaica*, reflects an ecotone where the wooded areas of the lower valleys of the Narón river converge with the Alpine environment of the *Serra dos Ancares*. The subsistence of both hunter-gatherers and carnivores focused on a diversified hunting strategy, centred on the exploitation of locally abundant species. The notable representation of leporids, unusual in the Cantabrian context, and the diversity of taxa present at the site evidence a varied exploitation of resources shared by both agents. However, only a small percentage of the remains show direct anthropogenetic modifications (5.92 %), suggesting a low-intensity exploitation or a compartmentalization of space, where the cave itself may not have served as the primary location for most carcass exploitation tasks, possibly due to its small size and the development of other domestic activities inside the cave, as evidenced by the lithic record.

On the other hand, the moderate amount of remains modified by carnivores (13.91 %) reflects the numerous episodes of occupation that occurred within a short period of time at the site, evidenced by the presence of remains brought by hunter-gatherers and later scavenged by *V. vulpes*. In addition to the possible use as a den by foxes, there is also evidence that both *U. arctos* and especially *C. lupus* also occupied Valdavara 1 at different times. Marks on the same taxa and even on the same bone specimens evidence a complex overlap of human and animal occupation, characteristic of a palimpsest.

Finally, the bone tools and personal ornaments place Valdavara 1 as a key site within the NW Iberia Magdalenian, with clear cultural connections to the Franco-Cantabrian region and especially to the nearby Nalón valley, in a dynamic of coastal-inland seasonal movements that would have led to the occupation of secondary campsites (Álvarez-Alonso et al., 2014). All of this highlights the importance of the site in understanding the occupation strategies and symbolic behaviour of the hunter-gatherer groups at the Late Glacial period in the NW Iberian Peninsula.

Funding

HBG is supported by the grant Ayudas para contratos predoctorales para la formación de doctores (PRE-2020-095452) funded by MCIN/AEI/10.13039/501100011033 and "FSE invierte en tu futuro". This paper contributes to the project PID2022-142337NB-I00 (Ministerio de Ciencia e Innovación, Gobierno de España). The archaeological excavations at Valdavara 1 Cave were funded by the Concello de Becerreá.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank all the students and volunteers who have participated in the archaeological excavation of the site between 2007 and 2013. As well as the editors of this special volume for including our contribution. We are also grateful to Alberto López Pérez, the owner of the property where the site is located, for permitting us to carry out the archeological excavations.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2025.105486.

Data availability

Data will be made available on request.

References

Alonso-Fernández, E.S., Vaquero, M., 2024. Ocupaciones magdalenienses en el extremo noroccidental de la Península Ibérica: la cueva de Valdavara (Becerreá, Lugo). In: Bernal Gómez, M.A. (Ed.), Magdaleniense. Iberia Tras El Último Máximo Glacial, Almuzara, Córdoba, pp. 125–150.

Altuna, J., 1992. El medio ambiente durante el Pleistoceno Superior en la región Cantábrica con referencia especial a sus faunas de mamíferos. MUNIBE (Antropologia-Arkeologia) 43, 13–29.

Altuna, J., 1972. Fauna de mamíferos de los yacimientos prehistóricos de Guipúzcoa, con catálogo de los mamíferos cuaternarios del Cantábrico y del Pirineo occidental. Munibe 24, 1–464.

Altuna, J., Mariezkurrena, K., 2011. Estudio de los macromamíferos del yacimiento de Aitzbitarte III (excavación de la entrada), in: Ocupaciones Humanas En Aitzbitarte III (País Vasco) 33.600 - 18.400 BP (Zona de Entrada a La Cueva). 395–480.

Álvarez Fernández, E., 2006. Los Objetos de adorno-colgantes del Paleolítico superior y del Mesolítico en la cornisa cantábrica y en el valle del Ebro: una visión europea. Universidad de Salamanca, Salamanca.

Álvarez Lao, D.J., 2003. Macromamíferos fósiles del Pleistoceno de Asturias. Revisión bibliográfica y datos actuales. Naturalia Cantabricae 2, 11–23.

Álvarez-Alonso, D., de Andrés, M., Álvarez, E., García-Ibaibarriaga, N., Jordá Pardo, J.F., Rojo, J., 2014. Los "campamentos secundarios" en el Magdaleniense cantábrico: resultados preliminares de la excavación en la Cueva del Olivo (Llanera, Asturias), in: Corchón, M.S., Menéndez, M. (Eds.), Cien Años de Arte Rupestre Paleolítico. Centenario del Descubrimiento de La Cueva de La Peña de Cándamo (1914-2014). Ediciones Universidad de Salamanca, Salamanca, 359–368.

Álvarez-Fernández, E., 2014. Un siglo de hallazgos: evidencias arqueozoológicas de origen marino en el Paleolítico superior asturiano, in: Los Grupos Cazadores-Recolectores Paleolíticos Del Occidente Cantábrico. Estudios en Homenaje a Francisco Jordá Cerdá en el Centenario de su Nacimiento. 1914-2014. Universidad Nacional de Educación a Distancia, Centro Asociado de Asturias, 265–282.

Anders, U., von Koenigswald, W., Ruf, I., Smith, B.H., 2011. Generalized individual dental age stages for fossil and extant placental mammals. Palaontol Z 85, 321–339. https://doi.org/10.1007/s12542-011-0098-9.

Andrés, M., Gidna, A.O., Yravedra, J., Domínguez-Rodrigo, M., 2012. A study of dimensional differences of tooth marks (pits and scores) on bones modified by small and large carnivores. Archaeol. Anthropol. Sci. 4, 209–219. https://doi.org/10.1007/s12520-012-0093-4.

Andrews, P., Cook, J., 1985. Natural modifications to bones in a temperate setting. Man, New Series 20, 675–691. https://doi.org/10.2307/2802756.

Andrews, P., Turner, A., 1992. Life and death of the Westbury bears. Ann. Zool. Fennici 28, 139–149.

Arilla, M., Rosell, J., Blasco, R., 2019a. Contributing to characterise wild predator behaviour: consumption pattern, spatial distribution and bone damage on ungulate carcasses consumed by red fox (Vulpes vulpes). Archaeol. Anthropol. Sci. 11, 2271–2291. https://doi.org/10.1007/s12520-018-0675-x.

Arilla, M., Rufà, A., Rosell, J., Blasco, R., 2019b. Small carnivores' cave-dwelling: neo-taphonomic study of a badger (Meles meles) sett and its archaeological implications. Hist. Biol. 32, 951–965. https://doi.org/10.1080/08912963.2018.1558449.

Azorit, C., Analla, M., Carrasco, R., Calvo, J.A., Muñoz-Cobo, J., 2002. Teeth eruption pattern in red deer (Cervus elaphus hispanicus) in southern Spain. An. Biol. 24, 107–114.

Azorit, C., 2011. Guía para la determinación de la edad del ciervo ibérico (Cervus elaphus hispanicus) a través de su dentición: revisión metodológica y técnicas de elección. ANALES 24, 235–264.

Bal-García, H., Rey-Rodríguez, I., de Lombera-Hermida, A., Díaz-Rodríguez, M., Fernández-Rodríguez, C., Rodríguez-Álvarez, X.P., Valcarce, R.F., 2025. Landscape and subsistence in NW Iberia during the Middle Palaeolithic (MIS3): Faunal analysis of Cova Eirós (Triacastela, Galicia, Spain). J. Archaeol. Sci. Rep. 64, 105149. https://doi.org/10.1016/j.jasrep.2025.105149.

Barandiarán, I., 1971. La Cueva la Paloma (Asturias). Munibe 2 (3), 255–283.

Barja Núñez, I., Corona-M., E., 2007. Análisis de excretas desde la etología y la arqueozoología. El caso del Lobo Ibérico, in: Corona-M. Eduardo, Arroyo-Cabrales, J. (Eds.), Human and Faunal Relationships Reviewed: An Archaeozoological Approach. Archaeopress, Oxford, 113–121.

Behrensmeyer, A.K., 1978. Taphonomic and ecology information from weathering. Paleobiology 4, 150–162.

Binford, L., 1981. Bones Ancient Men and Modern Myths, Academic Press. ed. Nueva York.

Blanco, J.C., 2011. Lobo - Canis lupus Linnaeus, 1758. In: Salvador, A., Cassinello, J. (Eds.), Enciclopedia Virtual de Los Vertebrados Españoles. Museo Nacional de Ciencias Naturales, Madrid.

Blasco, R., Rosell, J., 2009. Who was the first? An experimental application of carnivore and hominid overlapping marks at the Pleistocene archaeological sites. C R Palevol 8, 579–592. https://doi.org/10.1016/j.crpv.2009.06.003.

Blumenschine, R.J., Selvaggio, M.M., 1988. Percussion marks on bone surfaces as a new diagnostic of hominid behaviour. Nature 333, 763–765.

Boric, D., Cristiani, E., 2019. Taking Beads Seriously: Prehistoric Forager Ornamental Traditions in Southeastern Europe. PaleoAnthropology 208–239. https://doi.org/10.4207/PA.2019.ART132.

Brain, C.K., 1981. The Hunters or the Hunted? University of Chicago Press, Chicago, An Introduction to African Cave Taphonomy.

Brugal, J.P., Fourvel, J.B., 2024. Puncture game: let's play with the canines of carnivores. Quat. Sci. Adv. 13. https://doi.org/10.1016/j.qsa.2023.100129.

Camarós, E., Cueto, M., Teira, L.C., Ollé, A., Rivals, F., 2017. Walking with Carnivores: Experimental Approach to Hominin-Carnivore Interaction. In: Alonso Alcalde, R., Baena Preysler, J., Canales Camarero, D. (Eds.), Playing with Time: Experimental Archaeology and Study of the Past. Universidad Autónoma de Madrid, Madrid, pp. 159–164.

Capaldo, S.D., Blumenschine, R.J., 1994. A quantitative diagnosis of notches made by hammerstone percussion and carnivore gnawing of bovid long bones. Am. Antiq. 59, 724–748.

Castaños Ugarte, P.M., 2005. Revisión actualizada de las faunas de macromamíferos del Würm antiguo en la Región Cantábrica, in: Montes Barquín, R., Lasheras Corruchaga, J.A. (Eds.), Actas de La Reunión Científica: Neandertales Cantábricos, Estado de La Cuestión. Museo y Centro de Investigaciones de Altamira. Monografías No 17. Ministerio de Cultura, Santander, 201–207.

Coil, R., Yezzi-Woodley, K., Tappen, M., 2020. Comparisons of impact flakes derived from hyena and hammerstone long bone breakage. J. Archaeol. Sci. 120. https://doi.org/10.1016/j.jas.2020.105167.

Corchón Rodríguez, M.S., Ortega Martínez, P., Vicente Santos, F.J., 2015. El origen del Magdaleniense: una cuestión controvertida. La cueva de Las Caldas y los yacimientos del Nalón (Asturias, Norte de España). Munibe Antropologia-Arkeologia 66, 53–75. https://doi.org/10.21630/maa.2015.66.03.

Courtenay, L.A., Huguet, R., Yravedra, J., 2020. Scratches and grazes: a detailed microscopic analysis of trampling phenomena. J. Microsc. 277, 107–117. https://doi.org/10.1111/jmi.12873.

Crampe, J.P., Bon, R., Gerard, J.F., Serrano, E., Caens, P., Florence, E., Gonzalez, G., 2007. Site fidelity, migratory behaviour, and spatial organization of female isards (Rupicapra pyrenaica) in the Pyrenees National Park, France. Can. J. Zool. 85, 16–25. https://doi.org/10.1139/Z06-185.

Davis, S., 1987. The archaeology of Animals. Routledge, Londres.

Dobney, K., Rielly, K., 1988. A method for recording archaeological animal bones: the use of diagnostic zones. Circaea 5, 79–96.

Rasilla Vives, M., Guy Straus, L., 2004. El poblamiento en la Región Cantábrica en torno al Último Máximo Glacial: Gravetiense y Solutrense. KOBIE (Serie Anejos) 8, 209–242.

de Lombera-Hermida, A., 2011. Caves and people. Archaeological research at the Eastern margins of NW Iberia. In: de Lombera Hermida, A., Fábregas Valcarce, R. (Eds.), To the West of Spanish Cantabria: The Paleolithic Settlement of Galicia. British Archaeological Reports, Oxford, pp. 113–123.

de Lombera-Hermida, A., Rodríguez-Álvarez, X.P., Ameijenda Iglesias, A., Díaz Rodríguez, M., Rey-Rodríguez, I., Valverde Tejedor, I., Pérez-Alberti, A., Cunha, P.P., Bal García, H., Aldea Moreira, X., Lorenzo Salgueiro, C., Mosquera Castro, T., Fábregas Valcarce, R., 2021. Between two worlds: Cova Eirós and the Middle-Upper Palaeolithic transition in NW Iberia. C R Palevol 20, 859–886. https://doi.org/10.5852/cr-palevol2021v20a42.

de Lombera-Hermida, A., Rodríguez-Álvarez, X.P., Fábregas-Valcarce, R., 2014. El yacimiento arqueo-paleontológico de Cova Eirós (Triacastela, Lugo). In: Sala Ramos, R. (Ed.), Los Cazadores Recolectores Del Pleistoceno y Del Holoceno En Iberia y El Estrecho de Gibraltar. Universidad de Burgos, Burgos, pp. 25–28.

de Lombera-Hermida, A., Rodríguez-Rellán, C., Vaquero-Rodríguez, M., 2016. El sílex en el NW de la Península Ibérica. Un estado de la cuestión. CPAG 26, 137–155.

de Torres Pérez Hidalgo, T., 1988. Osos (Mammalia, Carnivora, Ursidae) del Pleistoceno Ibérico (U. deningeri Von Reichenau, U. spelaeus Rosenmüller-Heinroth, U. arctos Linneo): V. Dentición decidual, fórmula dentaria y dentición superior. Boletín Geológico y Minero XCIX, 660–714.

Debeljak, I., 1996. Ontogenetic development of dentition in the cave bear. Geologija 39, 13–77. https://doi.org/10.5474/geologija.1996.001.

Deevery, E.S., 1947. Life Tables for Natural Populations of Animals. Q. Rev. Biol. 22, 283–314. https://doi.org/10.1007/978-3-642-35858-6_.

Delaney-Rivera, C., Plummer, T.W., Hodgson, J.A., Forrest, F., Hertel, F., Oliver, J.S., 2009. Pits and pitfalls: taxonomic variability and patterning in tooth mark dimensions. J. Archaeol. Sci. 36, 2597–2608. https://doi.org/10.1016/j.jas.2009.08.001.

Diez Fernández-Lomana, C., 2006. Huellas de descarnado en el Paleolítico Medio: la cueva de Valdegoba (Burgos) 1. Zona Arqueológica 7, 304–317.

Domínguez Sanjurjo, A., Rodríguez Vázquez, F., Albornoz Pons, J., Pérez Méndez, T., 2009. El rebeco cantábrico, filogeografía e historia evolutiva. In: Pérez-Barbería, F. J., Palacios, B. (Eds.), El Rebeco Cantábrico Rupicapra Pyrenaica Parva. Conservación y Gestión de Sus Poblaciones, La Trébere, pp. 70–102.

Domínguez-Rodrigo, M., de Juana, S., Galán, A.B., Rodríguez, M., 2009. A new protocol to differentiate trampling marks from butchery cut marks. J. Archaeol Sci. 36, 2643–2654. https://doi.org/10.1016/j.jas.2009.07.017.

Domínguez-Rodrigo, M., Gidna, A.O., Yravedra, J., Musiba, C., 2012. A Comparative Neo-Taphonomic Study of Felids, Hyaenids and Canids: an Analogical Framework Based on Long Bone Modification Patterns. Journal of Taphonomy 10, 151–169.

Domínguez-Rodrigo, M., Piqueras, A., 2003. The use of tooth pits to identify carnivore taxa in tooth-marked archaeofaunas and their relevance to reconstruct hominid carcass processing behaviours. J. Archaeol. Sci. 30, 1385–1391. https://doi.org/10.1016/S0305-4403(03)00027-X.

Duarte Matías, E., Utrilla Miranda, P., Mazo Pérez, C., Rasilla Vives, M., 2012. ¿Ecos asturianos en el Magdaleniense de Abauntz? Las interrelaciones cántabro-pirenaicas a través de los motivos decorativos en soporte óseo. Trabajos de Arqueología Navarra.

Esteban-Nadal, M., Cáceres, I., Fosse, P., 2010. Characterization of a current coprogenic sample originated by Canis lupus as a tool for identifying a taphonomic agent. J. Archaeol. Sci. 37, 2959–2970. https://doi.org/10.1016/j.jas.2010.06.033.

Etxebarría, F., 1994. Aspectos macroscópicos del hueso sometido al fuego. Revisión de las cremaciones descritas en el País Vasco desde la Arqueología. MUNIBE (Antropologia-Arkeologia) 111–116.

Fábregas Valcarce, R., de Lombera Hermida, A., Serna González, M.R., Vaquero, M., Pérez Rama, M., Grandal ďAnglade, A., Rodríguez Álvarez, X.P., Alonso Fernández, S., Ameijenda Iglesias, A., 2012. Ocupacións prehistóricas e históricas nas cavidades das serras orientais galegas: Cova de Eirós (Triacastela) e Valdavara (Becerreá). Gallaecia 31, 17–45.

Fernández Rodríguez, C., Lloveras, L., Escosteguy, P., Ramil Rego, E., Nadal, J., 2018. Acumulaciones faunísticas y sus implicaciones socioculturales. Nuevos datos del registro arqueozoológico en la cueva de A Valiña (Castroverde, Lugo). Férvedes 9, 21–29.

Fernández-Jalvo, Y., Andrews, P., 2016. Atlas of Taphonomic Identifications. 1001+ Images of Fossil and Recent Mammal Bone Modification. Springer, Madrid.

Fisher, J.W., 1995. Bone Surface Modifications in Zooarchaeology. J. Archaeol. Method Theory 2, 7–68.

Fosse, P., Selvia, N., Smietana, W., Okarma, H., Wajrak, A., Fourvel, J.B., Madelaine, S., Esteban-Nadal, M., Cáceres, I., Yravedra, J., Brugal, J.P., Prucca, A., Haynes, G., 2012. Bone Modification by Modern Wolf (Canis lupus): A Taphonomic Study From their Natural Feeding Places. Journal of Taphonomy 10, 197–217.

Fuente Fernández, Ó., Rojo Hernández, J.A., Valles Fernández, M.A., 2018. Uso de los recursos bióticos en el entorno del río Sella (Asturias, España) durante el final del Pleistoceno superior. KOBIE Serie Anejo 18, 99–108.

Gabucio, M.J., Sanz, M., Daura, J., 2024. Lynxes and foxes among hyenas, bears and humans. Unit 3 of the Cova del coll Verdaguer Upper Pleistocene site (Barcelona, Iberian Peninsula). Quat. Sci. Rev. 333. https://doi.org/10.1016/j.quascirev.2024.108671.

García-González, R., 1985. Datos preliminares para el estudio de las poblaciones de sarrio (Rupicapra rupicapra pyrenaica Bonaparte, 1845) en el Pirineo Central. Munibe 37, 5–15.

Gaudzinski-Windheuser, S., Kindler, L., Rabinovich, R., Goren-Inbar, N., 2010. Testing heterogeneity in faunal assemblages from archaeological sites. Tumbling and trampling experiments at the early-Middle Pleistocene site of Gesher Benot Ya'aqov (Israel). J. Archaeol. Sci. 37, 3170–3190. https://doi.org/10.1016/j.jas.2010.07.018.

Gifford, D.P., Crader, D.C., 1977. A computer coding system for archaeological faunal remains. Am. Antiq. 42, 225–238.

Gonzalez, G., Crampe, J.-P., 2001. Mortality patterns in a protected population of isards (Rupicapra pyrenaica). Can. J. Zool. 79, 2072–2079. https://doi.org/10.1139/z01-173.

González Sainz, C., 1986. El Magdaleniense superior-final de la región cantábrica. Universidad de Cantabria, Santander.

González Sainz, C., González Urquijo, J.E., 2004. El Magdaleniense reciente en la región cantábrica. KOBIE (Serie Anejos) 8, 275–308.

Gümrükçü, M., Pante, M.C., 2018. Assessing the effects of fluvial abrasion on bone surface modifications using high-resolution 3-D scanning. J. Archaeol. Sci. Rep. 21, 208–221. https://doi.org/10.1016/j.jasrep.2018.06.037.

Haynes, G., 1980. Evidence of carnivore gnawing on Pleistocene and Recent mammalian bones. Paleobiology 6, 341–351. https://doi.org/10.1017/S0094837300006849.

Harris, S., 1978. Age determination in the Red fox (Vulpes vulpes) – an evaluation of technique efficiency as applied to a sample of suburban foxes. J. Zool. 184, 91–117. https://doi.org/10.1111/j.1469-7998.1978.tb03268.x.

Haynes, G., 1983. A guide for differentiating mammalian carnivore taxa responsible for gnaw damage to herbivore limb bones. Paleobiology 9, 164–172.

Haynes, G., 1980b. Prey Bones and Predators: Potential Ecologic Information from Analysis of Bone Sites. OSSA 7, 75–97.

Hernando, R., Lozano, M., Ceperuelo, D., Alonso, S., Vaquero, M., 2019. Los niños de la Cova de Valdavara (Becerreá, Lugo): Análisis morfológico, patológico y del microdesgaste dental. Munibe Antropologia-Arkeologia 70, 207–218. https://doi.org/10.21630/MAA.2019.70.17.

Hillson, S., 1992. Mammal Bones and Teeth. An Introductory Guide to Methods of Identification, 1992. University College London, Londres.

Hillson, S., 2005. Teeth, 2nd ed. Cambridge University Press, Cambridge.

Koby, F., 1952. La dentition lactéale d'Ursus spelaeus. Rev. Suisse Zool. 59, 511–541. https://doi.org/10.5962/bhl.part.75380.

Krajcarz, M., Krajcarz, M.T., 2014. The Red Fox (Vulpes vulpes) as an Accumulator of Bones in Cave-like Environments. Int. J. Osteoarchaeol. 24, 459–475. https://doi.org/10.1002/oa.2233.

Kreutzer, L.A., 1992. Bison and Deer Bone Mineral Densities: Comparisons and Implications for the Interpretation of Archaeological Faunas. J. Archaeol. Sci. 19, 271–294.

Kuhn, B.F., Berger, L.R., Skinner, J.D., 2010. Examining criteria for identifying and differentiating fossil faunal assemblages accumulated by hyenas and hominins using extant hyenid accumulations. Int. J. Osteoarchaeol. 20, 15–35. https://doi.org/10.1002/oa.996.

Kurtén, B., 1954. Population dynamics and evolution. Evolution (N Y) 8, 75–81. https://doi.org/10.1111/j.1558-5646.1954.tb00110.x.

Lam, Y.M., Chen, X., Pearson, O.M., 1999. Intertaxonomic variability in patterns of bone density and the differential representation of bovid, cervid, and equid elements in the archaeological record. Am. Antiq. 64, 343–362.

Lazzeri, L., Ferretti, F., Churski, M., Diserens, T.A., Oliveira, R., Schmidt, K., Kuijper, D.P. J., 2024. Spatio-temporal interactions between the red fox and the wolf in two contrasting European landscapes. Sci. Rep. 14. https://doi.org/10.1038/s41598-023-50447-z.

Llana Rodríguez, C., 1993. La presencia de los cazadores-recolectores en las montañas de Galicia. In: Pérez Alberti, A., Guitián Rivera, L., Ramil Rego, P. (Eds.), La Evolución Del Paisaje En Las Montañas Del Entorno de Los Caminos Jacobeos. Xunta de Galicia, Santiago de Compostela, pp. 193–209.

Lloveras, L., Moreno-García, M., Nadal, J., Maroto, J., Soler, J., Soler, N., 2010. The application of actualistic studies to assess the taphonomic origin of Musterian rabbit accumulations from Arbreda Cave (North-East Iberia). Archaeofauna 19, 99–119.

Lloveras, L., Moreno-García, M., Nadal, J., 2012. Feeding the Foxes: An Experimental Study to Assess Their Taphonomic Signature on Leporid Remains. Int. J. Osteoarchaeol. 22, 577–590. https://doi.org/10.1002/oa.1280.

Lloveras, L., Nadal, J., Fullola, J.M., 2020. Distinguishing the taphonomic signature of wolves from humans and other predators on small prey assemblages. Sci. Rep. 10. https://doi.org/10.1038/s41598-020-64716-8.

López-Cisneros, P., Linares-Matás, G., Yravedra, J., Maté-González, M.Á., Estaca-Gómez, V., Mora, R., Aramendi, J., Rodríguez Asensio, J.A., Barrera-Logares, J.M., González Aguilera, D., 2019a. Applying new technologies to the taphonomic study of La Lluera (Asturias, Spain). Geometric morphometrics and the study of bone surface modifications (BSM). Quat. Int. 517, 107–117. https://doi.org/10.1016/j.quaint.2019.02.020.

López-Cisneros, P., Yravedra, J., Álvarez-Alonso, D., Linares-Matás, G., 2019b. The exploitation of hunted resources during the Magdalenian in the Cantabrian region. Systematization of butchery processes at Coímbre cave (Asturias, Spain). Quat. Int. 506, 46–58. https://doi.org/10.1016/j.quaint.2018.05.035.

López-Felpeto, M.A., Llana, C., 1997. A Pena de Xiboi: a presencia aziliense na Terra Chá. CROA 7, 19–21.

López-García, J.M., Blain, H.A., Cuenca-Bescós, G., Alonso, C., Alonso, S., Vaquero, M., 2011. Small vertebrates (Amphibia, Squamata, Mammalia) from the late Pleistocene-Holocene of the Valdavara-1 cave (Galicia, northwestern Spain). Geobios 44, 253–269. https://doi.org/10.1016/j.geobios.2010.10.001.

López-González, F., Grandal-d'Anglade, A., Vidal-Romaní, J.R., 2006. Deciphering bone depositional sequences in caves through the study of manganese coatings. J. Archaeol. Sci. 33, 707–717. https://doi.org/10.1016/j.jas.2005.10.006.

Lubrano, V., Rufà, A., Blasco, R., Rivals, F., Rosell, J., 2025. Solving the puzzle of neanderthal occupations: a reassessment of temporal indicators of occupation duration. Archaeol. Anthropol. Sci. 17, 61. https://doi.org/10.1007/s12520-025-02163-0.

Lucas, C., 2014. Messages codés des chasseurs magdaléniens. Approche technologique et structurale des objets ornés de compositions géométriques par les Magdaléniens des Pyrénées nord-occidentales (16.500-12.000 ans cal, B.C.). Université de Paris I Panthéon-Sorbonne, París.

Lyman, R.L., 1984. Bone Density and Differential Survivorship of Fossil Classes. J. Anthropol. Archaeol. 3, 259–299.

Lyman, R.L., 2008. Quantitative paleozoology. Cambridge University Press, Cambridge.

Marean, C.W., Abe, Y., Frey, C.J., Randall, R.C., 2000. Zooarchaeological and taphonomic analysis of the Die Kelders Cave 1 Layers 10 and 11 Middle Stone Age larger mammal fauna. J. Hum. Evol. 197–233.

Marín, J., Saladié, P., Azorit, C., Rodríguez-Hidalgo, A., 2024. Identification of age at death in red deer (Cervus elaphus) through the upper dentition: Eruption pattern, wear stage and crown heights. J. Archaeol. Sci. 163. https://doi.org/10.1016/j.jas.2023.105934.

Martínez-Moreno, J., 2005. Una aproximación lógica al estudio de los patrones de subsistencia del Paleolítico Medio Cantábrico, in: Montes Barquín, R., Lasheras Corruchaga, J.A. (Eds.), Actas de La Reunión Científica: Neandertales Cantábricos, Estado de La Cuestión. Museo y Centro de Investigaciones de Altamira. Monografías No 17. Ministerio de Cultura, Santander, 209–230.

Martínez-Villa, A., Álvarez-Fernández, E., Álvarez-Vena, A., Arrojo, L., Ballesteros, D., Cubas, M., Drak, L., Llorente Rodríguez, L., Martín-Jarque, S., Gil, M., 2022. New insights into upper Palaeolithic and Mesolithic occupations in Les Pedroses cave (Asturies, north Spain). J. Archaeol. Sci. Rep. 45. https://doi.org/10.1016/j.jasrep.2022.103592.

Mateos Cachorro, A., 2002. Apuntes sobre estacionalidad y subsistencia de los grupos humanos del cantábrico occidental en torno al 13000 BP. Trab. Prehist. 59, 27–41.

Menéndez Fernández, M., Quesada López, J.M., 2008. Artistas y cazadores de ciervos. El papel del ciervo en el arte y la caza del Paleolítico superior cantábrico. Espacio, Tiempo y Forma. Serie I. Nueva época. Prehistoria y Arqueología 1, 155–166.

Menéndez, M., Álvarez-Alonso, D., de Andrés-Herrero, M., Carral, P., García-Sánchez, E., Jordá Pardo, J.F., Quesada, J.M., Rojo, J., 2018. The Middle to Upper Paleolithic transition in La Güelga cave (Asturias, Northern Spain). Quat. Int. 474, 71–84. https://doi.org/10.1016/j.quaint.2017.08.061.

Mielgo, C., López-Cisneros, P., Yravedra, J., Barrera-Logares, J.M., Rodríguez Asensio, J. A., 2022. Systematization of butchery processes during the last Glacial Maximum in the Cantabrian region, a view from La Lluera cave (Asturias, Spain). J. Archaeol. Sci. Rep. 42. https://doi.org/10.1016/j.jasrep.2022.103404.

Moclán, A., Domínguez-Rodrigo, M., Yravedra, J., 2019. Classifying agency in bone breakage: an experimental analysis of fracture planes to differentiate between hominin and carnivore dynamic and static loading using machine learning (ML) algorithms. Archaeol. Anthropol. Sci. 11, 4663–4680. https://doi.org/10.1007/s12520-019-00815-6.

Mondini, M., 1995. Artiodactyl prey transport by foxes in Puna Rock Shelters. Curr. Anthropol. 36, 520–524. https://doi.org/10.1086/204391.

Moure Romanillo, A., 1990. La cueva Tito Bustillo (Ribadesella, Asturias): el yacimiento paleolítico, in: Excavaciones Arqueológicas En Asturias: 1983-1986. Gobierno del Principado de Asturias, Servicio de Publicaciones, Oviedo, 107–127.

Novecosky, B.J., Popkin, P.R.W., 2005. Canidae volume bone mineral density values: An application to sites in western Canada. J. Archaeol. Sci. 32, 1677–1690. https://doi.org/10.1016/j.jas.2005.05.009.

Pales, L., Lambert, C., 1971. Atlas ostéologique pour servir à Íidentification des mammifères du Quaternaire. Herbivores. Editions du Centre National de la Recherche Scientifique, París.

Pales, L., Lambert, C., 1981. Atlas ostéologique pour servir à Íidentification des mammifères du Quaternaire. Carnivores. Editions du Centre National de la Recherche Scientifique, París.

Palomo, L.J., Gisbert, J., Blanco, J.C., 2007. Atlas y Libro Rojo de los Mamíferos Terrestres de España. Ministerio de Medio Ambiente, Gobierno de España.

Pavao, B., Stahl, P.W., 1999. Structural Density Assays of Leporid Skeletal Elements with Implications for Taphonomic, Actualistic and Archaeological Research. J Archaeol Sci 26.

Pérez-Barbería, F.J., 1994. Determination of age in Cantabrian chamois (Rupicapra pyrenaica parva) from jaw tooth-row eruption and wear. J. Zool. Lond 233, 649–656.

Pérez-Barbería, F.J., Mutuberría, G., 1996. Teeth eruption pattern in Cantabrian chamois Rupicapra pyrenaica parva. Acta Theotiologica 41, 217–221.

Pérez-Barbería, F.J., Pérez-Fernández, E., 2009. Identificación, biología y ecología del rebeco cantábrico. In: Pérez-Barbería, F.J., Palacios, B. (Eds.), El Rebeco Cantábrico Rupicapra Pyrenaica Parva. Conservación y Gestión de Sus Poblaciones, La Trébere, pp. 26–69.

Pickering, T.R., Egeland, C.P., 2006. Experimental patterns of hammerstone percussion damage on bones: Implications for inferences of carcass processing by humans. J. Archaeol. Sci. 33, 459–469. https://doi.org/10.1016/j.jas.2005.09.001.

Pineda, A., Cáceres, I., Saladié, P., Huguet, R., Morales, J.I., Rosas, A., Vallverdú, J., 2019. Tumbling effects on bone surface modifications (BSM): An experimental application on archaeological deposits from the Barranc de la Boella site (Tarragona, Spain). J. Archaeol. Sci. 102, 35–47. https://doi.org/10.1016/j.jas.2018.12.011.

Pizarro-Monzo, M., Domínguez-Rodrigo, M., 2020. Dynamic modification of cut marks by trampling: temporal assessment through the use of mixed-effect regressions and deep learning methods. Archaeol. Anthropol. Sci. 12. https://doi.org/10.1007/s12520-019-00966-6.

Poulle, M.L., Carles, L., Lequette, B., 1997. Significance of ungulates in the diet of recently settled wolves in the Mercantour mountains (southeastern France). Revue d'Ecologie (La Terre et la Vie) 52, 357–368. https://doi.org/10.3406/revec.1997.2238.

Quesada López, J.M., 1995. Las estrategias de caza durante el Paleolítico superior cantábrico. El caso del oriente asturiano. Complutum 6, 79–103.

Ramil Rego, E., Ramil Soneira, J., 1996. El fin de los tiempos glaciares en Galicia. Magdaleniense y Epipaleolítico. In: Fábregas-Valcarce, R. (Ed.), Os Primeiros Poboadores de Galicia: O Paleolítico. Sada, Ediciós do Castro, pp. 117–146.

Ramil Rego, E., 2014. Prehistoria antigua del occidente cantábrico [PhD Thesis]. Universidade de Santiago de Compostela.

Ramil Soneira, J., Vázquez Varela, J.M., 1983. Primer hallazgo de arte mueble paleolítico en Galicia. Ars Praehistórica 2, 191–193.

Ramil Soneira, J., Ramil Rego, E., Llana Rodríguez, C., Pérez Rodríguez, M., Pombo Mosquera, X., 1994. Prospección de yacimientos prehistóricos con industrias líticas en la provincia de Lugo (Galicia): primeros resultados. Colóquio Galaico-Minhoto III, 613–626.

Rasmussen, S.O., Bigler, M., Blockley, S.P., Blunier, T., Buchardt, S.L., Clausen, H.B., Cvijanovic, I., Dahl-Jensen, D., Johnsen, S.J., Fischer, H., Gkinis, V., Guillevic, M., Hoek, W.Z., Lowe, J.J., Pedro, J.B., Popp, T., Seierstad, I.K., Steffensen, J.P., Svensson, A.M., Vallelonga, P., Vinther, B.M., Walker, M.J.C., Wheatley, J.J., Winstrup, M., 2014. A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: Refining and extending the INTIMATE event stratigraphy. Quat. Sci. Rev. 106, 14–28. https://doi.org/10.1016/j.quascirev.2014.09.007.

Rojo Hernández, J.A., Menéndez Fernández, M., 2012. Nuevas aportaciones al debate especialización-diversificación en el Solutrense cantábrico. Espacio, Tiempo y Forma. Serie I. Nueva época. Prehistoria y Arqueología 5, 297–308.

Romairone Duarte, A., 2015. Estudio comparativo de diferentes métodos de determinación de la edad en el lobo ibérico, Canis lupus signatus, (Cabrera, 1907). Universidad de León, León.

Roulichová, J., Anděra, M., 2007a. Simple method of age determination in red fox, Vulpes vulpes. Folia Zool Brno 56, 440–444.

Roulichová, J., Anděra, M., 2007b. Age determination in the Red Fox (Vulpes vulpes): a comparative study. Lynx (Praha) 38, 55–71.

Sala, N., Arsuaga, J.L., Haynes, G., 2014. Taphonomic comparison of bone modifications caused by wild and captive wolves (Canis lupus). Quat. Int. 330, 126–135. https://doi.org/10.1016/j.quaint.2013.08.017.

Sanchis Serra, A., 2000. Los restos de Oryctolagus cuniculus en las tafocenosis de Bubo bubo y Vulpes vulpes y su aplicación a la caracterización del registro faunístico arqueológico. SAGVNTVM 32, 31–50.

Sanchis, A., Real, C., Sauqué, V., Núñez-Lahuerta, C., Égüez, N., Tormo, C., Pérez Ripoll, M., Carrión Marco, Y., Duarte, E., Rasilla, M., 2019. Neanderthal and carnivore activities at Llonín Cave, Asturias, northern Iberian Peninsula: Faunal study of Mousterian levels (MIS 3). C R Palevol 18, 113–141. https://doi.org/10.1016/j.crpv.2018.06.001.

Sauqué, V., García-González, R., Rabal-Garcés, R., Galán, J., Núñez-Lahuerta, C., Gisbert, M., Cuenca-Bescós, G., 2018. Los Batanes: A trap for the Pyrenean wild goat during the Late Pleistocene (Spain). Quat. Int. 481, 75–90. https://doi.org/10.1016/j.quaint.2017.09.011.

Sauvet, G., 2019. The lifeworld of hunter-gatherers and the concepts of territory. Quat. Int. 503, 191–199. https://doi.org/10.1016/j.quaint.2017.01.040.

Schmid, E., 1972. Atlas of animal bones. Elsevier, Nueva York.

Selva, N., Jędrzejewska, B., Jędrzejewski, W., Wajrak, A., 2005. Factors affecting carcass use by a guild of scavengers in European temperate woodland. Can. J. Zool. 83, 1590–1601. https://doi.org/10.1139/z05-158.

Selvaggio, M.M., Wilder, J., 2001. Identifying the involvement of multiple carnivore taxa with archaeological bone assemblages. J. Archaeol. Sci. 28, 465–470. https://doi.org/10.1006/jasc.2000.0557.

Shipman, P., Foster, G., Schoeninger, M., 1984. Burnt Bones and Teeth: an Experimental Study of Color, Morphology, Crystal Structure and Shrinkage. J. Archaeol. Sci. 11, 301–325.

Soulier, M.C., Costamagno, S., 2017. Let the cutmarks speak! Experimental butchery to reconstruct carcass processing. J. Archaeol. Sci. Rep. 11, 782–802. https://doi.org/10.1016/j.jasrep.2016.12.033.

Stanford, J.D., Rohling, E.J., Bacon, S., Roberts, A.P., Grousset, F.E., Bolshaw, M., 2011. A new concept for the paleoceanographic evolution of Heinrich event 1 in the North Atlantic. Quat. Sci. Rev. 30, 1047–1066. https://doi.org/10.1016/j.quascirev.2011.02.003.

Stiner, M.C., Kuhn, S.L., Weiner, S., Bar-Yosef, O., 1995. Differential Burning, Recrystallization, and Fragmentation of Archaeological Bone. J. Archaeol. Sci. 22, 223–237.

Straus, L.G., 1983. El solutrense vasco-cantábrico, una nueva perspectiva. Ministerio de Cultura, Santander.

Straus, L.G., Clark, G.A., 1986. La Riera Cave. Stone Age Hunter-Gatherer Adaptations in Northern Spain. Arizona State University.

Straus, L.G., González Morales, M.R., 2012. The Magdalenian settlement of the Cantabrian region (Northern Spain): The view from El Miron Cave. Quat. Int. 272–273, 111–124. https://doi.org/10.1016/j.quaint.2012.03.053.

Tapia, J., Álvarez-Fernández, E., Cueto, M., Portero, R., Bécares, J., Jordá-Pardo, J.F., 2018. Bone industry of the Lower Magdalenian in Cantabrian Spain: The square-section antler points of El Cierro Cave. Quat. Int. 472, 13–22. https://doi.org/10.1016/j.quaint.2017.10.029.

Thompson, C.E.L., Ball, S., Thompson, T.J.U., Gowland, R., 2011. The abrasion of modern and archaeological bones by mobile sediments: The importance of transport modes. J. Archaeol. Sci. 38, 784–793. https://doi.org/10.1016/j.jas.2010.11.001.

Torres-Iglesias, L., Marín-Arroyo, A.B., Rasilla, M., 2022. Estrategias de subsistencia durante el Solutrense cantábrico: el caso del Abrigo de La Viña (La Manzaneda, Asturias). Trab. Prehist. 79, 11–29. https://doi.org/10.3989/tp.2022.12284.

Trolle-Lassen, T., 1990. Butchering of Red Deer (Cervus elaphus L.) - A Case Study from the Late Mesolithic Settlement of Tybrind Vig. Denmark. Journal of Danish Archaeology 9, 7–37.

Utrilla Miranda, P., 2004. Evolución histórica de las sociedades cantábricas durante el tardiglacial: el Magdaleniense inicial, inferior y medio (16.500-13.000 BP). KOBIE (Serie Anejos) 8, 243–274.

Valverde Tejedor, I., 2012. Patrones de aprovechamiento faunístico del Pleistoceno Final - Holoceno Inicial en el NO de la Península Ibérica. Una aproximación a través del estudio zooarqueológico del yacimiento de Valdavara, Becerreá (Lugo, España). Universitat Rovira i Virgili, Tarragona.

Van Bree, P.J.H., Van Soest, R.W.M., Stroman, L., 1974. Tooth wear as an indication of age in Badgers (Meles meles L.) and Red Foxes (Vulpes vulpes L.). Z. Säugetierkunde 39, 243–248.

Vaquero, M., Alonso-Fernández, E.S., 2020. Technological changes and chrono-cultural boundaries: The role of expedient technologies in the upper paleolithic. J. Archaeol. Sci. Rep. 31, 1–13. https://doi.org/10.1016/j.jasrep.2020.102346.

Vaquero, M., van der Made, J., Blain, H.A., Ibáñez, N., López-García, J.M., Rivals, F., Alonso, S., Ameijenda, A., Bennàsar, M., Fernández-García, M., de Lombera-Hermida, A., Valverde, I., 2018. Fauna, environment and human presence during MIS5 in the North of Spain: The new site of Valdavara 3. C R Palevol 17, 557–593. https://doi.org/10.1016/j.crpv.2018.03.004.

Vaquero, M., Fernández, S.A., Alonso Fernández, C., Iglesias, A.A., Blain, H.A., Fábregas Valcarce, R., Merino, G.G., de Lombera Hermida, A., López-García, J.M., Lorenzo Merino, C., Lozano Ruiz, M., Rodríguez Rellán, C., Rosell i.Ardévol, J., Serna González, M.R., 2009. Nuevas fechas radiométricas para la prehistoria del noroeste de la península ibérica: La cueva de Valdavara (Becerreá, Lugo). Trab. Prehist. 66, 99–113. https://doi.org/10.3989/tp.2009.09014.

Varela, S., Rodríguez, J., 2004. Carnívoros ibéricos. MNCN, Madrid.

Vázquez Varela, J.M., 2000. El Paleolítico en el Noroeste de la Península Ibérica. SPAL 9, 69–79.

Vettese, D., Blasco, R., Cáceres, I., Gaudzinski-Windheuser, S., Moncel, M.H., Hohenstein, U.T., Daujeard, C., 2020. Towards an understanding of hominin marrow extraction strategies: a proposal for a percussion mark terminology. Archaeol. Anthropol. Sci. 12. https://doi.org/10.1007/s12520-019-00972-8.

Villa, P., Mahieu, E., 1991. Breakage patterns of human long bones. J. Hum. Evol. 21, 27–48. https://doi.org/10.1016/0047-2484(91)90034-S.

Villar Quinteiro, R., 2011. Secuencia do Paleolítico Superior en Galicia, in: Méndez Quintas, E. (Ed.), Estudos Sobre o Paleolítico. Homenaxe a Xose María Álvarez Blázquez. Instituto de Estudos Miñoranos, Gondomar, 347–372.

Villar Quinteiro, R., 1997. El Paleolítico superior y Epipaleolítico en Galicia. Zephyrus 50, 71–106.

Williams, R.C., Evans, H.E., 1978. Prenatal Dental Development in the Dog, Canis familiaris: Chronology of Tooth Germ Formation and Calcification of Deciduous Teeth. Vet. Med. C. Anat. Histol. Embryol 7, 152–163.

Yravedra, J., Cobo-Sánchez, L., 2015. Neanderthal exploitation of ibex and chamois in southwestern Europe. J. Hum. Evol. 78, 12–32. https://doi.org/10.1016/j.jhevol.2014.10.002.

Yravedra, J., 2002a. Especialización o Diversificación. Una nueva propuesta para el Solutrense y el Magdaleniense Cantábrico. MUNIBE (Antropologia-Arkeologia) 54, 3–20.

Yravedra, J., 2002b. Subsistencia en la transición del Paleolítico medio al Paleolítico superior de la Península Ibérica. Trab. Prehist. 59, 9–28.

Yravedra, J., 2006a. Aportes naturales y antrópicos en la Cueva del Esquilleu (Cantabria, España). Zona arqueológica 7, 280–289.

Yravedra, J., 2006b. Acumulaciones biológicas en yacimientos arqueológicos: Amalda VII y Esquilleu III-IV. Trab. Prehist. 63, 55–78.

Yravedra, J., 2007. Nuevas contribuciones en el comportamiento cinegético de la Cueva de Amalda. MUNIBE (Antropologia-Arkeologia) 58, 43–88.

Yravedra, J., 2010a. Zooarqueología y tafonomía del yacimiento de Hornos de la Peña (San Felices de Buelna, Cantabria). Complutum 21, 69–86.

Yravedra, J., 2010b. Tafonomía en la Cueva de Amalda: La intervención de carnívoros. Zona arqueológica 13, 175–184.

Yravedra, J., Gómez-Castanedo, A., Picado, J.A., Preysler, J.B., 2014. Specialised hunting of iberian ibex during neanderthal occupation at El Esquilleu cave, northern Spain. Antiquity 88, 1035–1049. https://doi.org/10.1017/S0003598X00115303.

Yravedra, J., Álvarez-Alonso, D., Estaca, V., López-Cisneros, P., Andrés-Chaín, M., Arrizabalaga, Á., Jordá Pardo, J.F., Elorza, M., Iriarte-Chiapusso, M.-J., Sesé, C., Uzquiano, P., 2017. Selection and exploitation of macro-vertebrate resources during the Upper Palaeolithic in Northern Spain. New evidence from Coímbre Cave (Peñamellera Alta, Asturias). Oxf. J. Archaeol. 36, 331–354.

Yravedra, J., Herranz, D., Sesé, C., López-Cisneros, P., Linares-Matás, G.J., Pernas-Hernández, M., Arrizabalaga, A., Jordá Pardo, J.F., Álvarez-Alonso, D., 2019. Lagomorph exploitation during the Upper Palaeolithic in the Northern Iberian Peninsula. New evidence from Coímbre Cave (Asturias, Spain). Quat. Int. 506, 59–68. https://doi.org/10.1016/j.quaint.2018.06.016.