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Methodological Challenges and Interpretive Potentials

Human Subsistence Before and After the 8.2 ka cal BP Event in Northern Iberia: Archaeozoology and Proteomic Data From the Macromammal Assemblage of El Mazo Rock Shelter

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ABSTRACT

El Mazo rock shelter (Asturias, Spain) contains a long and well-dated Mesolithic sequence that shows an extended human presence between 9 and 7.4 ka cal BP, including the climatic 8.2 ka cal BP event, characterized by abrupt temperature drops and drastic environmental changes. Human activities were evidenced by abundant lithic tools, fireplaces, marine and terrestrial specimens, and plant macroremains. This climatic event continues to trigger debates about the causes of changes in human behavior and subsistence strategies. Therefore, the El Mazo long sequence allows for identifying and comparing human subsistence patterns before, during, and after the 8.2 ka cal BP event. The archaeozoological and taphonomic analysis of the macromammal assemblage indicates red deer as the primary prey, followed by wild boar and roe deer, with a high representation of adults but also juveniles. Cut and percussion marks are associated with disarticulation and skinning activities on the carcasses. At the same time, burnt bones were abundant in the sequence. Despite the significant representation of axial bones, including ribs and vertebrae, and fetal/newborn elements, their high fragmentation drove those bones to be identifiable

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primarily to mammal size, which prevented more detailed information about hunting strategies, prey transport, and site seasonality. To tackle this morphological limitation, we applied Zooarchaeology by Mass Spectrometry (ZooMS) in this study to determine the whole spectrum of axial and newborn elements. Proteomics results indicate that adult and infant remains correspond mainly to red deer and wild boar. Besides, it shows a broader herbivore and carnivore spectrum than archaeozoology showed, including humans, bovines, small carnivores, or undetected species such as the Eurasian beaver. Finally, the mammal assemblage reveals how the sudden temperature decrease during the 8.2 ka cal BP significantly impacted terrestrial animal exploitation. After the 8.2 ka cal BP event, intensification indices show that the consumption of herbivores and marine resources increased significantly.

INTRODUCTION

In Iberia, the transition from the Pleistocene to the Holocene brought significant climatic and paleoeconomic changes, as evidenced in the archaeological record. From the late Magdalenian to the Mesolithic (16–6.7 ka cal BP), environmental and climatic proxies reveal a gradual increase in temperature, humidity, sea level, and tree cover. However, technological simplification in the lithic and bone industries, reduced human mobility and catchment areas, and sudden parietal rock art disappearance is observed in the Cantabrian region, north Spain. In parallel, other terrestrial mammals like roe deer and wild boar that were minimally exploited during the Upper Paleolithic, became abundant in the Mesolithic, in parallel to the intensification of marine resources such as limpets, crabs, or sea urchins (Bailey and Craighead 2003; Clark 1995; Fernández-Tresguerres 1983; García-Escárzaga 2020; García-Escárzaga et al. 2022; Gutiérrez-Zugasti 2009; Gutiérrez-Zugasti et al. 2016; Marín-Arroyo 2013; Mary 1992; Straus 1992). The early Holocene is characterized by its climatic stability although several cold events have been recorded. One of those is the "8.2 ka cal BP event", a period characterized by abrupt temperature drops and drastic environmental changes as noticed in pollen, shell, and speleothem isotopic records (García-Escárzaga et al. 2022). Unraveling the impact of these climatic changes on the ecological niches exploited by Mesolithic human groups and how this affected their subsistence is relevant for understanding human adaptations by late hunter-gatherer-shellfishers. El Mazo rock shelter (Figure 1) contains a long Mesolithic sequence between 9 and 7.4 ka cal BP composed of multiple shell-midden levels recently excavated with modern techniques and analyzed with a multidisciplinary approach, thus offering a detailed site formation process and precise information about the role of human activities in the site during the Mesolithic (García-Escárzaga et al. 2022; García-Escárzaga and Gutiérrez-Zugasti 2021).

It is crucial to obtain an accurate taxonomic identification of the faunal assemblages found in an archeological site to comprehend past ecological conditions and unravel dietary habits and seasonal human mobility for habitat exploitation (Torres-Iglesias 2023). However, those assemblages usually appear severely fragmented and affected by anthropic and natural taphonomic processes, limiting the interpretation of human strategies (Buckley et al. 2009; Marín-Arroyo 2009a; Sinet-Mathiot et al. 2019). Archaeozoology and taphonomy are relevant disciplines applied to mammal assemblages to discern human subsistence patterns (Marín-Arroyo et al. 2020), especially in highly fragmented assemblages produced by humans during the intense prey exploitation but also affected by postdepositional factors as occurred during the Paleolithic and Mesolithic. That high fragmentation of biological assemblages challenges the identification of an important proportion

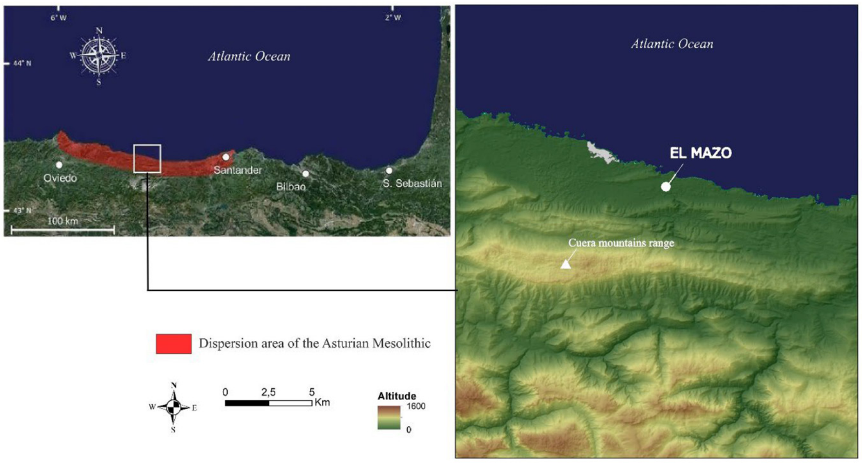

Figure 1. Location of the El Mazo rock shelter in the Cantabrian region, northern Spain, and its distance from the current coastline.

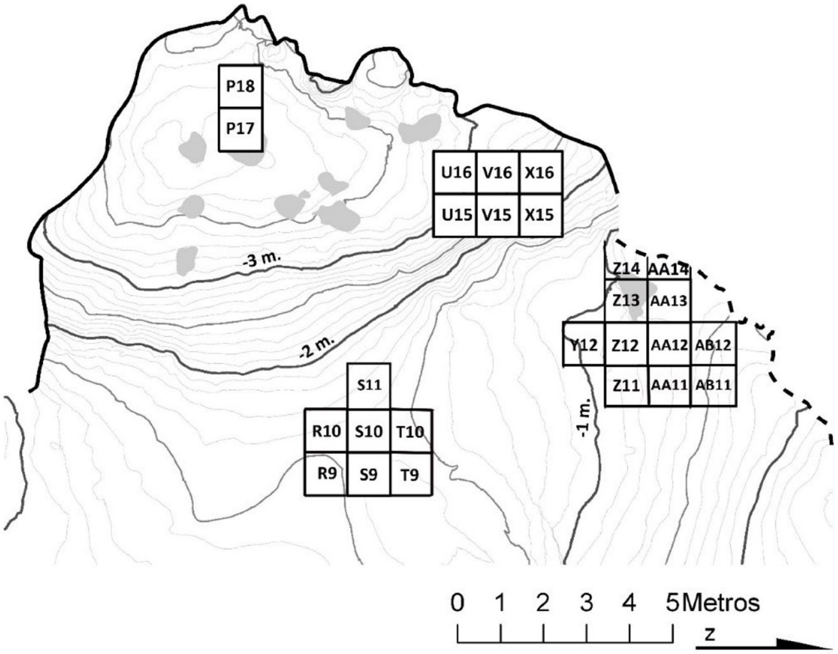

Figure 2. Topography of the El Mazo rock shelter and excavated square locations.

of the skeletal remains still preserved. Zooarchaeology by Mass Spectrometry (ZooMS), examining protein and peptide differences between species, facilitates species identification at these particular Late Pleistocene-Holocene sites, by requiring a small sample size, and being a minimally invasive method (Brandt et al. 2018; Buckley et al. 2009). In recent years, proteomic application to archaeological assemblages has revealed important data about human ecological habitats and economic decisions (Hublin et al. 2020; Pothier Bouchard et al. 2020; Ruebens et al. 2022, 2023; Silvestrini et al. 2022; Sinet-Mahiot et al. 2019, 2023; Torres-Iglesias et al. 2024).

Combining traditional archaeozoology and biomolecular ZooMS is an advantageous tool for analyzing fragmented axial bones and fetal/newborn remains, as it can provide taxonomic information for otherwise unidentified or size-classified remains. Therefore, the primary objectives of this paper are to expand the taxonomic information related to these indeterminate remains, improve the accuracy of prey skeletal profile, and unravel the type of hunting strategies and seasonal site use, which in combination with taphonomic data can provide a comparative study of the human subsistence strategies through the Mesolithic, specifically in the pre-, during-, and post-8.2 ka cal BP levels of El Mazo.

MATERIALS AND METHODS

THE MESOLITHIC SITE OF EL MAZO

El Mazo is a rock shelter in Asturias (N. Spain), in the village of Andrín (municipality of Llanes). It is located on the coastal platform, around 1km from the present coastline. (see Figure 1). The rock shelter is 18m long by 7m deep and was located at a maximum distance of 2.5km from the sea during the Mesolithic (Gutiérrez-Zugasti et al. 2016; Leorri et al. 2012). The first archaeological campaigns were carried out in 2009 and continued in 2010 and 2012 to 2017 (Supplementary Material Text 1) (Gutiérrez-Zugasti et al. 2018; Gutiérrez-Zugasti and González Morales 2013) (Figure 2).

A series of radiocarbon dates (Figure 3) was carried out along the different Stratigraphic Units (SUs), obtaining a total of 65 ^{14}C AMS measurements from 23 out of the 25 stratigraphic units documented in squares X15 and X16 of the shell midden. The Bayesian modeled sequence places the formation of this shell-midden in the Early and Middle Holocene, between 9.0 and 7.4 ka cal BP (García-Escárzaga et al. 2022). This coherent chronological resolution has provided an accurate reconstruction of the spatial use and the evolution of the exploitation patterns carried out by the late hunter-gatherer-shellfishers (García-Escárzaga 2020; Gutiérrez-Zugasti et al. 2014, 2016, 2018).

A large number of bioarchaeological remains, including marine food resources such as gastropods (mainly topshells *Phorcus lineatus* and limpets of the *Patella genus*), bivalves (*Mytilus galloprovincialis*), echinoids (*Paracentrotus lividus*), crustaceans (*Pollicipes pollicipes*), marine mammals (*Halichoerus grypus*), and fish remains, as well as different terrestrial species such as red deer, roe deer, wild boar, birds, and plant remains/seeds (such as *Corylus avellana, Arbutus unedo,* and *Erica terminalis*) were recovered (García-Escárzaga 2020; Gutiérrez-Zugasti and Gonzalez Morales 2013; Gutiérrez-Zugasti et al. 2013, 2014; López-Dóriga 2015; Marín-Arroyo et al. 2020). Regarding the technology, there are cores, flakes, and blades, and in terms of tools, geometric microliths, denticulates, side scrapers, and perforators have been recorded. The raw material mainly corresponds to local flint and radiolarite (Fuertes-Prieto et al.

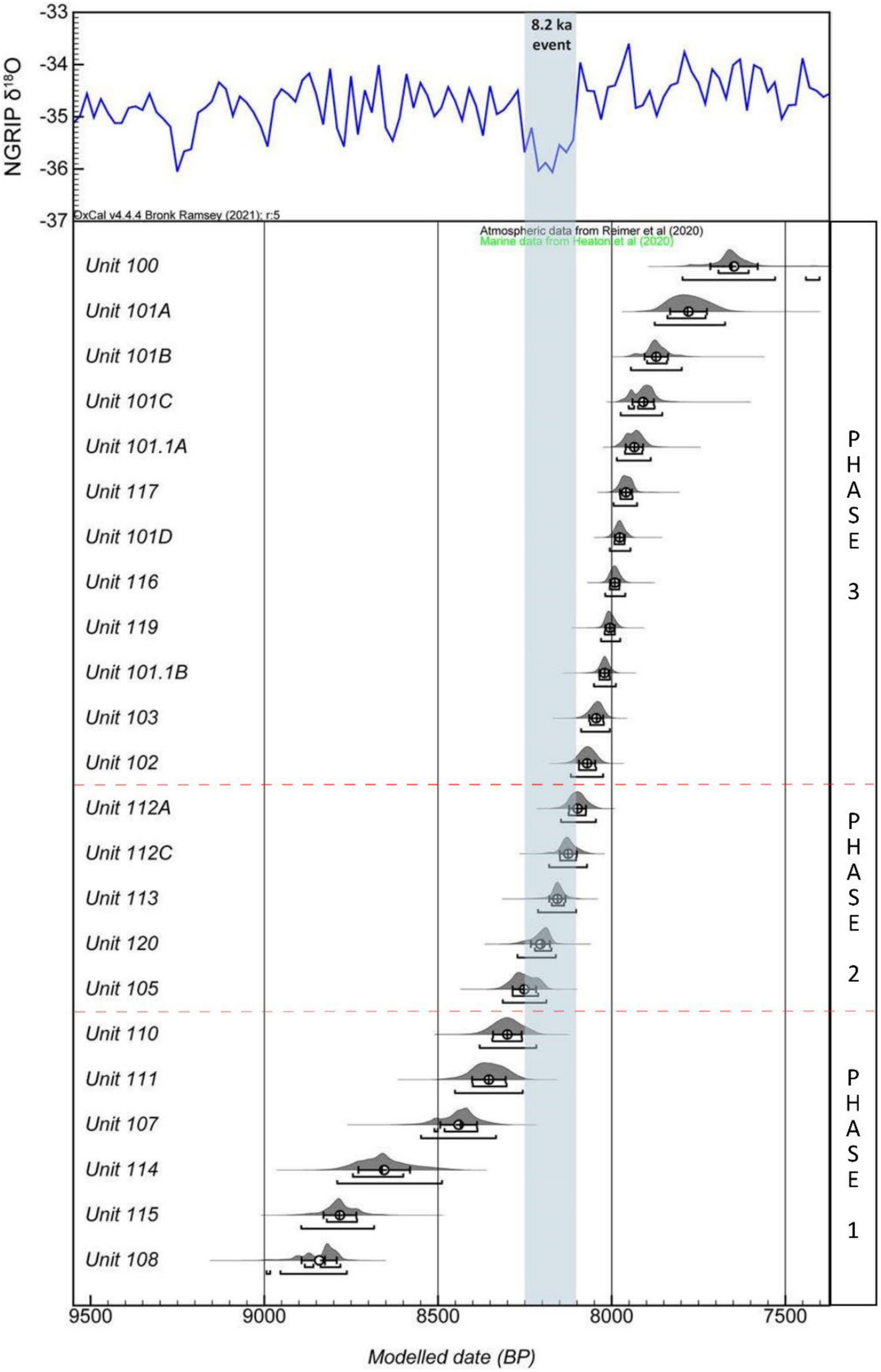

Figure 3. Radiocarbon chronology of the Mesolithic sequence of El Mazo rock shelter (Asturias, N. Spain) modeled using OxCal v.4.4.2 (Bronk Ramsey 2009) and the radiocarbon calibration curves IntCal20 (Reimer et al. 2020) and Marine20 (Heaton et al. 2020) (modified from García-Escárzaga et al. 2022: Figure 2) (CC BY 4.0 DEED https://creativecommons.org/licenses/by/4.0/).

2021; García-Escárzaga 2020; Gutiérrez-Zugasti et al. 2013, 2014). Several human remains were also recovered—seven teeth and a long bone. These remains correspond to at least four individuals (three adults and one infant) (Drak Hernández 2016; González-Rabanal 2022).

ARCHAEOZOOLOGICAL AND TAPHONOMIC RESEARCH

An archaeozoological and taphonomic analysis was applied to the study of the macromammal remains recovered in the 25 stratigraphic units (see Figure 2). For the anatomical and taxonomic classification of macrofaunal bones, we used several osteological atlases (Barone 1987; Hillson 2005; Pales and García 1981; Pales and Lambert 1971; Schmid 1972; Varela and Rodríguez 2004) in parallel to the reference collection of the EvoAdapta Group at the University of Cantabria. When fragmentation made precise taxonomy unfeasible, remains were classified into mammal size categories based on body weight—size 2 or small mammals (<20kg), lagomorphs and small carnivores; size 3 or medium mammals (20–100kg), caprid, small cervid and wolf; size 4 or medium-large mammals (100–300kg) red deer and wild boar; and size 5 large mammals (>300kg), horse and bovines. Bone fragments lacking morphologically determinant characteristics or highly fragmented elements were classified as "indeterminate." Mortality profiles were estimated using bone fusion, tooth eruption, and dental wear (Payne 1985) for cervids (Azorit et al. 2002; Mariezkurrena 1983; Tomé and Vigne 2003), suids, and bovines (Habermehl 1961; Silver 1980).

Several indices were applied for the quantification and interpretation of intensification—Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI), Minimum Number of Skeletal Elements (MNE), the ratio between juvenile and adult individuals, the ratio between low (roe deer) and high ranked (large bovines, red deer, wild boar) resources, fragmentation (NISP/MNE) (Marín-Arroyo 2009a, 2010), Inverse of Simpson's Index (1/D), and considering both NISP and MNI (Magurran 1988; Simpson 1949). The biomass of ungulates was calculated by multiplying the usable meat values of each individual by the MNI according to their age (Marín-Arroyo and González Morales 2009). For juveniles, the value is 66.7% of an adult's weight, and for infants is 33.3% (Garrard 1998). The data on meat yield provided by molluscs at El Mazo were included to determine their contribution to the human diet. To extrapolate the mollusc biomass data (see García-Escárzaga 2020) to the total excavated area, the data were multiplied by 5. An anatomical code was used to more easily facilitate bone quantification (Marean et al. 2001; Romandini 2012).

The taphonomic study was conducted along with the archaeozoological analysis, considering anthropic and natural alterations relevant to understanding the origin of these materials. Fresh fractures, cut or impact marks, and fire alterations were analyzed among the anthropic modifications (Binford 1981; Blasco Sancho 1992; Fernández et al. 2013; Pérez Ripoll 1992; Shipman et al. 1984; Villa and Mahieu 1991). Post-depositional changes such as carnivore marks, trampling, root marks, water dissolution, weathering, manganese, or concretion were also examined (Behrensmeyer 1978; Binford 1981; Fisher 1995; Geiling et al. 2018; Marín-Arroyo et al. 2008; Olsen and Shipman 1988). All the archaeozoological and taphonomic information was compiled using the database created during the ERC CoG Subsilience project.

Despite the total archaeofaunal assemblage containing 12,369 remains, only those stratigraphic units directly dated (7,691 faunal elements) were considered and grouped per comparison through time to evaluate the evolution of human subsistence along the sequence. Thus, phase 1 comprises the units dated before the 8.2 ka cal BP event, and they are 107, 108, 110, 111, 114, and 115. Phase 2 corresponds to the duration of the event, and they are units 105, 112A, 112B, 112C, 113, and 120. Finally, phase 3 corresponds to after the event with units 3, 101A, 101B, 101C, 101D, 101.1A, 101.1B, 100/101, 100, 102, 103, 103.1, 116, and 119. It is important to note that the duration of these three phases is different. According to the Bayesian model of the chronology obtained (García-Escárzaga et al. 2022), the first phase lasted about 500 years, the second phase was about 225 years, and the third phase was about 440 years.

PROTEOMIC ANALYSIS (ZOOARCHAEOLOGY BY MASS SPECTROMETRY)

This study analyzed 211 bones (Supplementary Material Table 1), exclusively focused on the axial skeleton of all ages (vertebrae, ribs, and sternal fragments; n=133), fetal/newborn (n=27), juveniles (n=7), and adult elements (n=44) recovered from six squares (T10, S10, V15, V16, X15, and X16). The aim was to: 1) unravel taxonomy, 2) enhance seasonality data, and 3) ascertain carcass transport. We focused the proteomic analysis on the axial skeleton as these remains are often represented in macrofaunal assemblages, but due to their fragmentation, they are hardly identified taxonomically and tend to be classified as mammal size or as indeterminate, biasing the prey skeletal profiles. To refine skeletal profiles and expand taxonomic information on those represented prey, we selected axial bones (fragments of ribs, sternums, and vertebrae). We excluded from the study those remains that were burned, and when several bone fragments could be refitted or could belong to the same skeletal element, only one of the fragments was selected to avoid MNE and MNI overestimation.

The soluble collagen was obtained using the AmBic technique (van Doorn et al. 2011), in which each sample (~10–30mg) was incubated in 100μL of 50mM ammonium-bicarbonate (NH_3CO_3, AmBic) buffer at 65°C for one hour. After, we demineralized the samples in 150μL of 0.6M HCl at 4°C for 18 hours (Buckley et al. 2009; Welker et al. 2015). Following that, the samples were incubated in 100μL of AmBic for 1 hour at 65°C to extract the bone collagen. Afterwards, 50μL of the resulting supernatant was digested using trypsin (0.5μg/μL, Promega) for 12–18 hours at 37°C, acidified by adding 1μL of 10% TFA, and cleaned using C18 ZipTips (Thermo Scientific). Finally, the peptides

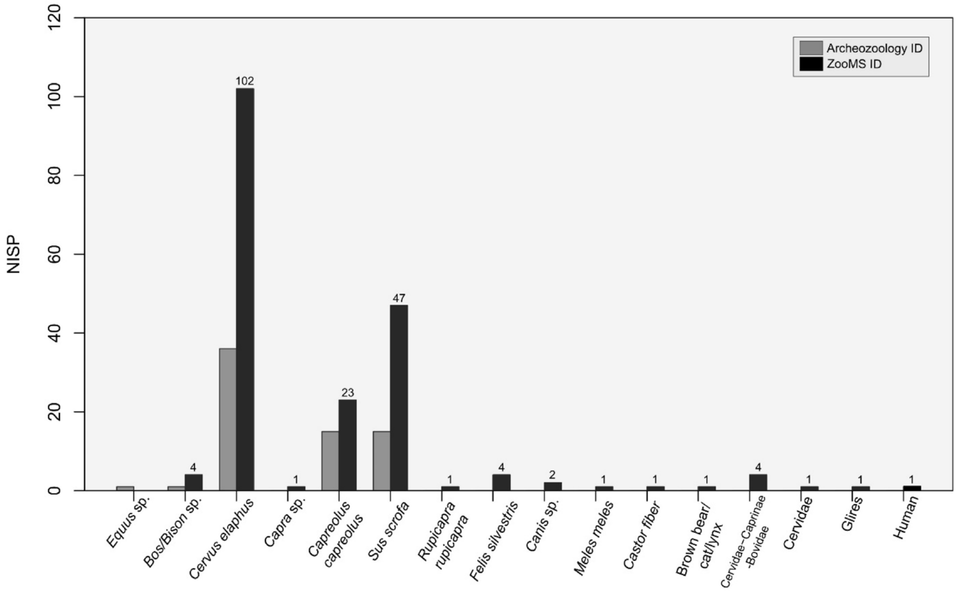

Figure 4. Comparison of species identified by archaeozoology (morphology) and proteomics (ZooMS) at El Mazo rock shelter.

were applied in triplicate to a Bruker MALDI plate mixed with a matrix solution of α-cyano-4-hydroxycinnamic acid (CHCA). The plate was then sent to the University of York (UK) for analysis using MALDI-TOF MS on a Bruker ultraflex III machine. For taxonomic identification, we compared spectra manually using mMass v.5.5.0 (Strohalm et al. 2008) with a reference library of acknowledged peptide markers. This library contains medium and large mammalian species from the European Pleistocene (Buckley et al. 2009; Jensen et al. 2020; Kirby et al. 2013; Welker et al. 2016).

RESULTS

ARCHAEOZOOLOGICAL RESULTS BEFORE ZOOMS RESULTS

Before the implementation of ZooMS, a comprehensive archaeozoological analysis of the entire macrofaunal assemblage at El Mazo was carried out, including those levels without direct dating. In total, 12,369 macrofaunal remains were quantified (Supplementary Material Table 2). Three percent (n=399) of the bones were identified taxonomically and anatomically. These belong to 271 elements (MNE) and 93 individuals (MNI). Fragmentation was remarkably high, with 91% of the assemblage belonging to undetermined elements, and 4% identified as mammal size. Among the macromammal remains, undetermined remains of birds (n=15) and fish (n=210) were recovered, representing 2% of the assemblage. Further bird and fish remains have been recovered during excavations but have not been included in this study. Medium-large or size 4 mammals comprised 63% of the elements categorized as mammal size.

Concerning the NISP, *Cervus elaphus* was the most represented ungulate (59%), followed by *Sus scrofa* (18%) and *Capreolus capreolus* (14%). Other ungulates, such as *Bos/Bison* sp. and *Equus* sp., were also identified with a low incidence (<0.5%). Six remains of three different terrestrial carnivores and one marine mammal were also found: *Canis lupus, Felis silvestris, Ursus* sp., and *Halichoerus grypus*. A *Homo sapiens* tooth was identified among the faunal remains, corresponding to an M1 with an advanced wear stage.

ZOOMS ANALYSIS

Of the 211 elements, 89% of the samples provided good results, while due to poor collagen preservation, 24 samples failed. Figure 4 illustrates the correlation between the initial archaeozoological identification, and the final identification generated by ZooMS.

Proteomic results indicate that the Cervidae samples were the most abundant. Based on the archaeozoological and morphometric evidence, they were considered red deer. Due to the absence of some specific markers, some of the samples could not be distinguished between Cervidae and Caprinae-Bovidae.

The axial elements sampled correspond mostly to red deer (n=68). Among these, 72% are adults, 12% are juveniles, and 16% are newborn red deer. The wild boar (n=23) is the second most represented species among the axial elements—83% of the remains are vertebrae from adults, 4% from a juvenile, 9% from newborns, and 4% from a fetal individual (vertebral disc). For roe deer, 11 axial remains belong to adult and juvenile individuals, and 3 to an adult bovine. Additional species were identified from the axial bones, including a rib fragment of a newborn ibex, an adult dog/wolf vertebra, and an adult carnivore vertebra that could correspond to a brown bear, cat, or lynx according to the peptide markers. The latter is most likely a wild cat based on size and morphology. Regarding dogs and wolves, their peptide markers are identical, so considering the existence of domesticated dogs in the Mesolithic (Detry and Cardoso 2010; Pires et al. 2019), it was decided to classify it as *Canis* sp. In summary, ZooMS analysis has confirmed red deer as the primary species within the inde-

TABLE 1. TAXONOMIC IDENTIFICATION OF FETAL/NEWBORN INDIVIDUALS ANALYZED BY ZooMS (excluding axial elements).

Species	NISP	Bone element	Age estimation
***Bos/Bison* sp.**	1	Long bone	Newborn
Cervus elaphus	1	Cranium	Fetal
	1	Long bone	Fetal
	1	Cranium	Newborn
	1	Long bone	Newborn
	2	Radius	Newborn
	1	Pelvis	Juvenile
Sus scrofa	1	Pelvis	Fetal
	1	Long bone	Newborn
	2	Humerus	Newborn
	1	Radius	Newborn
	1	Pelvis	Newborn
	2	Phalanx I	Newborn
	1	Phalanx II	Newborn
Felis silvestris	1	Femur	Newborn
Meles meles	1	Mandible	Newborn
Castor fiber	1	Incisive Indet.	Newborn
Glires	1	Incisive Indet.	Juvenile
Human	1	Rib	Indeterminate
Total	**22**		

terminate axial remains, followed by wild boar, roe deer, carnivores, and ibex. Ibex was not identified during the archeozoological study. Table 1 shows the taxonomy of infant and juvenile individuals identified through ZooMS.

HUMAN SUBSISTENCE BEFORE, DURING, AND AFTER THE 8.2 CAL BP EVENT

Quantification Results

A total of 7,691 macrofaunal remains were analyzed from the stratigraphic units directly dated (Table 2). After applying ZooMS methodology to a further 211 samples, the percentage of remains identified taxonomically increased significantly from 3% to 7%, with 3% identified as mammal size and 87% remaining unidentified. The remaining 3% are fish and birds. The results showed that a minimum of 254 elements (MNE) and 79 individuals were quantified, mainly from phase 3 (Supplementary Material Table 3).

During phase 1, in terms of MNI, the most represented ungulate species was *Cervus elaphus* at 38%, followed by *Sus scrofa* at 31%, and *Capreolus capreolus,* and *Bos/Bison* sp. at 15% each. During phase 2, the presence of *Cervus elaphus* and *Sus scrofa* persists, although *Cervus elaphus* represents 45% of the total. The representation of *Capreolus capreolus* decreased slightly (9%), and no *Bos/Bison* sp. remains were found. An adult individual of *Rupicapra rupicapra* (9%) was identified. However, there was a notable change at phase 3. *Sus scrofa* became the most commonly found species with 36%, followed by *Cervus elaphus* (34%). The representation of *Capreolus capreolus* also increased to 22%. *Bos/Bison* sp. (7%) appears again in this phase, more abundant than before the event. In addition, there was one juvenile individual of *Capra* sp. During phase 3, there is an increase in species diversity and the number of individuals. In temporal terms, this indicates an intensification in the exploitation of terrestrial resources during this phase in comparison with previous ones (Table 3). Results show a considerable dietary diversity with a preference towards *Cervus elaphus* and *Sus scrofa*.

The taxonomic diversity of carnivores was more notable—in phase 1, an isolated tooth of *Ursus* sp. (left canine) and another of *Castor fiber* (incisor) represented; in phase 2, *Meles meles* and *Canis* sp. bones; and in phase 3 bone remains of *Felis silvestris, Canis lupus, Canis* sp., and a pelvis fragment of *Halichoerus grypus* (Figure 5). Among the macromammal remains, there were also various birds (n=12) and fish remains (n= 10), mostly from phase 3. A human remain was also discovered during ZooMS analysis—one right rib fragment.

Taphonomy of the Mesolithic Assemblage

The taphonomic study was crucial for identifying the

TABLE 2. TOTAL NUMBER OF IDENTIFIED SPECIMENS (NISP), MINIMUM NUMBER OF ELEMENTS (MNE), MINIMUM NUMBER OF INDIVIDUALS (MNI), AND THE PERCENTAGE (MNI%) AND THE BIOMASS (kg) OF THE MESOLITHIC ASSEMBLAGE OF EL MAZO AFTER ZooMS ANALYSIS*.

EL MAZO **PHASE 1- Pre-8.2 ka cal BP**

Taxa	**NISP**	**MNE**	**MNI**					**MNI%**	**Biomass (kg)**
			I	**J**	**SAd**	**Ad**	**Total**		
Bos/Bison sp.	6	3	1			1	2	15	533
Cervus elaphus	47	35	1	1	1	2	5	38	300
Capra sp.									
Capreolus capreolus	3	3			1	1	2	15	24
Sus scrofa	13	8		2		2	4	31	177
Rupicapra rupicapra									
Total Ungulata	**69**	**49**	**2**	**3**	**2**	**6**	**13**		**1034**
Felis silvestris									
Halichoerus grypus									
Ursus sp.	1	1				1	1		
Canis sp.									
Canis lupus									
Meles meles									
Castor fiber	1	1	1				1		
Homo sapiens	1	1				1	1		
Total Carnivores and Others	**3**	**3**	**1**			**2**	**3**		
Bird									
Fish	19								
Total Identified	**91**	**52**	**3**	**3**	**2**	**8**	**16**		
Size 1 (smaller than rabbit)									
Size 2 (rabbit-small carnivore)	10								
Size 3 (caprid, small cervid, wolf)	1								
Size 4 (red deer, pig, reindeer, ass, bear)	49								
Size 5 (elk, giant deer, horse, bovid)									
Indeterminate	1167								
GRAND TOTAL	**1318**								

*I=Infantile; J=Juvenile; SAd=Subadult; Ad=Adult.

origin of the bone accumulation and its postdepositional modifications. Earlier research by Andreu Alarcón (2013) confirmed that due to burned remains, cut, and percussion marks, the bone assemblage was human accumulated. Our study (Supplementary Material Tables 4 and 5) confirms this assumption and reveals that anthropic modifications (Figure 6) were more abundant during phase 3, showing a large variability of butchering marks. During phase 3, various remains of red deer, wild boar, undetermined birds, and mammals size 3 and 4 showed cut marks. The butchering incisions were found on various bones, including the cranium, hyoid, mandible, vertebrae, ribs, humerus, radius, ulna, carpals, pelvis, metapods, and tarsal. Based on the cut marks position, they are associated with skinning, scraping, and disarticulation or dismemberment activities. Furthermore, percussion marks were mainly on short bones (chop marks) of red deer, roe deer, and wild boar. Notches have been documented on long bones and isolat-

TABLE 2. TOTAL NUMBER OF IDENTIFIED SPECIMENS (NISP), MINIMUM NUMBER OF ELEMENTS (MNE), MINIMUM NUMBER OF INDIVIDUALS (MNI), AND THE PERCENTAGE (MNI%) AND THE BIOMASS (kg) OF THE MESOLITHIC ASSEMBLAGE OF EL MAZO AFTER ZooMS ANALYSIS (continued)*.

EL MAZO **PHASE 2- During 8.2 ka cal BP**

Taxa	**NISP**	**MNE**	**MNI**					**MNI%**	**Biomass (kg)**
			I	**J**	**SAd**	**Ad**	**Total**		
Bos/Bison sp.									
Cervus elaphus	31	21		2		3	5	45	325
Capra sp.									
Capreolus capreolus	10	4				1	1	9	12
Sus scrofa	11	8	1	1	1	1	4	36	159
Rupicapra rupicapra	1	1				1	1	9	43
Total Ungulata	**53**	**34**	**1**	**3**	**1**	**6**	**11**		**539**
Felis silvestris	1	1	1				1		
Halichoerus grypus									
Ursus sp.									
Canis sp.	1	1				1	1		
Canis lupus									
Meles meles	1	1	1				1		
Castor fiber									
Homo sapiens									
Total Carnivores and Others	**3**	**3**	**2**			**1**	**3**		
Bird	2								
Fish	21								
Total Identified	**79**	**37**	**3**	**3**	**1**	**7**	**14**		
Size 1 (smaller than rabbit)									
Size 2 (rabbit-small carnivore)									
Size 3 (caprid, small cervid, wolf)	1								
Size 4 (red deer, pig, reindeer, ass, bear)	24								
Size 5 (elk, giant deer, horse, bovid)									
Indeterminate	761								
GRAND TOTAL	**865**								

*I=Infantile; J=Juvenile; SAd=Subadult; Ad=Adult.

ed flakes, potentially related to the fracturing process for extracting marrow. Fire alteration was the most common alteration observed through the three phases (1–3), representing 28%, 46%, and 41%, respectively. Occasionally, the bones displayed other colorations, such as black-gray and gray-white. The fragmentation index of ungulates (see Table 3) also shows notable intensification during phase 3. In the first phase, the fragmentation was 1.4; in the second, 1.6; and in the last phase, up to 2.4.

Carnivore marks were present only during phase 2 (0.2%) and phase 3 (0.1%). A carpal (semilunar) of a wild boar was slightly modified through digestion, identified during phase 2. During phase 3, two pits were identified in the first phalanx of a red deer and the thoracic vertebra of a mammal with a size of 4. The scarcity of these marks suggests that carnivores played a minor role as scavengers of human leftovers.

TABLE 2. TOTAL NUMBER OF IDENTIFIED SPECIMENS (NISP), MINIMUM NUMBER OF ELEMENTS (MNE), MINIMUM NUMBER OF INDIVIDUALS (MNI), AND THE PERCENTAGE (MNI%) AND THE BIOMASS (kg) OF THE MESOLITHIC ASSEMBLAGE OF EL MAZO AFTER ZooMS ANALYSIS (continued)*.

EL MAZO **PHASE 3 - Post-8.2 ka cal BP**

Taxa	NISP	MNE	MNI					MNI%	Biomass (kg)
			I	J	SAd	Ad	Total		
Bos/Bison sp.	3	3			1	2	3	7	1200
Cervus elaphus	199	93	2	3	3	6	14	34	875
Capra sp.	1	1	1				1	1	14
Capreolus capreolus	42	28	1	2	2	4	9	22	92
Sus scrofa	129	30	3	5	3	4	15	36	600
Rupicapra rupicapra									
Total Ungulata	**374**	**155**	**7**	**10**	**9**	**16**	**42**		**2781**
Felis silvestris	4	4				3	3		
Halichoerus grypus	1	1	1				1		
Ursus sp.									
Canis sp.	1	1				1	1		
Canis lupus	3	3				1	1		
Meles meles									
Castor fiber									
Homo sapiens	1	1				1	1		
Total Carnivores and Others	**10**	**10**	**1**			**6**	**7**		
Bird	10								
Fish	170								
Total Identified	**564**	**165**	**8**	**10**	**9**	**22**	**49**		
Size 1 (smaller than rabbit)	1								
Size 2 (rabbit-small carnivore)	7								
Size 3 (caprid, small cervid, wolf)	33								
Size 4 (red deer, pig, reindeer, ass, bear)	133								
Size 5 (elk, giant deer, horse, bovid)	1								
Indeterminate	4769								
GRAND TOTAL	**5508**								

*I=Infantile; J=Juvenile; SAd=Subadult; Ad=Adult.

Human Subsistence Evolution Through the Mesolithic

Before using ZooMS on the macrofaunal assemblage, the skeletal representation of the species was unclear. This was because the axial unit was classified as a mammal size, resulting in a biased representation of skeletal parts towards the fore and hindlimbs. However, the sampled axial bones mainly corresponded to red deer, indicating that the axial unit was transported to the site, independently of the prey age (Supplementary Material Figure 1). In this case, all skeletal elements of red deer were present, suggesting that these were entirely transported and exploited during all three phases, particularly during phase 3.

In the three phases, adult individuals (including subadults) predominated according to the MNI by age. A newborn red deer (0–6 months) was identified in phase 1 (based on an unerupted M1 germ stage and axial bones with tiny size and very porous bone surface) (see Figure 5). Juvenile wild boar and red deer individuals were identified through

TABLE 3. INTENSIFICATION RATES OBSERVED IN THE MACROFAUNAL ASSEMBLAGE OF EL MAZO BEFORE, DURING, AND AFTER THE 8.2 KA CAL BP EVENT.

	PHASE 1	PHASE 2	PHASE 3
	Pre-8.2 ka cal BP	During-8.2 ka cal BP	Post-8.2 ka cal BP
Fragmentation	1.4	1.6	2.4
Juvenile vs. Adult	0.4	0.6	0.7
Simpson's Inverse Index (NISP)	1.9	2.3	2.4
Simpson's Inverse Index (MNI)	3.4	2.8	3.4
Biomass (kg) of ungulates	1,034	539	2,781
Biomass (kg) of shellfish	45	62	75
Ratio Low vs. High	0.22	0.22	0.31

Figure 5. Cervus elaphus *bones of phase 3: A) fragment of hyoid of an adult individual with cut marks; B) fragment of long bone of fetal individual; C) rib fragment of newborn individual.* Sus scrofa *bones of phase 1: D) distal epiphysis of Phalanx I of newborn individual; E) vertebral disc of fetal individual.* Sus scrofa *bones of phase 3: F) rib fragment of newborn individual; G) thoracic vertebra of juvenile individual. H)* Capreolus capreolus *rib fragment (phase 3), I) femur fragment of infant* Felis silvestris *(phase 2), J)* Castor fiber *incisor (phase 1), K) rib fragment of an adult individual of* Bos/Bison *sp. (phase 3).*

Figure 6. Anthropic marks recorded in different Mesolithic stratigraphic units of El Mazo. Phase 1: A) phalanx II of Cervus elaphus *with a chop mark; B) general box of burnt bones. Phase 2: C) bird long bone with cut marks. Phase 3: D) metacarpus of* Capreolus capreolus, *fractured when fresh and with a notch and adhering flake; E) fragment of a possible point.*

the state of bone fusion and porosity in the case of the long bone shafts. During phase 2, wild boars of all ages were hunted. Through ZooMS, we discovered that one of the small and porous pelvis fragments corresponded to an infant wild boar. This phase also revealed juvenile individuals of red deer and wild boar (see Figure 5), characterized by the fusion of their phalanges and long bones. During phase 3, hunting pressure on infants and juveniles increases significantly (MNI=17) on the main ungulates, with wild boar being the most consumed prey. At this time, humans were focused on exploiting entire populations of wild boar, red deer, and roe deer, including fetal individuals (<0 months) of red deer and wild boar. Large bovines were again hunted, including adult and subadult individuals (>24 months). The hunted ibex also corresponds to a newborn individual.

The ratio of juveniles to adults indicates that there was an intensive and increased exploitation of younger individuals from phase 1 to the other two phases (see Table 3). Specifically, during phase 3 all available plains, forest, and mountain resources were exploited. Seasonality data enhanced with ZooMS taxonomic identification confirm the presence of fetal, newborn, and juvenile individuals of wild boar and red deer likely hunted between February and late summer. The presence of fetal individuals suggests that they would preferentially pursue pregnant females and their newborn calves. During phase 1, seasonality data suggest hunting between April and June, when red deer are usually born. During phase 2, through the presence of a young wild boar and juvenile red deer, we can determine a seasonality from February until early summer.

Table 3 provides the calculated biomass for ungulates, including the meat yield provided by shellfish calculated at El Mazo. During phase 1, the biomass of ungulates was 1,034kg. The highest contribution derives from large bovines (533kg) and red deer (300kg), while the biomass contribution of molluscs was much lower (45kg). However, during phase 2, the biomass decreased to 539kg, which could be related to environmental conditions that affected the net primary productivity and, thus, the herbivore populations. Red deer contributed the most biomass, with 325kg in phase 2. In the case of molluscs, biomass contribution increases considerably (62kg), even providing a higher meat yield than roe deer or chamois. Due to abrupt climate change, terrestrial mammals would decrease, forcing human groups to capture marine resources more intensively (Marín-Arroyo 2013; Marín-Arroyo and González Morales 2009; Straus 2004). Despite being better adapted to warmth, some limpet species show high resistivity to cold and continued to be available during the abrupt cold that caused the 8.2 ka cal BP (García-Escárzaga et al. 2022). During phase 3, ungulate biomass increases significantly to 2,781kg, doubling the phase 1 results. The most outstanding contribution comes from large bovines (1,200kg) and red deer (875kg), followed by wild boar (600kg). In phase

3, the meat contribution of molluscs increased (75kg). The ratio between low and high prey species shows an increase in low prey in phase 3 (0.31), suggesting that they were intensively exploiting all available resources.

DISCUSSION

This study provides new insights into the subsistence patterns of Mesolithic groups that inhabited El Mazo during the Early and Middle Holocene. Two methods were applied to the macromammal assemblage: a traditional archeozoogical and taphonomic study and ZooMS, a pioneering biomolecular technique, never applied before to a Mesolithic site located in the Cantabrian region, northern Iberia. The results have provided information on the human diet, hunting patterns, butchering processes, prey transport, and site seasonality, before, during, and after the 8.2 ka cal BP event.

The application of the proteomic method has provided an accurate taxonomic identification of skeletal elements that usually are categorized as mammal size or in most of the cases, as indeterminate in archaeozoological studies, such as the axial and neonatal/infant species transported to the site. ZooMS identified that the axial bones mostly belonged to adult and infant red deer, wild boar, and juvenile roe deer. The results of the infant elements revealed that the most prevalent species was wild boar. The skeletal representation of red deer before ZooMS indicated that forelimbs and hindlimbs were primarily exploited; in contrast, taxonomic identification of axial bones indicated that these prey items were transported to the site entirely (see Figure 5). Therefore, the combination of both methodologies confirms a complete transport of the main ungulates to the rock shelter, independently of the animal's age and size. This transport could indicate that the prey were hunted nearby El Mazo rock shelter.

Likewise, ZooMS provides visibility to the "ghost species," i.e., species not identified or poorly identified during the archeozoological study, mostly due to the fragmentation state and postdepositional alterations. Thus, bones categorized as "mammal size 2" generally correspond to wild cats. *Bos/Bison* sp. was more abundant than initially assumed, and sporadic ibex hunting was also noted. Curiously, a tooth classified as mammal size 1 was identified as a beaver. In Iberia, the presence of this taxon is scarce and primarily represented in the late Pleistocene at Atapuerca (Gran Dolina TD5 and TD6, and Portalón) or Cova Negra (Valencia) (Cuenca-Bescós et al. 2017). In Zatoya cave (Navarra), beaver was also found during the Azilian (level II) (Mariezkurrena 2011). By using ZooMS, it was possible to identify one new human remain (Figure 7), added to seven teeth and one long bone identified during the excavation (González-Rabanal 2022) and another one during the archaeozoological study.

Taphonomy confirmed the anthropogenic origin of the Mesolithic macrofaunal assemblage accumulated at El Mazo, and this conclusion is based primarily on the abundance of burned remains, fractures, and cut marks on the ungulate bones associated with skinning, disarticulation, and the exploitation of bone fat and marrow. Similarly, the scarce marks left by carnivores suggest that they may have exploited human waste in the absence of humans. However, it is worth noting that human occupation intensified after the 8.2 ka cal BP event. Before the 8.2 ka cal BP event, humans captured ungulates like red deer, wild boar, and roe deer. The presence of bovines was more limited, although they may have contributed significantly to the meat yield (533kg), as in other contemporaneous sites such as La Fragua (Marín-Arroyo 2004) or Mazaculos II (Marín-Arroyo and González Morales 2009). Before 8.2 ka cal BP, the total biomass of ungulates was 1,034kg.

Figure 7. A human rib (phase 1) identified by ZooMS in the stratigraphic sequence of El Mazo.

During the 8.2 ka cal BP oscillations, there was a rapid temperature drop that might have affected the ecosystems and available ungulate resources (Marín-Arroyo 2009b; Marín-Arroyo and González Morales 2009). This climatic change is observed in El Mazo, though not as severely as in other areas (evidence of depopulation of surrounding areas, such as the Castilian Plateau and the Ebro Valley) (García-Escárzaga et al. 2022). As a result, terrestrial resources became scarce, as revealed by the taxonomic diversity during this period that decreased significantly. Red deer became the main prey (45%) for the hunter-gatherer-shellfishers, and the biomass contribution was reduced to 539kg. The presence of a chamois suggests that humans would occasionally also move to nearby mountainous areas. The pattern is also seen in Mazaculos II, and it is considered a human adaptive response to environmental fluctuations (Marín-Arroyo and González Morales 2009). During the 8.2 ka cal BP event, population growth began, as suggested by the greater intensity of the occupations, the appearance of geometric microliths (Fuertes et al. 2021), and the arrival of foreign populations (Allentoft et al. 2024). This population increase led to an intensification in the exploitation of ungulates, which can be observed during phase 3. After the 8.2 ka cal BP event, around 7.9 ka cal BP, the increase in temperature and humidity led to significant forest growth (García-Escárzaga et al. 2022;

García Moreno 2007), which provided a suitable environment for a significant presence of wild boars. Due to the increasing population, the consumption of wild boars also rose exponentially. In addition, previously unrepresented species, such as the ibex, were included. This suggests how humans exploited diverse available resources intensively, even moving away from the settlement and the coastal areas to the nearby Cuera mountains range. The biomass obtained increased to 2,781kg during this period. This growth would have favored the intensification of marine resources and the overexploitation of terrestrial resources (González-Rabanal 2022).

Another difference is the age profile of the prey hunted during the Mesolithic. Before 8.2 ka cal BP, the presence of infant individuals was relatively low and primarily concentrated in fawns. This might suggest that humans were focused on hunting female red deer and their newborn calves during the spring and early summer (Marín-Arroyo 2010). However, after 8.2 ka cal BP, infant red deer, ibex, roe deer, and wild boar are all continuously included in the diet despite their low input of meat and marrow. The presence of infant and adult individuals and lower-ranking species leads us to infer that there was a likely resource overexploitation (Marín-Arroyo 2013).

These data imply that ungulates were likely the primary source of animal protein for human communities in terms of yield. García-Escárzaga and Gutiérrez-Zugasti (2021) estimated the meat yield of molluscs at El Mazo, comparing it with the previous archaeozoological data of Andreu Alarcón (2013). Since 8.2 ka cal BP, marine resources were intensified by humans, decreasing the shells' size over time. The size of the shells increased again between 7.9 and 7.8 ka cal BP (García-Escárzaga et al. 2022). Molluscs represent almost 20% of the total yield (García-Escárzaga 2020), while the meat contribution of ungulates is much higher, representing 60%. Considering that these would not be the only resources is essential. El Mazo also yielded various fish bones that were significantly valuable to the human diet during the Mesolithic. The use of marine and estuarine resources has been found in other sites in the region: La Riera (Ortea 1986), Poza l'Egua (Arias et al. 2007), La Fragua (Gutiérrez-Zugasti 2011), El Toral III (Rigaud and Gutiérrez-Zugasti 2016). There were also bird bones with cut marks and plant resources, though underrepresented due to their poor preservation, that would have comprised a significant portion of the human diet.

CONCLUSIONS

Archaeozoological and ZooMS studies at the El Mazo site offer valuable insights into how Mesolithic populations exploited the landscape through time and adopted a diverse paleoeconomic behavior adapted to the continuous climatic and environmental changes. The macrofaunal assemblage studied with traditional archeozoological and taphonomic analysis in combination with proteomics applied to highly fragmented axial elements and delicate infant individuals have widened the information about human subsistence strategies and thus revealed an intensification of the mammal resources during the Mesolithic. Compared to previous periods, a significant intensification after the 8.2 ka cal BP event is observed in the macromammal assemblage. During the 8.2 ka cal BP climatic oscillations, exploitation of ungulates dropped, being relatively limited, and a decrease in taxonomic diversity and prey abundance was observed. However, after that, the increase in temperature and humidity during the Middle Holocene facilitated the expansion of forests, providing an environment suitable for a significant presence of wild boars and including previously unrepresented species such as the ibex. Similarly, marine resources were essential for these human groups, which intensified significantly during the 8.2 ka cal BP event.

DATA AVAILABILITY STATEMENT

A list of the observed peptide markers for each sample is presented in Supplementary Material Table 1 and merged spectra are available at: https://github.com/ERC-Subsilience/ZooMS-archaeozoology-at-El-Mazo-rockshelter-

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Special Issue: Integrating ZooMS and Zooarchaeology:
Methodological Challenges and Interpretive Potentials

Supplement 1: Human Subsistence Before and After the 8.2 ka cal BP Event in Northern Iberia: Archaeozoology and Proteomic Data From the Macromammal Assemblage of El Mazo Rock Shelter

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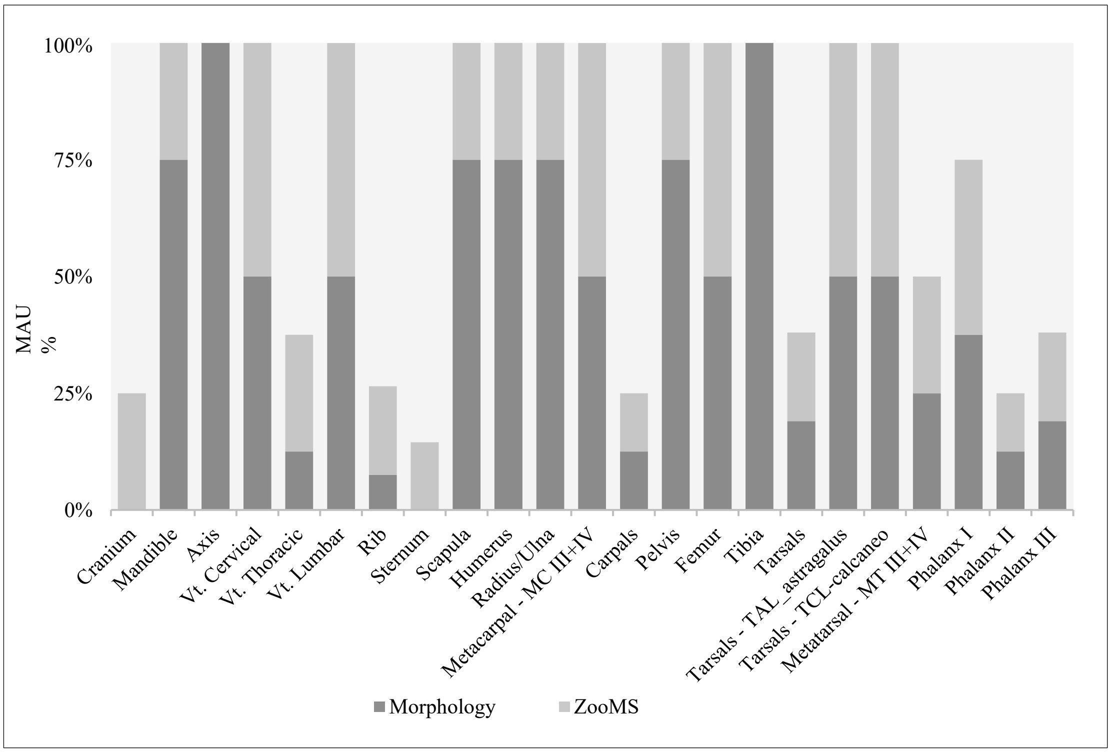
SUPPLEMENT 1

This supplementary material includes: Supplementary Text 1, Supplementary Figure 1, and Supplementary Tables 1–5.

Supplementary Text 1: The Mesolithic site of El Mazo (Asturias, N Spain)

In 2009 and 2010, a test pit was carried out in the area closest to the entrance of the rock shelter (“Sondeo Abrigo”, excavation squares V15 and V16), in which a total of eight SUs were identified (100/101, 102, 103, 103.1, 104, 105, 106 and 107) (Gutiérrez-Zugasti et al. 2016, 2018). During these excavations, the base of the shell pit was reached, so during the 2012 campaign, a profile was sampled for various analyses. The test pit was expanded in 2012 to squares X15 and X16, allowing the opportunity to refine the stratigraphy in that site area because some units included other units and were identified in the adjacent squares. In addition, during 2009-2010 remains of cemented shells were identified on the walls at various points in the shelter, suggesting that the shells had been subjected to severe erosion processes, which were more pronounced at the entrance. The north profile was sampled in a limited extension (2 m in the east-west axis x 0.25 m in the north-south axis), recording a total of 25 stratigraphic units (García-Escárzaga et al. 2022; Gutiérrez-Zugasti et al. 2018; Gutiérrez-Zugasti and Gonzalez Morales 2013). In 2009, 2014, and 2015, a test pit was carried out in front of the rock shelter (“Sondeo Entrada”, excavation squares S10 and T10). A shell-midden unit (3) and two Mesolithic units without shells (1B and 1C) were excavated here.

Supplementary Figure 1. Comparison of the skeletal representation of *Cervus elaphus* identified by archeozoology (morphology) and proteomics (ZooMS) at El Mazo rock shelter after the 8.2 ka cal BP event.



Supplementary Table 1. Peptide markers identified in the Mesolithic samples of El Mazo.

Samples	ZOOARCH ID	Bone element	Age estimation	ZOOMS ID	COL1α1 508 - 519	COL1α2 978 - 990	COL1α2 484 - 498	COL1α2 502 - 519	COL1α2 292 - 309	COL1α2 793 - 816	COL1α2 454 - 483	COL1α1 586 - 618	COL1α2 757 - 789	COL1α1 910 - 934
MAZ02	Size 2 (rabit-small carnivore)	Vt. Cervical	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ03	Indeterminate	Vt. Indet	Juvenile	Capreolus	1105	x	1427	1550	1648	2131	x	2883	3059+3043	
MAZ04	Indeterminate	Vt. Indet	Juvenile	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ05	Indeterminate	Rib	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ06	Size 3 (caprid, small cervid, wolf)	Rib	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ07	Size 3 (caprid, small cervid, wolf)	Rib	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ08	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Cervus	1105	1196	1427	1550	1648	2131	x	2883	3033	2216
MAZ09	Size 3 (caprid, small cervid, wolf)	Vt. Cervical	Fetal	Failed	x	x	x	x	x	x	x	x	x	
MAZ10	Size 2 (rabit-small carnivore)	Rib	Adult	Felis silvestris	x	x	x	1566	x	2163	x	x	x	
MAZ11	Indeterminate	Vt. Indet	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033	
MAZ12	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Lumbar	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883+2889	3033	
MAZ13	Cervus elaphus	Vt. Thoracic	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ14	Indeterminate	Rib	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033+3017	
MAZ15	Indeterminate	Rib	Adult	Capreolus	1105	x	1427	x	1648	2131	x	x	3059	
MAZ16	Indeterminate	Rib	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883+2899	3033	
MAZ17	Indeterminate	Rib	Adult	Caprinae/Cervidae/Bovidae	x	x	x	x	1648	2131	x	x	3033	
MAZ18	Indeterminate	Rib	Adult	Sus scrofa	1105	x	1453	1550	x	2131	x	x	3033	
MAZ19	Indeterminate	Rib	Adult	Sus scrofa	1105	x	1453	x	x	2131	x	2883	3033	
MAZ20	Indeterminate	Vt. Indet	Adult	Caprinae/Cervidae/Bovidae	x	x	x	x	1648	2131	x	x	x	
MAZ21	Indeterminate	Vt. Indet	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033	
MAZ22	Indeterminate	Vt. Indet	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ23	Indeterminate	Vt. Thoracic	Adult	Capreolus	1105	x	1427	x	1648	2131	x	x	3059	
MAZ24	Indeterminate	Vt. Indet	Adult	Sus scrofa	x	x	1453	x	x	2131	x	x	3033	
MAZ25	Indeterminate	Vt. Indet	Adult	Cervus	1105	1196	1427	1550	1648	2131	x	x	3033	
MAZ26	Indeterminate	Atlas	Adult	Sus scrofa	1105	x	1453	x	x	2131	x	2883	3033	
MAZ27	Indeterminate	Rib	Adult	Caprinae/Cervidae/Bovidae	1105	x	1427	x	1648	2131	x	x	x	
MAZ28	Size 2 (rabit-small carnivore)	Rib	Adult	Brown bear/cat/lynx	x	x	x	x	x	2163	x	x	x	
MAZ29	Indeterminate	Vt. Indet	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ30	Indeterminate	Vt. Indet	Adult	Sus scrofa	1105	x	1453	x	x	2131	x	x	3033	
MAZ31	Indeterminate	Vt. Indet	New born	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ32	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ33	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ34	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Cervus	1105	x	1427	x	1648	2131	x	x	3033	
MAZ35	Size 4 (red deer, pig, reindeer, ass, bear)	Rib	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ36	Capreolus capreolus	Vt. Lumbar	Juvenile	Failed	x	x	x	x	x	x	x	x	x	
MAZ37	Cervus elaphus	Vt. Lumbar	Adult	Cervus	1105	x	1427	X	1648	2131	x	x	3033	
MAZ38	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Cervus	1105	x	1427	x	1648	2131	x	x	3033	
MAZ39	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883+2899	3033	
MAZ40	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883+2899	3033+3017	
MAZ41	Cervus elaphus	Rib	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ42	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Canis sp.	1105	x	1453	x	x	2131	x	2853+2869	2999	
MAZ43	Size 3 (caprid, small cervid, wolf)	Rib	New born	Cervus	1105	1196	1427	1550	1648	2131	x	2883	3033	
MAZ44	Indeterminate	Rib	New born	Cervus	1105	1196	1427	x	1648	2131	x	2883	3033	
AMBMAZ45	Indeterminate	Rib	New born	Capra sp.	1105	1196	1427	1580	1648	2131	2792	2883+2899	3093	
MAZ46	Indeterminate	Rib	New born	Cervus	1105	1196	1427	1550	1648	2131	x	2883	3033	
MAZ47	Indeterminate	Rib	New born	Cervus	1105	x	1427	x	1648	2131	x	x	3033	
MAZ48	Capreolus capreolus	Rib	New born	Cervus	1105	x	x	x	1648	2131	x	2883	3033	
MAZ49	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033+3017	
MAZ50	Size 4 (red deer, pig, reindeer, ass, bear)	Rib	Adult	Bos/Bison	1105	x	1427	x	1648	2131	x	2853+2869	3033+3017	
MAZ51	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Failed	1105	x	x	x	x	x	x	2883+2899	x	
MAZ52	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ53	Size 4 (red deer, pig, reindeer, ass, bear)	Rib	Juvenile	Capreolus	1105	x	1427	x	1648	2131	x	2883	3043+3059	
MAZ54	Size 4 (red deer, pig, reindeer, ass, bear)	Rib	Juvenile	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ55	Size 4 (red deer, pig, reindeer, ass, bear)	Rib	Juvenile	Failed	x	x	x	x	x	x	x	x	x	
MAZ56	Size 4 (red deer, pig, reindeer, ass, bear)	Rib	Juvenile	Failed	x	x	x	x	x	x	x	x	x	
MAZ57	Sus scrofa	Vt. Thoracic	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ58	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Thoracic	Adult	Capreolus	1105	1196	1427	1550	1648	2131	x	2883	3033	
MAZ59	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Thoracic	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ60	Indeterminate	Vt. Cervical	Adult	Felis silvestris	x	x	x	1566	1609	2163	x	x	x	
MAZ61	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Cervical	Juvenile	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033	
MAZ62	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Cervical	Juvenile	Cervus	1105	x	1427	x	1648	2131	x	2883+2899	3033	
MAZ63	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Cervus	1105	1196	1427	x	1648	2131	x	2883	3033	
MAZ64	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Cervical	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033+3017	
MAZ65	Size 3 (caprid, small cervid, wolf)	Sternum	Adult	Capreolus	1105	x	1427	x	1648	2131	x	x	3059	
MAZ66	Size 3 (caprid, small cervid, wolf)	Sternum	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883+2899	3033+3017	
MAZ67	Capreolus capreolus	Vt. Cervical	Adult	Caprinae/Cervidae/Bovidae	x	x	x	x	1648	2131	x	x	3033	
MAZ68	Cervus elaphus	Vt. Cervical	Adult	Sus scrofa	1105	x	1453	x	x	2131	x	2883	3033	
MAZ69	Cervus elaphus	Rib	Adult	Indeterminate	x	x	x	x	1648	2131	x	x	x	
MAZ70	Cervus elaphus	Vt. Lumbar	Juvenile	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ71	Cervus elaphus	Rib	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ72	Cervus elaphus	Vt. Thoracic	Juvenile	Capreolus	1105	x	1427	x	1648	2131	x	x	3059	
MAZ73	Cervus elaphus	Vt. Lumbar	Adult	Sus scrofa	x	x	1453	x	x	2131	x	x	3033	
MAZ74	Cervus elaphus	Vt. Lumbar	Adult	Cervus	1105	1196	1427	1550	1648	2131	x	x	3033	
MAZ75	Cervus elaphus	Vt. Indet	Adult	Sus scrofa	1105	x	1453	x	x	2131	x	2883	3033	
MAZ76	Cervus elaphus	Vt. Lumbar	Juvenile	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ77	Cervus elaphus	Vt. Cervical	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ78	Cervus elaphus	Vt. Cervical	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ79	Cervus elaphus	Vt. Cervical	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ80	Cervus elaphus	Vt. Thoracic	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3017+3033	2216
MAZ81	Indeterminate	Rib	Adult	Capreolus	1105	1196	1427	1550	1648	2131	x	2883+2899	3059	
MAZ82	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033	
MAZ83	Sus scrofa	Rib	Adult	Sus scrofa	1105	x	1453	1550	x	2131	x	2883	3033	
MAZ84	Size 3 (caprid, small cervid, wolf)	Rib	New born	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033	
MAZ85	Cervus elaphus	Axis	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
MAZ86	Bos/Bison sp.	Rib	Adult	Bos/Bison	1105	1208	1427	1580	1648	2131	x	2853+2869	3033	
MAZ87	Cervus elaphus	Vt. Lumbar	Adult	Cervus	1105	1196	1427	1550	1648	2131	x	2883	3033	2216
MAZ88	Capreolus capreolus	Vt. Thoracic	New born	Cervus	1105	1196	1427	x	1648	2131	x	2883	3033+3017	
MAZ89	Size 3 (caprid, small cervid, wolf)	Rib	New born	Caprinae/Cervidae/Bovidae	1105	x	1427	x	1648	2131	x	x	x	
MAZ90	Capreolus capreolus	Vt. Thoracic	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883	3033+3017	2216
MAZ91	Equus sp.	Rib	Adult	Bos/Bison	1105	x	1427	x	1648	2131	x	2853	x	
MAZ92	Indeterminate	Vt. Cervical	Adult	Capreolus	1105	1196	1427	1550	1648	2131	x	2883	3059	
MAZ93	Indeterminate	Vt. Indet	Juvenile	Cervus	1105	1196	1427	1550	1648	2131	x	2883	3033+3017	
MAZ94	indeterminate	Vt. Indet	Adult	Sus scrofa	1105	x	1453	1550	x	2131	x	2883	3033	
MAZ95	Capreolus capreolus	Vt. Thoracic	Adult	Sus scrofa	1105	1196	1453	1550	x	2131	x	2883	3033	
MAZ96	Capreolus capreolus	Vt. Thoracic	Juvenile	Sus scrofa	1105	x	1453	x	x	2131	x	2883	3033	
MAZ97	Cervus elaphus	Vt. Thoracic	Adult	Cervus	1105	1196	1427	1550	1648	2131	x	2883	3033	2216
MAZ98	Indeterminate	Vt. Cervical	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033+3017	
MAZ99	Indeterminate	Rib	Indeterminate	Human	1105	1235	1477	1580	x	2115	x	2869+2885	2957	
MAZ100	Indeterminate	Rib	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033	2216
MAZ101	Indeterminate	Vt. Indet	New born	Sus scrofa	1105	x	1453	1550	x	2131	x	2883+2899	3033	
MAZ102	Size 3 (caprid, small cervid, wolf)	Rib	New born	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033	
MAZ103	Indeterminate	Vt. Indet	New born	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033+3017	
MAZ104	Indeterminate	Rib	Adult	Cervus	1105	1196	1427	1550	1648	2131	x	2883	3033	
MAZ105	Indeterminate	Rib	Adult	Sus scrofa	1105	1196	1453	1550	x	2131	x	2883+2899	3033	
MAZ106	Indeterminate	Rib	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ107	Indeterminate	Rib	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ108	Indeterminate	Rib	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ109	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ110	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Sus scrofa	1105	1196	1453	1550	1647	2131	x	2883+2899	3033+3017	
MAZ111	Indeterminate	Vt. Indet	Fetal	Sus scrofa	1105	1196	1453	1550	1647	2131	2820	2883+2899	3033+3017	
MAZ112	Size 3 (caprid, small cervid, wolf)	Rib	Juvenile	Capreolus	1105	1196	1427	1550	1648	2131	x	2883+2899	3059+3043	
MAZ113	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ114	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033+3017	
MAZ115	Cervus elaphus	Rib	Juvenile	Failed	x	x	x	x	x	x	x	x	x	
MAZ116	Capreolus capreolus	Vt. Cervical	Adult	Canis sp.	1105	x	1453	1556	x	2131	x	2853+2869	2999	
MAZ117	Size 3 (caprid, small cervid, wolf)	Vt. Thoracic	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033+3017	
MAZ118	Size 3 (caprid, small cervid, wolf)	Vt. Lumbar	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	
MAZ119	Size 2 (rabit-small carnivore)	Rib	Adult	Felis silvestris	x	x	x	1566	x	2163	x	x	x	
MAZ120	Size 2 (rabit-small carnivore)	Rib	Adult	Sus scrofa	1105	1196	1453	1550	1647	2131	x	2883	3017	

Samples	ZOOARCH ID	Bone element	Age estimation	ZOOMS ID	COL1α1 508 - 519	COL1α2 978 - 990	COL1α2 484 - 498	COL1α2 502 - 519	COL1α2 292 - 309	COL1α2 793 - 816	COL1α2 454 - 483	COL1α1 586 - 618	COL1α2 757 - 789	COL1α1 910 - 934
MAZ121	Indeterminate	Vt. Indet	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ122	Size 3 (caprid, small cervid, wolf)	Rib	Adult	Failed	x	x	x	x	x	x	x	x	x	
MAZ123	Cervus elaphus	Vt. Lumbar	Adult	Sus scrofa	1105	1196	1453	1550	x	2131	2820	2883+2899	3033+3017	
MAZ124	Size 4 (red deer, pig, reindeer, ass, bear)	Rib	Adult	Sus scrofa	1105	1196	1453	1550	x	2131	2820	2883+2899	3033	
MAZ125	Sus scrofa	Vt. Thoracic	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033	2216
MAZ126	Indeterminate	Rib	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033	2216
MAZ127	Indeterminate	Rib	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033	2216
MAZ128	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033	2216
MAZ129	Size 4 (red deer, pig, reindeer, ass, bear)	Vt. Indet	Adult	Sus scrofa	1105	1196	1453	1550	x	2131	2820	2883+2899	3033	
MAZ130	Size 3 (caprid, small cervid, wolf)	Mandible	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ131	Indeterminate	Long bone	Fetal	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ132	Size 3 (caprid, small cervid, wolf)	Phalanx I	New born	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033	
MAZ133	Size 4 (red deer, pig, reindeer, ass, bear)	Humerus	New born	Sus scrofa	1105	1196	1453	x	1647	2131	2820	2883+2899	3033+3017	
MAZ134	Indeterminate	Long bone	New born	Bos/Bison	1105	1192+1208	1427	1580	1648	2131	x	2792+2853	3033	
MAZ135	indeterminate	Rib	New born	Sus scrofa	1105	1196	1453	1550	x	2131	2820	2883+2899	3033+3017	
MAZ136	Indeterminate	Long bone	New born	Cervidae	1105	x	1427	1550	1648	2131	x	x	x	
MAZ137	Indeterminate	Vt. Thoracic	New born	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ138	Indeterminate	Humerus	New born	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033+3017	
MAZ139	Indeterminate	Cranium	Fetal	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ140	Size 2 (rabit-small carnivore)	Femur	New born	Felis silvestris	x	1223	1453	1566	x	2163	x	x	x	
MAZ141	Indeterminate	Pelvis	Fetal	Sus scrofa	1105	1196	1453	1550	1647	2131	2820	2883+2899	3033+3017	
MAZ142	Indeterminate	Cranium	New born	Failed	x	x	x	x	x	x	x	x	x	
MAZ143	Indeterminate	Long bone	New born	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883	3033	
MAZ144	Indeterminate	Long bone	New born	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ145	Indeterminate	Pelvis	New born	Sus scrofa	1105	x	1453	x	1647	2131	2820	2883+2899	3033+3017	
MAZ146	Size 3 (caprid, small cervid, wolf)	Cranium	New born	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ147	Size 3 (caprid, small cervid, wolf)	Radius	New born	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ148	Indeterminate	Radius	New born	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033+3017	2216
MAZ150	Indeterminate	Incisive Indet.	Juvenile	Glires	1105	x	x	x	x	2129	x	x	x	
MAZ151	Size 3 (caprid, small cervid, wolf)	Radius	New born	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033+3017	
MAZ152	indeterminate	Mandible	New born	Meles	1105	1235	1453	1566	1609	2147	x	2853+2869	2973	
MAZ153	Size 4 (red deer, pig, reindeer, ass, bear)	Phalanx I	New born	Sus scrofa	1105	x	1453	1550	1647	2131	2820	2883+2899	3033	
MAZ154	Sus scrofa	Phalanx II	New born	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033+3017	
MAZ155	Size 4 (red deer, pig, reindeer, ass, bear)	Pelvis	Juvenile	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
MAZ156	Size 1 (smaller than rabbit)	Incisive Indet.	New born	Castor	1105	x	1427	x	x	2129	x	x	x	
EM103Ce1	Cervus elaphus	Tibia	Adult	Cervus	1105	x	1427	x	1648	2131	x	2899+2883	3033+3017	
EM103Ce3	Indeterminate	Tibia	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2899+2883	3033+3017	2216
EM103Ce5	Indeterminate	Tibia	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
EM103Cp2	Cervus elaphus	Mandible	Adult	Capreolus	1105	x	1427	x	1648	2131	x	2883	3043+3059	
EM103Su1	Sus scrofa	Atrophic phl I	Adult	Sus scrofa	1105	x	1453	1550	x	2131	x	2883	3033	
EM103Su2	Sus scrofa	Atrophic phl II	Adult	Sus scrofa	1105	x	1453	1550	1647	2131	2820	2883+2899	3033+3017	
EM103Ud1	Size 4 (red deer, pig, reindeer, ass, bear)	Femur	Adult	Sus scrofa	1105	x	1453	1550	x	2131	x	2883	3033	
EM103Ud2	Size 4 (red deer, pig, reindeer, ass, bear)	Epif. Indet	Adult	Cervus	1105	x	1427	x	1648	2131	2792	2883+2899	3033	2216
EM103Ud3	Indeterminate	Indeterminate	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033	
EM103Mm1	Size 4 (red deer, pig, reindeer, ass, bear)	Scapula	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
EM103Mm2	Size 4 (red deer, pig, reindeer, ass, bear)	Indeterminate	Adult	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883	3033	
EM103Mm3	Size 3 (caprid, small cervid, wolf)	Indeterminate	Adult	Capreolus	1105	x	1427	x	1648	2131	x	2883	3059	
EM103Mm6	Size 3 (caprid, small cervid, wolf)	Indeterminate	Adult	Capreolus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3043+3059	
EM103Mm9	Size 3 (caprid, small cervid, wolf)	Indeterminate	Adult	Capreolus	1105	x	1427	1550	1648	2131	2792	2883+2899	3043+3059	
EM105Ce1	Cervus elaphus	Tibia	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033+3017	
EM105Ce3	Cervus elaphus	Tibia	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
EM105Ce4	Cervus elaphus	Long bone	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033+3017	
EM105Cp1	Capreolus capreolus	Mandible	Adult	Capreolus	1105	x	1427	1550	1648	2131	2792	2883+2899	3043+3059	
EM105Cp2	Capreolus capreolus	Tibia	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883+2899	3033	2216
EM105Cp3	Capreolus capreolus	Humerus	Adult	Capreolus	1105	x	1427	x	1648	2131	x	2883	3043+3059	
EM105Cp5	Capreolus capreolus	Humerus	Adult	Capreolus	1105	x	1427	1550	1648	2131	x	2883+2899	3043+3059	
EM105Cp6	Capreolus capreolus	Humerus	Adult	Capreolus	1105	x	1427	x	1648	2131	x	2883+2899	3043+3059	
EM105Su1	Sus scrofa	Carpal (semilunare)	Adult	Sus scrofa	1105	1196	1453	1550	1647	2131	2820	2883+2899	3033+3017	
EM105Su3	Sus scrofa	Phalanx II	Juvenile	Sus scrofa	1105	x	1453	1550	x	2131	x	2883+2899	3033	
EM105Su4	Sus scrofa	Phalanx II	New born	Sus scrofa	1105	1196	1453	1550	1647	2131	x	2883+2899	3033	
EM105Su5	Sus scrofa	Atrophic phl II	New born	Sus scrofa	1105	x	1453	x	x	2131	x	2883	3033	
EM105Su6	Sus scrofa	Metapodium	New born	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033	2216
EM105Su7	Sus scrofa	Phalanx II	New born	Sus scrofa	1105	1196	1453	1550	1647	2131	2820	2883+2899	3033+3017	
EM105Mm1	Size 4 (red deer, pig, reindeer, ass, bear)	Cranium	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
EM105Mm2	Size 4 (red deer, pig, reindeer, ass, bear)	Cranium	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883	3033+3017	2216
EM105Mm3	Size 3 (caprid, small cervid, wolf)	Long bone	Juvenile	Rupicapra	1105	x	1427	1580	1648	2131	2792	2883+2899	3033	
EM105Mm4	Size 4 (red deer, pig, reindeer, ass, bear)	Cranium	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
EM105Mm5	Size 4 (red deer, pig, reindeer, ass, bear)	Mandible	Juvenile	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033+3017	
EM105Mm6	Size 4 (red deer, pig, reindeer, ass, bear)	Cranium	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883	3033+3017	
EM105Mm7	Size 4 (red deer, pig, reindeer, ass, bear)	Cranium	Juvenile	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033+3017	
EM105Mm8	Size 4 (red deer, pig, reindeer, ass, bear)	Cranium	Adult	Cervus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
EM105Mm9	Size 4 (red deer, pig, reindeer, ass, bear)	Long bone	Adult	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033+3017	
EM105Mm10	Size 4 (red deer, pig, reindeer, ass, bear)	Long bone	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883+2899	3033+3017	
EM105Mm13	Size 3 (caprid, small cervid, wolf)	Indeterminate	Adult	Capreolus	1105	x	1427	1550	1648	2131	2792	2883	3059	
EM105Mm15	Size 4 (red deer, pig, reindeer, ass, bear)	Cranium	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883	3017+3033	2216
EM107Ce1	Cervus elaphus	Humerus	Adult	Cervus	1105	x	1427	x	1648	2131	x	2883	3033	
EM107Ce2	Cervus elaphus	Vt. Thoracic	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	
EM107Ce5	Cervus elaphus	Phalanx I	Adult	Cervus	1105	1196	1427	x	1648	2131	x	2883+2899	3033	
EM107Ce6	Cervus elaphus	Humerus	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033	
EM107Ce7	Cervus elaphus	Metacarpal	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883	3033+3017	
EM107Ce8	Cervus elaphus	Femur	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033+3017	
EM107Ce9	Cervus elaphus	Metatarsal	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033+3017	
EM107Ce10	Cervus elaphus	Tibia	Adult	Cervus	1105	x	1427	1550	1648	2131	x	2883+2899	3033+3017	
EM107Ce11	Cervus elaphus	Scapula	Adult	Capreolus	1105	x	1427	x	1648	2131	x	2883+2899	3059	
EM107Cp1	Capreolus capreolus	Pelvis	Adult	Capreolus	1105	1196	1427	1550	1648	2131	2792	2883+2899	3059	
EM107Cp2	Capreolus capreolus	Long bone	Adult	Sus scrofa	1105	1196	1453	1550	x	2131	2820	2883+2899	3033	
EM107Su1	Sus scrofa	Cranium	Juvenile	Sus scrofa	1105	x	1453	x	x	2131	x	2883	3033+3017	
EM107Su2	Sus scrofa	Cranium	Juvenile	Sus scrofa	1105	x	1453	1550	x	2131	2820	2883+2899	3033	
EM107Mm1	Size 4 (red deer, pig, reindeer, ass, bear)	Long bone	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	
EM107Mm2	Size 4 (red deer, pig, reindeer, ass, bear)	Long bone	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033+3017	2216
EM107Mys2	Sus scrofa	Rib	Adult	Cervus	1105	x	1427	x	1648	2131	2792	2883+2899	3033	
EM107Mys3	Cervus elaphus	Rib	Adult	Cervus	1105	x	1427	1550	1648	2131	2792	2883+2899	3033	

Supplementary Table 2. Total Number of Identified Specimens (NISP), Minimum Number of Elements (MNE), and Minimum Number of Individuals (MNI) found at Mesolithic assemblage of El Mazo before ZooMS analysis.

Taxa	NISP	MNE	MNI
Equus sp.	3	3	3
Bos/Bison sp.	4	4	3
Cervus elaphus	248	166	39
Capreolus capreolus	61	51	19
Sus scrofa	76	47	29
Total Ungulata	**392**	**271**	**93**
Felis silvestris	1	1	1
Ursus sp.	1	1	1
Halichoerus grypus	1	1	1
Canis lupus	3	3	2
Total Carnivores	**6**	**6**	**5**
Bird	15	6	6
Fish	210		
Homo sp.	1	1	1
Total Identified	**624**	**284**	**105**
Size 1 (smaller than rabbit)	2		
Size 2 (rabbit-small carnivore)	25		
Size 3 (caprid, small cervid, wolf)	127		
Size 4 (red deer, pig, reindeer, ass, bear)	301		
Size 5 (elk, giant deer, horse, bovid)	23		
Indeterminate	11267		
Grand Total	**12369**	**284**	**105**

Supplementary Table 3. Anatomical representation of the species identified before, during and after the 8.2 ka cal BP event at El Mazo.

	PHASE 1- Pre 8.2 ka cal BP				PHASE 2 - During 8.2 ka cal BP				PHASE 3 - Post 8.2 ka cal BP				
Ungulates	*Bos/Bison sp.*	*Cervus elaphus*	*Capreolus capreolus*	*Sus scrofa*	*Cervus elaphus*	*Capreolus capreolus*	*Sus scrofa*	*Rupicapra rupicapra*	*Bos/Bison sp.*	*Cervus elaphus*	*Capra sp.*	*Capreolus capreolus*	*Sus scrofa*
Cranium	1	5	1	5	3	3	2		1	23		11	17
Axial	2	16		7	9				2	54	1	12	28
Appendicular	3	26	2	1	19	7	9	1		123		20	85
Total	6	47	3	13	31	10	11	1	3	200	1	43	130

	PHASE 1 - Pre 8.2 ka cal BP		PHASE 2 - During 8.2 ka cal BP			PHASE 3 - Post 8.2 ka cal BP			
Carnivores and others	*Ursus sp.*	*Castor fiber*	*Felis silvestris*	*Canis sp.*	*Meles meles*	*Felis silvestris*	*Halichoerus grypus*	*Canis sp.*	*Canis lupus*
Cranium	1	1			1				
Axial				1		3		1	
Appendicular			1			1	1		3
Total	1	1	1	1	1	4	1	1	3

Supplementary Table 4. Total Number of Identified Specimens (NISP) and the percentage (%NISP) of the anthropic and natural taphonomic modifications found at the Mesolithic site of El Mazo.

	PHASE 1		PHASE 2		PHASE 3	
Taphonomic modifications	Pre-8.2ka		During-8.2ka		Post-8.2ka	
	NISP	%NISP	NISP	%NISP	NISP	%NISP
Anthropic modifications						
Percussion marks	13	0,9	3	0,6	19	0,5
Impact point					2	0,1
Cut marks	4	0,3	1	0,2	27	0,7
Worked bone					1	0,03
Thermoalteration	400	28,3	248	45,9	1644	41,1
Non-anthropic modifications						
Carnivore marks					2	0,1
Digestion			1	0,2		
Concretion	692	49,0	200	37,0	1178	29,5
Manganese coating	21	1,5	31	5,7	174	4,4
Root vermiculation	206	14,6	24	4,4	351	8,8
Dissolution	62	4,4	22	4,1	447	11,2
Exfoliation			3	0,6	57	1,4
Trampling	1	0,1			8	0,2
Weathering	5	0,4	6	1,1	75	1,9
Bacteria/fungus	5	0,4			8	0,2
Polishing	2	0,1	1	0,2	6	0,2

Supplementary Table 5. Anthropogenic marks identified at El Mazo, before, during, and after the 8.2 ka cal BP event. IP = Impact Points, CM = Cut Marks, PM = Percussion Marks, WB = Worked Bones, BB = Burned Bones.

	PHASE 1				PHASE 2				PHASE 3					
EL MAZO	Pre-8.2 ka				During 8.2 ka				Post-8.2 ka					
Taxa	NISP	CM	PM	BB	NISP	CM	PM	BB	NISP	IP	CM	PM	WB	BB
Cervus elaphus	4	1	3		6		2	4	39	2	17	8		20
Capreolus capreolus									6		1	4		2
Sus scrofa					2		1	1	3		1			2
Bird					1	1			2		1			1
Fish					15			15	4					4
Size 1 (smaller than rabbit)									1					1
Size 3 (caprid, small cervid, wolf)					1			1	8		3			6
Size 4 (red deer, pig, reindeer, ass, bear)	8	3	1	5	4			4	21		1	1		19
Size 5 (elk, giant deer, horse, bovid)									1					1
Indeterminate	404		9	395	223			223	1597		3	6	2	1588
Total	*416*	*4*	*13*	*400*	*252*	*1*	*3*	*248*	*1682*	*2*	*27*	*19*	*2*	*1644*