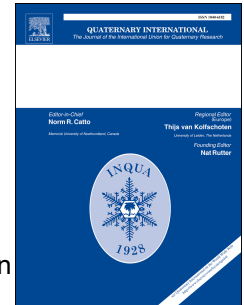


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## The persistence of red deer (*Cervus elaphus*) in the human diet during the Lower Magdalenian in northern Spain: insights from El Cierro cave (Asturias, Spain)

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### Abstract:

The dominance of red deer in Magdalenian records in Cantabrian Spain is a well-studied issue. Given the great accumulations of this species in those deposits, researchers have offered diverse interpretations of the phenomenon, related to ecology, orography or ethology. However, fewer papers carry out comparative intra-site analysis, which is able to document the existence of changes or continuities in the subsistence strategies at an archaeological site.

The aim of this paper is to present the results of the archaeozoological analysis of Levels F and G in El Cierro cave (Asturias, Spain), both of them dated during Greenland Stadial 2, in the Lower Magdalenian (15,460±75 and 15,580±75 BP, respectively). Similar percentages of mammals have been documented in the two levels, as well as the same meat and fat consumption and processing strategies. Thus, this paper intends to determine how much energy red deer supplied to the diet of the humans that inhabited El Cierro, in comparison with other hunted and consumed fauna during the Lower Magdalenian.

This study highlights the continuity of exploitation patterns of faunal resources in El Cierro cave during the Lower Magdalenian. This continuity is specifically seen in red deer, since the geographic characteristics of the Sella Valley, the abundance of the biotype, and the economic profitability of this species made it the main resource of animal origin for the hunter-gatherers at that site.

### Keywords:

Subsistence strategies, Zooarchaeology, Taphonomy, *Cervus elaphus*, Cantabrian Region, Upper Pleistocene.

## 1. Introduction

Red deer (*Cervus elaphus*) hunting was a widespread practice in the north of the Iberian Peninsula during the Lower Magdalenian, as shown by almost thirty archaeological sites that currently make up the faunal map of Cantabrian Spain between 20,000 and 17,000 cal BP (Figure 1). In some of these sites, the abundance of this ungulate in the archaeological record was noticed by the researchers who were beginning to carry out their research in the north of the Iberian Peninsula in the 1970s and 80s (Altuna, 1972, 1976; Castaños, 1980, 1982, 1983). It was then that the first monographs that included faunal remains studied by a specialist in Cantabrian Spain began to appear: e.g. Tito Bustillo (Altuna, 1976), La Riera (Altuna, 1986), El Juyo (Klein and Cruz-Urbe, 1987), El Rascaño (Altuna, 1981), Ekain (Altuna and Mariezkurrena, 1984) and Erralla (Altuna and Mariezkurrena, 1985).

In the following decades, several factors were postulated by different researchers for the large proportion of red deer in this area: environmental and geographic aspects (Altuna, 1995; Furundarena and Jiménez, 1998; Quesada, 1998a, 1998b), as well as those related to the subsistence patterns and economic strategies followed by the Magdalenian groups in the region (Straus, 1986a; González Sainz, 1989; Quesada, 1997; Yravedra, 2002a y 2002b; Marín, 2010), among others. These works stressed the problems that exist when investigating subsistence strategies, such as the antiquity of some of the excavations, the need to use archaeozoological methods, or the importance of dating the levels with radiocarbon. Nowadays, many of these problems have been solved by radiocarbon-dating the deposits, the detailed analysis of the fauna, and the use of modern excavation methods, enabling better investigation results (e.g. Álvarez-Fernández et al., 2016; Álvarez-Alonso and Yravedra, 2017; Corchón, 2017).

To date, faunal studies during the Lower Magdalenian in Cantabrian Spain have highlighted the existence of hunting specialization focused on two main taxa: red deer and Iberian ibex. This specialization is directly related to the orography of the archaeological site; in this way, if it was located in areas of open valleys, we would find a predominance of red deer, while if it was located in rocky areas with steep slopes, we would find a predominance of Iberian ibex (González Sainz, 1989, 1992; Altuna, 1995; Quesada, 1997; Yravedra, 2002a). Historiography agrees that this specialization in one or another taxon begins in the Solutrean and lasts until the Azilian (Altuna, 1972; 1995; Freeman, 1973; Straus, 2010), although this specialization has been attested during the Middle Paleolithic in some sites (Yravedra, 2013).

In this paper we compare the results of the archaeozoological and taphonomic study of the faunal remains from two levels (F and G) at El Cierro cave. With this we intend to outline the subsistence patterns of the hunter-gatherer groups that inhabited this archaeological site, searching for changes or continuities in the preparation and consumption strategies of the ungulates in the levels. The comparative analysis of the two levels will also allow the results to be framed within the Spanish Cantabrian Region.

## 2. El Cierro cave

El Cierro cave (Ribadesella, Asturias, Spain) is located at the eastern end of the Asturian massif in the Cantabrian Mountains, 82m above sea level and about 2 km from the current shore line (Figure 1). This is a large and senile karst cave, with two entrances that are connected by a doline. The site has been subject to various archaeological fieldwork seasons, carried out by different researchers since the 1950s (Álvarez-Fernández et al., 2016). They have highlighted the existence of one of the most important Upper Paleolithic stratigraphies in Cantabrian Spain, with a total of 14 sedimentary units that span from the Middle Paleolithic to the Mesolithic (Álvarez-Fernández et al., 2014, 2016 and 2018).

The Magdalenian levels studied in this paper (Levels F and G) were excavated by Gómez Fuentes and Jordá Cerdá between 1977 and 1979. The excavation of these levels followed the natural stratigraphic units, but the thickest levels were dug by thinner arbitrary layers (from 2 to 5 cm) to maintain control. Level F is 35 cm wide and 15 cm thick and is formed by silts and light brown clays with thin and very thin rounded quartz sands. Its shape is irregular and is located between the two bags of level G (Jordá Pardo et al., 2018) (Figure 2). The radiocarbon date for Level F is  $15,460 \pm 75$  BP (OxA-27869) (18,810 – 18,640 cal BP  $2\sigma$ ), and for Level G it is  $15,580 \pm 75$  BP (OxA-27870) (18,910 – 18,750 cal BP  $2\sigma$ ) (Álvarez-Fernández et al., 2016). Both of these results date the occupations in Greenland Stadial 2, during the Lower Magdalenian.

## 3. Materials and Methods

The faunal remains in the levels studied here were recovered with an excavation method that allowed the picking up of even the smallest bone fragments (Álvarez-Fernández et al., 2016: 542).

For the anatomical and taxonomic study of the remains, the osteological collections at the University of Salamanca and Aranzadi Science Society were used, as well as different osteological atlases (e.g. Pales and Lambert, 1972; Schmid, 1972; Pales and Garcia, 1981). When it was not possible to assign the remains to a specific taxon, they were grouped in different categories of mammals, according to their large, medium or small size. The first category includes heavy taxa such as bovids, the second includes taxa the size of a red deer, and the third taxa such as Iberian ibex or roe deer (Díez et al., 1999).

To evaluate the skeletal element representation in Levels F and G at El Cierro cave, the Number of Remains (NR), Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI), Minimum number of Animal Units (MAU) and its percentage (%MAU) were calculated. We took into account the most represented anatomical part, the laterality of the bone, and the age and sex of the individual (Binford, 1981; Brain, 1981; Lyman, 1994; Reitz and Wing, 2003). To evaluate diversity, the Simpson index ( $D = \sum n_i[n_i - 1] / N[N - 1]$ , where  $n_i$  = the number of specimens of the  $i$ th species and  $N$  = the total number of specimens) and the Shannon index ( $H' = -\sum p_i \ln p_i / \ln S$ , with  $S$  taken to be the number of non-overlapping taxa in the assemblage and  $p$  the proportion of

specimens of the *i*th species) have been calculated (Magurran, 1988; Graison and Delpech, 2002).

To analyze the skeletal profiles, we have classified the remains according to the parts of the cranial (skull, jaw, antler/horn, teeth), axial (rib, vertebra, scapula, pelvis, flat bone), fore limb (humerus, ulna radius, metacarpus, carpal bones), and hind limb (femur, tibia, patella, metatarsus, tarsal bone) skeleton. In those cases in which, due to difficulty in classification, it has not been possible to determine whether a remain belonged to a fore or hind limb, they were included in a broader category named “limb” (long bone, phalanx, sesamoid, metapodial) (Yravedra and Domínguez-Rodrigo, 2009).

The bone surfaces of all the faunal remains were observed, both at macroscopic level, with using hand magnifiers of 3x and 5x, and at microscopic level, using two binocular stereomicroscopes Leica EZ4 (6.55-32x) and Zeiss Stemi 2000C (6.5-50x). From the taphonomic point of view, alterations of anthropic origin have been identified by analyzing the fracturing processes of the long bones for the extraction of the marrow (percussion marks, percussion notches, flakes, and percussion pits), as well as the different cut marks and their morphology and position on the bone surface in relation to its longitudinal axis (Binford, 1981; Potts and Shipman, 1981; Shipman and Rose, 1983; Blumenschine and Selvaggio, 1988; Capaldo and Blumenschine, 1994; Lyman, 1994).

The exposure of the bone remains to heat sources was also analyzed. We have identified different stages of fire exposure ranging from 0 to 6 (from unburned to calcined), using the criteria of Stiner et al. (1995).

The marks and damage caused by carnivores have been taken into account, classifying them according to their morphology: pits, punctures, scores, furrowing, and crenulated edges (Haynes, 1980, 1983; Binford, 1981; Selvaggio, 1994).

Other types of alterations related to deposit formation have also been studied, such as weathering, calcium carbonate precipitation, and the presence of manganese oxides on the surface, as well as those related to postdepositional processes, such as root marks, trampling, or bone polishing due to rolling (Brain, 1967; Berhensmayer, 1978; Gifford-Gonzalez et al., 1985; Berhensmayer et al., 1986; Olsen and Shipman, 1998).

Finally, in order to provide a more complex view of the reason for red deer hunting success in El Cierro and in Cantabrian Spain, we estimated the kilocaloric energy that each of the taxa at the site contributed to the nutrition of the inhabitants of the cave. We have established a prey ranking of the most consumed animals through the MNI of each species. For this purpose, the estimated average weight of both sexes and their proportion will be established through current natural populations, that is, the sex ratio of each species (Clutton-Brock and Iason, 1986). Secondly, an estimate of the weight of meat and fat of each animal by species is made as proposed by Binford (1978). Third, we have calculated the number of calories per kg of each of the species represented in the cave (USDA, 2006; BEDCA, 2007; Marín, 2010). Finally, the total energy (Kcal) that each resource contributed to the diet is established through the MNI. In addition to these energy data, it is necessary to take into account the search, capture, and transport processes (search time and handling time) of each of the taxa, since they can influence success in the hunting of a given animal (Marín, 2008, 2010). Here, we

have estimated the total amount of kilocaloric energy supplied by each species although we are aware that the real use of animals could be total or partial, depending on the specific circumstances of the hunting activity or cultural norms. In this regard, ethnographic observations indicate that human groups tend to take full advantage of the hunted prey (Bunh, 1993; Steele and Baker, 1993).

The information about deer hunting from both levels of El Cierro will be compared with the available data on the presence of this ungulate in archaeological sites with Lower Magdalenian levels in the River Sella Valley and the rest of the Cantabrian Region. A total of 24 stratigraphic levels from 17 sites with radiocarbon dates between 20,000 and 17,000 cal. BP (Weninger and Jöris, 2008) and whose fauna has been studied by a specialist and comes from modern archaeological excavations has been considered.

#### 4. Results

Of a total of 1,672 remains in Level F, 64% have been taxonomically assigned to four species, while those that could not be allocated to a given taxon were classified into the categories of medium mammal and small mammal. Regarding the MNI, red deer predominate, followed by Iberian ibex, roe deer and large bovid (Table 1).

In Level G, out of a total of 2,153 remains, 26% have been allocated to five species at taxonomic level. We have also documented three dental pieces that probably belong to a marine mammal, whose species we have not yet been able to identify. Those that could not be assigned to a given taxon were classified into large, medium, and small categories. Regarding the MNI, we have observed, as in the previous level, a predominance of red deer, followed by Iberian ibex, roe deer, large bovid, and horse (Table 1). Regarding the anatomically identified species NISP, Simpson and Shannon indexes show low diversity and dominance of red deer in the sequence (Table 2).

In the skeletal distribution in both levels, axial elements are well represented. Appendicular bones, especially autopodia (bones of the distal part of a limb) and zeugopodia (radius, ulna, tibia and fibula), are also widely documented in both levels, as they are the elements that maintain a high marrow content (Binford, 1978). In some taxa, as in the case of red deer, the percentage of the skeletal elements in both levels is very similar (Tables 3 and 4). In both Levels, metacarpus is the highest represented element of red deer. Nevertheless, there are some small differences between the levels: in Level G fibula and metatarsus MAU percentages stand out, while in Level F, femur and tibia show high MAU percentages (Figure 3).

From the taphonomic point of view, the two bone assemblages are characterized by a high degree of anthropic fractures, which is observed in different percussion points on the bones, as well as in numerous flakes resulting from these impacts with a total of 95 resultant flakes (70 in Level F and 25 in Level G). In addition, a fracture pattern has been observed in the long bones, which contributes to dismiss accidental breakage (falling stones, trampling...). Long bones were selected to extract marrow, which has great nutritional value (Outram, 2002). A remarkable example of this practice can be found in 96 red deer phalanges, whose use patterns are similar in both levels. In the first



phalanges, the percussions were made mainly on the posterior side, while in the second phalanges the impacts fell on the lateral or medial side indistinctly. Additionally, some cut marks related to the disarticulation of the legs of this ungulate have been identified (Figure 4). The percussion of these phalanges responds to the consumption of the marrow in this anatomical region, since they constitute one of the last fat reserves remaining in an animal (Binford, 1978; Speth and Spielmann, 1983; Mateos, 2003; Llorente-Rodríguez et al., 2014).

The analysis of the cut marks and their position on the bone has allowed us to relate them to different activities in the processing of the prey. They include marks pertaining to the skinning of the prey (longitudinal marks on the posterior face of the metapodials and scratching marks on the skull), marks of disarticulation of the long bones (short marks located in the areas of union with the tendons of long and compact bones), evisceration marks (cuts and scrapes on the inner side of the ribs), and filleting marks (short, transverse, and parallel marks on the diaphyses of the long bones) (Table 5). These types of marks are found mainly in the medium and small size animals. In the case of the identified taxa, the anthropic manipulation marks are located mainly on red deer, where we find all the steps in the complete processing of the animal (Figure 5A).

Data on burnt bones has also been collected; for Level F a total of 147 thermo-altered remains (8.7% of the total NR), and for Level G, 241 thermo-altered remains (11.2% of the total NR). Among the different degrees of fire exposure, most of the modifications are brown in color (68% in Level F and 96% in Level G) (Figure 5C).

Carnivores constitute another agent that has modified the faunal assemblage at El Cierro. Their intervention is shown in tooth marks, grooves, depressions, and digestion marks located on the bone surfaces of the limbs and the axial skeleton. The scarce presence of these marks (<10% in both levels) shows that access of carnivores to bone remains in Levels F and G was secondary, made as scavenging (Figure 5B).

Other agents that have been part of the formation and modification of the bone assemblage are natural agents and postdepositional processes. They include subaerial exposure of the bones (5.9% of the total NR), which has generated fissures and cracks in a large part of the archaeozoological record. Water and humidity were present in the formation of the deposit, resulting in the presence of manganese oxides (4.5% of the total NR), calcium carbonate precipitations (2.4% of the total NR), and watermarks on the surface of the bones (3.8% of the total NR). Some rolled bones (4.1% of the total NR) have been found and trampling (<1% of the total NR) and root marks (21.8% of the total NR) have also damaged the bone surfaces (Table 6).

Data on the faunal composition in both levels has been used to make an estimative analysis of the proportion of caloric energy that each of the species documented in the Lower Magdalenian at El Cierro cave could have provided. Thus, we established the sex ratio for each taxon and estimated the numbers of each sex and their proportion, using current natural populations as a guide. The weight of meat and fat on each animal has been established for each species. In this way, the number of calories per kg provided by red deer, Iberian ibex, roe deer, bison, and horse was established. Finally, the total energy (Kcal) each resource might contribute was determined through the MNI and the skeletal standards represented in both levels (Tables 7 and 8).

The result of the caloric analysis shows *a priori* that the bovids, deer, and equids were the animals that provided most energy for the group. However, this calculation does not take into account the search and handling times of each individual, nor the selective transport of certain body parts, especially those of large size. In addition, it is necessary to take into account the encounter rate and the population density that can be estimated for these prey during the Lower Magdalenian in the Cantabrian Region. Thus, small size animals such as Iberian ibex, roe deer, or chamois, would have a higher population density, resulting in a higher encounter rate than larger animals (Damuth, 1981; Nowak, 1999).

For red deer and Iberian ibex, studies indicate a handling time of approximately 2 hours; for roe deer of approximately 1.5 hours; and 9 hours for bovines (Marín, 2008, 2010). For wild boar, given its size and composition, we can establish a handling time similar to that of red deer and Iberian ibex, of around 2 hours; for horse, due to its agility and size, it can be estimated at around 9 hours, the same as bison. These data would be related to the complete transport of the individual, given that the estimated load of cargo per individual would be approximately 18 kg (Marín, 2010), which would explain why animals such as Iberian ibex, roe deer or chamois, were transported complete more often than others, such as horse, wild boar and bison.

In this way, correlating all the data on the individual contribution of energy, the handling time, the encounter rate and population density, red deer can be placed at the head of the prey ranking, given its caloric energy, shorter handling time, its population density, and its higher encounter rate. These same characteristics made red deer the most consumed taxon in both levels in the El Cierro sequence.

## 5. Discussion

The persistence in *Cervus elaphus* hunting and consumption in the Lower Magdalenian sequence is one of the main characteristics that can be inferred from the studied bone remains at El Cierro. Their presence in relation to other identified taxa is higher in both levels (>75% NISP). In addition, all the anatomical regions of this ungulate are represented, in very similar percentages in both levels. A high degree of anthropic manipulation has also been demonstrated, which in the case of red deer has allowed the different steps in the butchering process to be identified and the degree of fire exposure of the remains, as well as the systematic use of fat attested in the fracturing of the first and second phalanges. All these elements demonstrate the great use of this ungulate and its continuity in subsistence practices in the two Lower Magdalenian levels in El Cierro cave. In contrast, carnivores have affected the bone assemblage very marginally. No carnivore remains have been detected in the studied levels.

According to the estimated volume of their meat and fat, red deer contributed a large amount of kilocalories to the diet of the inhabitants of El Cierro. In Level F, red deer would have contributed a total of 325,896 Kcal, which can be estimated as sufficient to feed a group of 10 people during 9 days, if we set the average energy per day intake of an adult at 3,500 Kcal. In the case of Level G, red deer would have



provided a total of 448,107 Kcal to the human group, thus allowing the subsistence of 10 people during 12 days, eating this resource alone. Actually, both levels provide the same amount of caloric energy in relation to the NISP, which indicates that there is no variation in the consumption in them (Table 9).

The success of *Cervus elaphus* is guaranteed by the economic profitability of its hunting, since this species would have a high encounter rate in the valley of the River Sella, where this prey could be acquired in a short search time. Together with a short handling and transport time, this would make red deer an affordable prey from an economic point of view.

The ethology of a species can favor its hunting in certain moments and places. Red deer especially likes woodland and its optimal habitat is found in mixed forest with conifers and deciduous trees, as it is an ungulate that prefers transition areas between forested and herbaceous areas (Gómez Fuentes, 1983; Carranza, 2004). In addition, as a gregarious animal, it lives in society and tends to form small herds. Females and males live in separate groups most of the time, and come together during mating season, in September. Male groups usually have similar ages, while those of females usually include the family group (females and their offspring). In both cases, a strong hierarchy can be seen (Carranza, 2004). Red deer is a migratory animal that during winter months is located below 500 m above sea level, moving in spring to higher areas, and living from June to July at areas higher than 500 m above sea level (Gómez Fuentes, 1983). This allows human groups to track the migrating herds.

As we have argued earlier in this paper, the existence of a hunting specialization in two main taxa (*Cervus elaphus* and *Capra pyrenaica*), depending on the situation and the orography of the site, has been noted since the beginning of Paleolithic faunal research in Cantabrian Spain. If an archaeological site is located in an area close to open valleys, far from rocky areas, we would find a predominance of red deer in the Lower Magdalenian levels; while if the site is located in a rocky and steep area we would find a predominance of Iberian ibex hunting (González Sainz, 1989, 1992; Altuna, 1995; Quesada, 1997; Yravedra, 2002a). In the case of El Cierro, this observation about red deer hunting specialization is valid, since it is a site located at 82 m above sea level, close to open valleys and far from rocky areas, with percentages of red deer representativeness of over 90% of NISP.

In the case of the Sella Valley, Menéndez et al. (2005) have proposed three hunting exploitation models for the river area during de Lower Magdalenian: a coastal model specialized in red deer, which would correspond to Tito Bustillo (Ribadesella), and now also to El Cierro; an inner valley model, characterized by diversification of species, represented by La Güelga (Cangas de Onís); and a mountain model specialized in Iberian ibex, which corresponds to Collubil (Camporrión).

This same scheme is applicable to the Cantabrian Region in general, where 24 archaeological levels in 17 sites have been dated by radiocarbon during the GS2 and their fauna studied by a specialist. We have also collected information regarding the altitude at which the cave is located, and its distance from the present coast in a straight line (Table 7). Thus, archaeological sites with high red deer percentages, such as El Juyo (Levels 4 and 7), La Riera (Level 19), Santimamiñe (Level Csr-Camr), Ekain

(Level VII), Tito Bustillo (Levels 1 and 2), Altamira (Level 2) and Cova Rosa (Level B6) are located in areas of low altitude ( $\leq 200$  m), close to the coast ( $< 8$  km). Sites with more diversified patterns include the aforementioned La Güelga (Level 3), Arangas (Level F), Las Caldas (Levels XIII to XI) and Coimbre (Level B4). And finally, those sites with high Iberian ibex percentages, such as Erralla (Level V), Rascaño (Levels 3, 4, and 5), Los Canes (Level 2) and El Mirón (Level 504) are located far from the present coastline ( $> 9$  km), at a higher altitude ( $> 200$  m), and generally close to rocky and steep-sloping areas (Table 10).

The strength of this strategy is shown not only in the reoccupation of the Lower Magdalenian at El Cierro (Levels F and G), as we have seen, but also in other sites such as El Juyo, Tito Bustillo, or Rascaño, where the representation pattern of these species was maintained at different occupation times during the Lower Magdalenian.

## 6. Conclusions

Hunting behavior maintains a clear continuity in the Lower Magdalenian levels in El Cierro cave. This is supported not only by the similar proportion of ungulates consumed in each level, but also by the similarity in the processing patterns of taxa such as the red deer. The intra-site analysis of El Cierro shows how, from the economic point of view, the Magdalenian human groups maintained an exploitation system in the valley areas near the cave, places where red deer would be present given its preference for this environment.

However, this hunting strategy is not only related to the proximity and abundance of this resource in the surrounding area, but also to the economic profitability of red deer, given its shorter search and transport times in relation to its kilocaloric input to the group. These characteristics put red deer at the top of the prey ranking of the hunted species during the Lower Magdalenian in Cantabrian Spain. The greater or lesser representation of other species, such as roe deer, bison, or horse, depended on their opportunistic hunting at certain times, and the group's alimentary needs, in which they provided a seasonal dietary complement, but never exceeding 15% of representation (NISP).

The results provided by the comparison of Levels F and G allow them to be situated in a much broader framework, first in the River Sella valley and second, in Cantabrian Spain. In this case, geography plays a decisive role, and we have been able to discriminate three types of environment exploitation, which depend on the location of the archaeological sites. In the case of the sites located in the Sella valley:

- Sites close to the coast, specializing in hunting red deer (as is the case of El Cierro F and G, and Tito Bustillo 1 and 2),
- Sites located in open valleys, close to different ecosystems, which allows mixed environment exploitation, resulting in greater hunting diversification (as is the case of La Güelga 3c), and
- Sites located in mountain areas, with a predominance of crag species such as *Capra pyrenaica* or *Rupicapra pyrenaica* (as is the case of Collubil).

In the rest of Cantabrian Spain this strategy seems to be maintained within the Lower Magdalenian levels at the sites, as seen in El Cierro cave (Levels F and G), but also in Rascaño (Levels 3, 4, and 5), El Juyo (Levels 4 and 7) and Tito Bustillo (Levels 1 and 2) among others. This indicates that the persistence in the hunting of *Cervus elaphus* during the Lower Magdalenian is related to multiple economic factors -hunting efficiency and capture optimization-, as well as geography -the location of the caves and their proximity to different ecological niches-, and biological characteristics related to the ethological behavior of the species.

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Fig 1. Lower Magdalenian sites in Cantabrian Spain dated between 20,000 and 17,000 cal BP with faunal remains. 1-La Paloma. 2-Las Caldas (Sala II). 3-Entrefoces. 4-Cova Rosa. 5-El Cierro. 6- La Güelga. 7- Collubil. 8-Tito Bustillo (Área de Hábitat). 9-La Riera. 10-Los Canes. 11-Arangas. 12-Coimbre. 13- El Linar. 14- Las Aguas. 15-Cualventi. 16- Altamira. 17-El Castillo. 18-Hornos de la Peña. 19-El Juyo. 20- El Pendo. 21-El Rascaño. 22-La Garma A. 23-El Mirón. 24-Antoliña. 25-Santimamiñe. 26-Bolinkoba. 27-Praile Aitz I. 28-Urtiaga. 29-Ekain. 30-Erralla.

Fig 2. Drawing of stratigraphic section of El Cierro made by Francisco Jordá Cerdá and Alejandro Gómez, where the studied levels are highlighted (Source Alejandro Gómez Fuentes).

Fig 3. Left: MAU percentage from Level G of El Cierro. Right: MAU percentage from Level F of El Cierro.

Fig 4. Fracture patterns and cut marks on phalanges of *Cervus elaphus* of El Cierro. A: Level F. B: Level G.

Fig 5. Faunal remains of Levels F and G from El Cierro. A: Cut marks in red deer bones. B: Mammal bones modified by carnivores (scores, pits, and punctures). C: Burned bones showing different coloration stages (grades 1 and 2 *apud* Stiner et al. 1995).



	Kcal	%	NRdet.	%
Level F	325,896	42.1	1,672	43.7
Level G	448,107	57.9	2,153	56.3
Total	774,003	100	3,825	100

Table 9. Caloric energy supply by taxa from levels F and G in relation to determined NR and its percentage per level.

Site and level	Main Species (%NISP)	Chronology cal BP	M.A.S.L. (m)	Distance to the present coastline (km)	References
Altamira 2	Red deer (95,1%)	17156 ± 279	160	4	Castaños and Castaños, 2014 González-Echegaray, 1988
Arangas F	Iberian Ibex (43,4%)	18174 ± 263	340	10	Cueto et al., 2015
Las Caldas XIII	Red deer (79,5%)	18324 ± 273	160	30	Altuna and Maríezkurrena, 2017 Corchón, 2017
Las Caldas XIII	Red deer (61,9%)	18156 ± 282			
Las Caldas XII	Horse (50%)	17635 ± 282			
Las Caldas XI	Horse (49%)	16881 ± 230			
Los Canes 2	Iberian Ibex (69%)	19849 ± 349	325	11	Castaños, in Arias, unpublished results
Cierro F	Red deer (92%)	18595 ± 249	82	2	Álvarez-Fernández et al., 2016
Cierro G	Red deer (90%)	18848 ± 205			
Coimbre B4	Iberian Ibex (67,5%)	17014 ± 228	135	10,5	Álvarez-Alonso and Jordá Pardo, 2017 Yravedra et al., 2017
Cova Rosa B6	Red deer (83,3%)	19026 ± 221	170	4	Álvarez-Fernández et al., in press
Ekain VII	Red deer (85%)	19793 ± 399	90	7	Altuna and Maríezkurrena, 1984 Merino, 1984
		19462 ± 409			
		19213 ± 311			
		19156 ± 293			
		18516 ± 380			
Erralla V	Iberian Ibex (89%)	18986 ± 287	230	10	Altuna, 1985 Altuna and Maríezkurrena, 1985
		19407 ± 390			
		19482 ± 408			
La Güelga 3c	Iberian Ibex and chamois (55%)	17274 ± 241	180	15	Menéndez et al., 2005 Soto-Barreiro, 2003
Juyo 7	Red deer (92%)	17353 ± 287			Fernández, 1987
		17590 ± 295	92	4,5	Klein and Cruz-Urbe, 1987
Juyo 4	Red deer (91%)	17127 ± 354			
Mirón 504	Iberian Ibex (63%)	16713 ± 168	260	20	Marín and Geiling, 2015
		17032 ± 225			
Rascaño 5	Iberian Ibex (92%)	19742 ± 327	275	20	Barandiarán and González Echegaray, 1981 Altuna, 1981
Rascaño 4	Iberian Ibex (89%)	19155 ± 266			
Rascaño 3	Iberian Ibex (94%)	18328 ± 275			
Riera 19	Red deer (78%)	19679 ± 554	30	1,5	Altuna, 1986 Straus, 1986b
		18688 ± 486			
		18388 ± 351			
Santimamiñe Csn-Camr	Red deer (91%)	17993 ± 377	137	6	López Quintana and Guenaga, 2011 Castaños and Castaños, 2011
		17974 ± 381			
Tito Bustillo 2	Red deer (95%)	18063 ± 466	200	1	Altuna, 1976 Moure, 1997
Tito Bustillo 1c	Red deer (82,4%)	17996 ± 380			
		17056 ± 358			
		16406 ± 489			
Tito Bustillo 1b	Red deer (77,5%)	15458 ± 345			
Tito Bustillo 1a	Red deer (76,4%)	18544 ± 422			Altuna, 1976
		18350 ± 338			Moure, 1997
		17469 ± 347			Álvarez-Fernández et al., 2015
		17444 ± 282			
		18312 ± 254			
		18323 ± 259			

Table 10. Data on hunting specialization, cal BP radiocarbon chronology, altitude and distance to the current coastline from the selected Cantabrian Lower Magdalenian archaeological sites. The radiocarbon determinations have been calibrated using calpal program (Weninger and Jöris, 2008).

Level F					Level G				
	NR	NISP	MNI	MNE		NR	NISP	MNI	MNE
<i>Cervus elaphus</i>	993	993	8	690	<i>Cervus elaphus</i>	506	506	11	368
<i>Capreolus</i>	7	7	2	6	<i>Capreolus</i>	6	6	1	5
<i>capreolus</i>					<i>capreolus</i>				
<i>Bos/Bison</i>	6	6	1	6	<i>Bos/Bison</i>	6	6	1	5
<i>Capra pyrenaica</i>	70	70	2	52	<i>Capra pyrenaica</i>	34	34	2	18
Medium size	294			120	<i>Equus ferus</i>	3	3	1	2
Small size	302			97	Marine mammal?	3	3	1	3
					Large size	29			10
					Medium size	1295			289
					Small size	271			54
<b>Total</b>	<b>1672</b>	<b>1076</b>	<b>13</b>	<b>971</b>		<b>2153</b>	<b>558</b>	<b>17</b>	<b>754</b>

Table 1. NR (Number of Remains), NISP (Number of Identified Specimens), MNI (Minimum Number of Individuals) and MNE (Minimum Number of anatomical Elements) of the faunal sample from levels F and G of El Cierro.

LEVELS	NISP	NTAXA	E	1/D	H'
<b>CIERRO F</b>	1076	4	0,14401922	0,85598078	0,31354092
<b>CIERRO G</b>	558	6	0,173693812	0,826306188	0,41285968

Table 2. Results of Simpson and Shannon index from F and G levels of El Cierro (NTAXA=number of taxa; E=evenness; 1/D=dominance; H'=specific biodiversity).

	<i>Cervus elaphus</i>		<i>Capra pyrenaica</i>		<i>Bos/bison</i>		<i>Capreolus capreolus</i>		Medium mammal	Small mammal
	NISP	NMI	NISP	NMI	NISP	NMI	NISP	NMI	NISP	NISP
Skull & Tooth	161	6	3	1	-	-	-	-	44	-
Antler & horn	22	2	-	-	-	-	-	-	-	-
Hyoid	4	4	-	-	2	1	-	-	-	-
<b>Subtotal cranial</b>	<b>187 (18.83%)</b>		<b>3 (4.28%)</b>		<b>2 (33.33%)</b>		<b>-</b>		<b>44 (9.18%)</b>	<b>-</b>
Vertebrae	1	1	-	-	-	-	-	-	68	79
Ribs	5	1	-	-	-	-	-	-	155	111
Pelvis	20	1	-	-	-	-	-	-	-	5
Scapula	7	2	-	-	-	-	-	-	-	4
<b>Subtotal axial</b>	<b>33 (3.32%)</b>		<b>-</b>		<b>-</b>		<b>-</b>		<b>183 (62.24%)</b>	<b>199 (65.89%)</b>
Humerus	48	5	-	-	-	-	-	-	-	9
Radius & Ulna	57	7	10	2	-	-	1	1	-	20
Carpals	25	6	-	-	-	-	2	2	-	-
Metacarpus	114	7	-	-	1	1	-	-	-	5
Femur	52	7	22	2	-	-	-	-	13	13
Patella	1	1	-	-	-	-	-	-	-	-
Tibia	100	8	-	-	1	1	-	-	-	5
Tarsals	65	6	4	2	1	1	-	-	-	6
Metatarsus	74	8	3	1	-	-	2	1	-	7
Metapodials	76	-	4	-	1	1	-	-	-	23
Phalanges	161	3	24	2	-	-	2	1	14	15
<b>Subtotal limbs</b>	<b>773 (77.85%)</b>		<b>67 (95.72%)</b>		<b>4 (66.66%)</b>		<b>7 (100%)</b>		<b>27 (9.18%)</b>	<b>103 (34.10%)</b>
<b>TOTAL</b>	<b>993</b>		<b>70</b>		<b>6</b>		<b>7</b>		<b>294</b>	<b>302</b>

Table 3. NISP, NMI and percentage of skeletal parts by taxa and size categories from level F of El Cierro.

	<i>Cervus elaphus</i>		<i>Capra pyrenaica</i>		<i>Bos/bison</i>		<i>Capreolus capreolus</i>		<i>Equus ferus</i>		Marine mammal?	Large mammal	Medium mammal	Small mammal
	NISP	NMI	NISP	NMI	NISP	NMI	NISP	NMI	NISP	NMI	NISP	NISP	NISP	NISP
Skull & Tooth	121	11	6	2	-	-	3	1	3	1	3	1	13	8
Mandible	10	4	-	-	-	-	-	-	-	-	-	-	17	4
Antler & horn	5	1	10	-	-	-	-	-	-	-	-	-	-	-
<b>Subtotal cranial</b>	<b>136 (26.87%)</b>		<b>16 (47.05%)</b>		<b>-</b>		<b>3 (50%)</b>		<b>3 (100%)</b>		<b>3 (100%)</b>	<b>-</b>	<b>30 (2.31%)</b>	<b>12 (4.43%)</b>
Vertebrae	13	1	1	1	-	-	-	-	-	-	-	3	130	17
Ribs	11	1	8	1	-	-	-	-	-	-	-	1	92	72
Sternum	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Pelvis	5	2	-	-	-	-	-	-	-	-	-	-	5	6
Scapula	-	-	-	-	-	-	-	-	-	-	-	-	10	8
Flat bone	-	-	-	-	-	-	-	-	-	-	-	1	186	41
<b>Subtotal axial</b>	<b>29 (5.73%)</b>		<b>9 (26.47%)</b>		<b>-</b>		<b>-</b>		<b>-</b>		<b>-</b>	<b>5 (17.3%)</b>	<b>424 (32.74%)</b>	<b>144 (53.13%)</b>
Humerus	5	2	-	-	-	-	-	-	-	-	-	2	21	3
Radius & Ulna	16	3	-	-	1	1	1	1	-	-	-	1	18	5
Carpals	29	5	1	1	-	-	-	-	-	-	-	-	1	-
Metacarpus	44	8	-	-	-	-	-	-	-	-	-	-	19	1
Femur	5	2	-	-	-	-	-	-	-	-	-	-	24	3
Patella	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Tibia	11	4	-	-	-	-	-	-	-	-	-	-	15	1
Fibula	14	6	-	-	-	-	-	-	-	-	-	1	-	-
Calcaneus	3	2	-	-	-	-	-	-	-	-	-	-	1	-
Astragalus	6	4	-	-	-	-	-	-	-	-	-	-	1	-
Tarsals	54	5	2	1	-	-	-	-	-	-	-	-	4	-
Metatarsus	41	8	-	-	1	1	-	-	-	-	-	1	25	1
Metapodials	10	-	2	1	-	-	-	-	-	-	-	-	70	3
Phalanges	102	4	4	1	4	1	2	1	-	-	-	2	55	23
Long bone	-	-	-	-	-	-	-	-	-	-	-	17	587	75
<b>Subtotal limbs</b>	<b>341 (67.4%)</b>		<b>9 (26.47%)</b>		<b>6 (100%)</b>		<b>3 (50%)</b>		<b>-</b>		<b>-</b>	<b>24 (82.7%)</b>	<b>841 (64.95%)</b>	<b>115 (42.44%)</b>
<b>TOTAL</b>	<b>506</b>		<b>34</b>		<b>6</b>		<b>6</b>		<b>3</b>		<b>3</b>	<b>29</b>	<b>1295</b>	<b>271</b>

Table 4. NISP, NMI and percentage of skeletal parts by taxa and size categories from level G of El Cierro.

Species	Skinning	Disarticulation	Evisceration	Filleting marks	NR
<i>Cervus elaphus</i>	2	10	1	103	126
<i>Capra pyrenaica</i>	1			4	5
<i>Capreolus capreolus</i>				1	1
<i>Bos/bison</i>		1		1	2
Large mammal		1		11	12
Medium mammal	13	4	4	134	155
Small mammal	2	2		36	40
<b>TOTAL</b>	<b>18</b>	<b>18</b>	<b>5</b>	<b>290</b>	<b>341</b>

Table 5. NR with anthropic marks for species from levels F and G of El Cierro.

Assemblage	Weathering	Rootmarks	Watermarks	Manganese oxides	Calcium carbonate	Trampling	Rolled	NR
<b>Level F</b>	88	369	120	137	77	5	101	897
<b>Level G</b>	140	466	28	37	17	26	58	772
<b>TOTAL</b>	<b>228</b>	<b>835</b>	<b>148</b>	<b>174</b>	<b>94</b>	<b>31</b>	<b>159</b>	<b>1669</b>

Table 6. NR with marks produced by natural agents.

Specie	Middle-Weigh (kg)	MNI	Meat + fat (kg)	Calorie (kcal/kg)	Total Energy (kcal)	References
<i>Cervus elaphus</i>	93.5	8	293.6	1,110	325,896	Carranza, 2004 Clutton-Brock and Iason, 1986 Marín, 2010
<i>Capreolus capreolus</i>	24.2	1	9.5	1,110	10,545	Mateos-Quesada, 2005 Marín, 2010
<i>Bos/Bison</i>	600	1	300	1,220	366,000	Krasinska and Krasinski, 2002 Marín, 2008
<i>Capra pyrenaica</i>	51.2	2	19.4	1,140	44,232	Alados and Escos, 2003 Marín, 2010

Table 7. Caloric energy supplied by the main consumed macro-mammals from Level F of El Cierro, based on the MNI.

Specie	Middle-Weigh (kg)	MNI	Meat + fat (kg)	Calorie (kcal/kg)	Total Energy (kcal)	References
<i>Cervus elaphus</i>	93.5	11	403.7	1,110	448,107	Carranza, 2004 Clutton-Brock and Iason, 1986 Marín, 2010
<i>Capreolus capreolus</i>	24.2	1	9.5	1,110	10,545	Mateos-Quesada, 2005 Marín, 2010
<i>Bos/Bison</i>	600	1	300	1,220	366,000	Krasinska and Krasinski, 2002 Marín, 2008
<i>Capra pyrenaica</i>	51.2	2	19.4	1,140	44,232	Alados and Escos, 2003 Marín, 2010
<i>Equus ferus</i>	210.25	1	147.1	1,080	158,868	Outram and Rowley-Conwy, 1998 USDA, 2007

Table 8. Caloric energy supplied by the main consumed macro-mammals from Level G of El Cierro, based on the MNI.



