



Long-term dog consumption during the Holocene at the Sierra de Atapuerca (Spain): case study of the El Portalón de Cueva Mayor site

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Abstract

Evidence of dog consumption at the El Portalón de Cueva Mayor site (Sierra de Atapuerca, Spain) from the Holocene is revealed for the first time. The taxonomical and taphonomical studies of the animal bones from the El Portalón site have been carried out. The morphological and metrical analyses indicate that 130 dog bone remains have been identified from the El Portalón site, including from the Neolithic (NISP = 23), Chalcolithic (Pre-Bell Beaker Chalcolithic and Bell Beaker Chalcolithic) (26), Early Bronze Age, Middle Bronze Age and Late Bronze Age (81). The anthropic evidence encompasses cut marks, fresh bone fractures, human tooth marks and fire modifications, thus constituting clear evidence of cynophagy, at least in the Chalcolithic and Bronze Age levels in different contexts (habitat and funerary) from the El Portalón site (Atapuerca, Burgos). Furthermore, the fire alterations on two bone remains from the Neolithic suggest likely dog consumption due to the domestic character of the stratigraphical units where these bone remains were found. The taphonomic evidence suggests that domestic dogs were, at least occasionally, part of the diet of the humans who inhabited the El Portalón site, a fact that might be caused either by food shortages and hunger or as dog meat was considered as a delicacy.

Keywords Cynophagy · Neolithic · Chalcolithic · Bronze Age · Northern Plateau · Diet

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Introduction

Nowadays, eating dog meat is considered taboo in many cultures, while it is perfectly acceptable, even considered a delicacy, in other cultures. Cynophagy is a common practice in different regions of the world: Southeast Asia (in the Philippines, there is a typical dish made of dog meat called *Asocena*), North and South America, the Pacific and in Northern Africa (the Amazigh are known for their custom of eating dogs: Simoons 1991, 1994). On the other hand, some societies (Hindus, Buddhists, Westerners and Muslims) are anti-dog eating for different reasons and Islamic law forbids dog consumption (The Encyclopaedia of Islam 1999) because it is considered an impure animal.

In Europe, there is evidence of cynophagy from the Mesolithic to the Iron Age (Böyönki 1975). Historical evidence for dog eating has been documented in both Rome and Greece (Simoons 1994), but only for medicinal purposes. During the nineteenth and twentieth centuries, in Munich (Germany), dog consumption was related to industrialization and population growth. Dogs were mainly consumed by poor and working-class people due to its lower cost compared with other kinds of meats (Geppert 1992). However, authors like Gautier (1990) believe that dogs are not an important source of protein due to their small size; however, according to Simoons (1994), dog meat contains as much protein and less fat than pork and is very tasty.

Regarding the zooarchaeological evidence, dog consumption in the Iberian Peninsula is documented during the Early Neolithic at the nearby El Mirador archaeological site in the Sierra de Atapuerca (Burgos, Spain) located 1 km from the El Portalón de Cueva Mayor site. It constitutes one of the oldest evidences found in the Iberian Peninsula (5230–4920 cal BC) and the first case where human tooth marks have been used to show dog consumption (Martín et al. 2014). In addition, evidence of cynophagy has been observed in another Iberian Neolithic site, the La Sarsa site (Mediterranean Iberia) (López and Molero 1984); however, this site does not provide a precise chronology. There are more dog remains with evidence of anthropic consumption (cut marks on the surface of the dog bones and fractures in fresh bones) from the Bronze Age period, such as the Lloma de Betxí; Pic del Corbs; the Cabezo Redondo sites in Comunidad Valenciana (Sanchis and Sarrión 2004); Castellón Alto; Terrera del Reloj (Milz 1986); the Cerro de la Encina sites (Friesch 1987) in Granada; the Palacios and Azuer sites in Ciudad Real (Driesch Von Den and Boessneck, 1980); the Gatas site in Almería; and La Bastida in Murcia (Andúgar Martínez 2016) (see Table 1).

Here, we present the taxonomic study of the canids and the taphonomic analysis in terms of the specific aspects

of consumption found in the domestic canid remains from Neolithic to Bronze Age archaeostratigraphical sequence of the El Portalón de Cueva Mayor site (Sierra de Atapuerca, Burgos). The objective of the taphonomic study is to characterise the presence of human-induced modifications, carnivore activities and post-depositional signs on dog bones to trace the consumption of these canids from the Neolithic to Bronze Age periods at this site.

The El Portalón de Cueva Mayor archaeological site

The El Portalón de Cueva Mayor site is located in a cave in the Sierra de Atapuerca (Burgos) on the Northern Plateau of Spain (Fig. 1A). It is the current entrance to the Cueva Mayor-Cueva del Silo karstic system. Prolonged human occupation has been documented, ranging from the Late Pleistocene to the Medieval Age (Clark et al. 1979; Carretero et al. 2008; Pérez-Romero et al. 2010, 2013, 2015). The archaeo-stratigraphic sequence exceeds 10 m of depth and is divided into 11 stratigraphic units, which are in turn grouped into two sedimentary units: the Late Pleistocene (level 11 and level 10, which is the Pleistocene/Holocene transition) and the Holocene. During the Holocene, there is evidence of human occupations in the Neolithic/Mesolithic (level 9); the Chalcolithic (levels 8, 7 and 6); the Early, Middle and Final Bronze Ages (level 5 and levels 3/4); Iron Age I (level 2); the Roman Age (level 1); and the Middle Ages (level 0) (Carretero et al. 2008; Pérez-Romero et al. 2015).

Ongoing archaeological excavations are being carried out in the earliest Neolithic layers located in level 9. The time between the Neolithic and Chalcolithic periods has been described as a short hiatus in human occupations of the cave, marked by an archaeologically sterile natural cave entrance and terrigenous silty sediments with abundant pellets. The Chalcolithic stratigraphic units are further divided into three archaeological contexts: the oldest corresponds to a funerary context during the early Pre-Bell Beaker Chalcolithic (level 8), an intermediate phase (level 7) during the Pre-Bell Beaker Chalcolithic includes sheepfold activity and the last unit during the Bell Beaker Chalcolithic (level 6) corresponds to the use of the site for a sheepfold (Pérez-Romero et al. 2017). Finally, the Bronze Age level has been further divided into Early, Middle and Final Bronze Age (levels 3/4 and 5) occupations (Pérez-Romero et al. 2016), all of them from a domestic habitat context (Fig. 1B).

Dating

Two carbonised *Triticum* sp. grains and two faunal bone remains from different Neolithic stratigraphic units were dated for this work (Table 2). Chalcolithic and Bronze Age stratigraphic units containing dog bone remains with evidence

Table 1 Iberian sites from the Neolithic to the Bronze Age where dog bone remains show evidence of being consumed and the types of evidence located on the bones

Sites	Locality	Chronology	Cut marks	Fresh bone fracture	Tooth marks	Heating modifications	Reference bibliography
Cueva de la Sarsa	Valencia	Neolithic (without precise chronological context)			x		López and Molero (1984)
Cueva del Nacimiento	Jaén	Neolithic				x (uncertain)	Alfárez Delgado et al. (1981); García-Moncó (2008)
Lloma de Betxí	Comunidad Valenciana	Bronze Age	x				Sanchis and Sarrión (2004)
Pic del Corbs	Comunidad Valenciana	Bronze Age	x	x			Sanchis and Sarrión (2004)
Cabezo Redondo	Comunidad Valenciana	Bronze Age	x	x			Sanchis and Sarrión (2004)
Los Jovades	Comunidad Valenciana	Eneolithic	x	x			Martínez-Valle (1993)
Castellón Alto	Granada	Argaric	x				Milz (1986)
Terrera del Reloj	Granada	Argaric	x				Milz (1986)
Palacios	Ciudad Real	Argaric	x				Driesch and Boessneck (1980)
Azuer	Ciudad Real	Argaric	x				Driesch and Boessneck (1980)
Gatas	Turre (Almería)	Argaric	x				Andúgar Martínez (2016)
La Bastida	Totana (Murcia)	Argaric	x				Andúgar Martínez (2016)
Cerro de La Encina	Granada	Argaric and Final Bronze Age	x	x			Friesch (1987)
El Mirador	Atapuerca (Burgos)	Neolithic, Bronze Age	x	x	x	x	Martín et al. (2014)

of consumption were previously dated (Carretero et al. 2008; Pérez-Romero et al. 2015) (Table 2). Four animal and human bone remains and one seed from different Chalcolithic stratigraphic units, where dog remains were found, were dated using accelerator mass spectrometry (AMS) at Beta Analytic Inc. (Miami, Florida) and six charcoal remains, one organic sediment sample and one animal bone from the Bronze Age levels were dated using AMS at different radiocarbon dating laboratories (Table 2). Dates were calculated and calibrated to years cal. BP using OxCal v4.4 software based on the IntCal20 radiocarbon age calibration curve.

Materials and methods

The identified faunal sample found in the Neolithic to Bronze Age levels from the El Portalón de Cueva Mayor site comprises 5431 determinable remains, of which 130 (2.4%) are attributed to dog remains.

The dog bones from the Bronze Age were recovered during excavations carried out from 1973 to 1983 by J.M. Apellániz, and were studied at the Museo de Burgos. The Chalcolithic and Neolithic level dog remains were

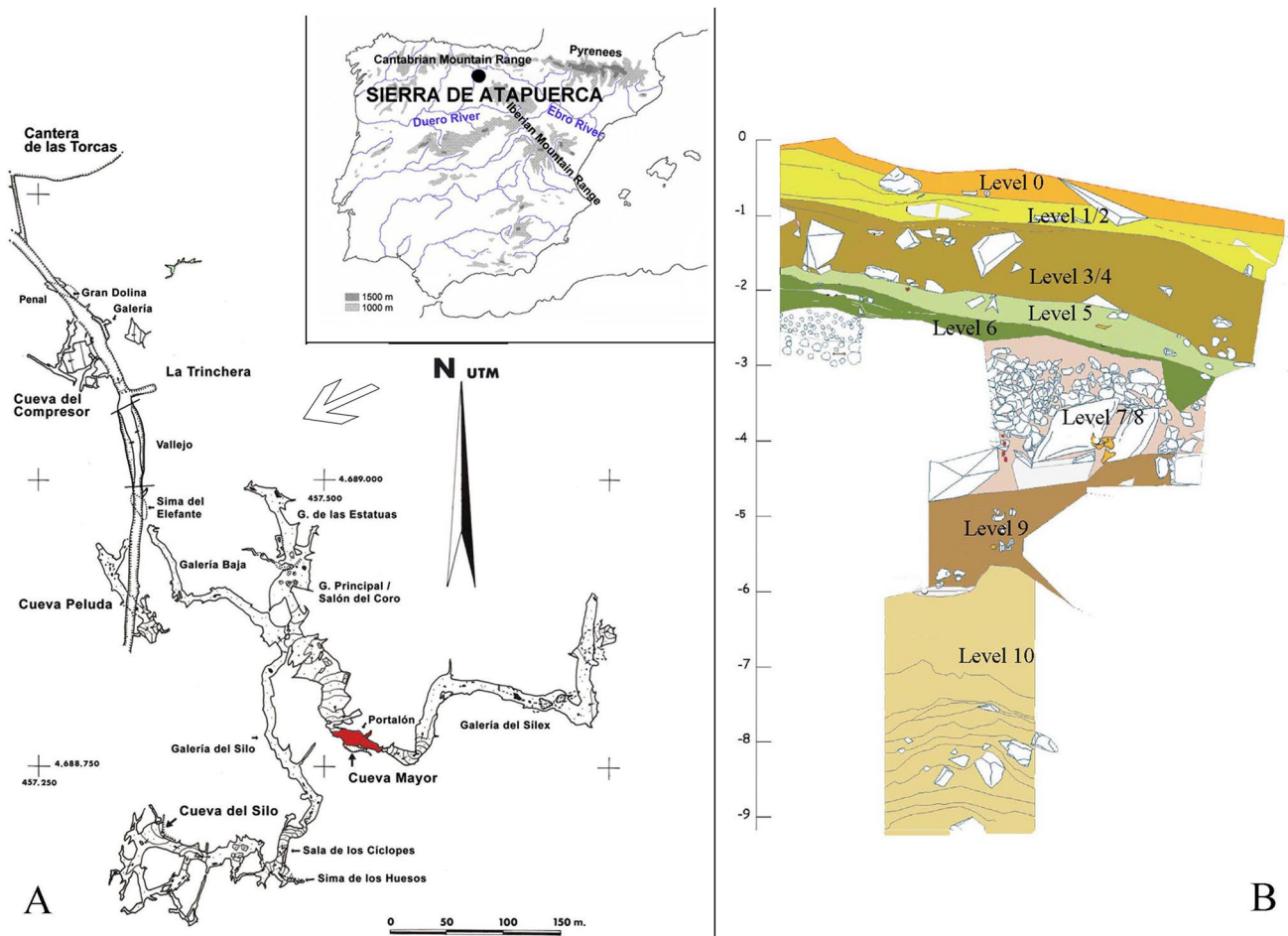


Fig. 1 **A** Geographical location of the El Portalón de Cueva Mayor site. **B** Archaeo-stratigraphic sequence of the southern section of El Portalón de Cueva Mayor (modified from Pérez-Romero et al. 2016)

recovered during recent excavations carried out by the current Atapuerca Research Project, specifically in field work conducted from 2007 to 2018. All the bone remains analysed in this work belong to the Colección Museística de Castilla y León of the Junta de Castilla y León.

Anatomical and taxonomic identification

The anatomical and taxonomic identification of the remains from El Portalón was carried out using atlases of animal anatomy (Schmid 1972; Pales and Garcia 1981; Barone 1999) and the collection of comparative anatomy at the Centro Mixto UCM-ISCIH de Evolución y Comportamiento Humanos in Madrid. The dog bones were quantified using the following criteria: NISP (number of identified specimens) (Binford 1978). The age of death was estimated in accordance with criteria for dental eruption and epiphyseal fusion criteria proposed by Schmid (1972) taking account the MNI (minimum number of individuals; Klein and Uribe 1984).

The diagnostic features of canid crania considered in the taxonomical identification were shorter snout, a more pronounced forehead area and a wide palate (Germonpré et al. 2009; Morey 2014; Sablin and Khlopachev 2002). The shortening of the snout in dogs suggests a strong mandible and well-developed carnassial (P^4 and M_1) (Germonpré et al. 2009), so the measurements of P^4 and M_1 were taken. Another criterion that is used as evidence of domestication is the crowding of teeth due to the absence of diastema (or shortening of the snout) (Boudadi-Maligne and Escarguel 2014).

The taxonomic identification was completed taking measurements of cranial and postcranial bone remains, to discriminate between *Canis lupus lupus* and *Canis lupus familiaris*. All measurements were documented using a Sylvac digital calliper (03.02/SYL-235-F, D, E/681.046–100) to the nearest 0.01 mm, following Driesch (1976).

Dental measurements from the length of M_1 (carnassial) and mesio-distal diameter of P^4 were taken and included within the metrical variation of teeth from recent and

Table 2 Radiocarbon dates for the levels of the El Portalón de Cueva Mayor site. *Cal*, calibrated

Cultural period	Dated material	Laboratory code	Radiocarbonical datation (year cal BP)	Dog bone code	Dating
Neolithic	Cattle tooth	wk-51513	5570–5320	ATP15.UE507.392	This study
	Seed	Beta-570626	5584–5446	AT16.UE524.302	This study
	Seed	Beta-570625	7169–6988	AT18.UE548.776	This study
	Horse bone	wk-51504	7240–7000	ATP17.UE536.425	This study
Early Chalcolithic (Pre-Campaniform): funerary context	Human bone	Beta-269494	5572–5319	ATP13.UE79a.10	Günther et al. (2015)
	Animal bone	Beta-269494	4430–4290	ATP10.UE 20.62; ATP10.UE20.55	This study
Early Chalcolithic (Pre-Campaniform): stabling context	Seed	Beta-347580	4957–4821	ATP12.212b.570	Pérez-Romero et al. (2010)
	Human bone	Beta-368289	5211–4866	ATP08.UE23.F10; ATP08.UE23.101	This study
	Human bone	Beta-368290	4957–4821	ATP08.UE21.83	Günther et al. (2015)
Final Chalcolithic	Human tibia	Beta-269494	4423–4158	ATP07UE4-F1	Carretero et al. (2008)
Early Bronze Age	Tooth	Beta-184838	4240–3990	CMI-A6-72–41; CMI-A10-73–6;	Carretero et al. (2008)
	Charcoal	Beta-184839	4230–3980	CMI-A8-73–7; CMI-A8-73–8;	
	Charcoal	Beta-184843	4240–3850	CMI-A8-73–9; CMI-A8-73–10;	
	Tooth	Beta-224079	4140–3890	CMI-A8-73–12; CMI-B2-78–9;	
	Charcoal	Beta-153362	4080–3840	CMI-B4-84–2; CMI-B6-87–3;	
	Charcoal	Beta-153361	4140–3900	CMI-C2-92–1; CMI-C2-96–1;	
	Charcoal	Beta-212188	3860–3650	CMI-D2-104–10	
	Middle Bronze Age	Organic sediment	Beta-153360	3710–3390	
Bone	Beta-222336	3980–3700	CMI-C4-47–3; CMI-A6-48–4;		

archaeological Eurasian dogs and wolves, which were collected from bibliographic sources: Benecke (1987); Böyönki (1975); Boudadi-Maligne et al. (2012); Chaix (2000); Clark (1995); Clutton-Brock (1962); Dayan (1994); Davis (1978); Davis (2006); Degerbol (1961); Detry and Cardoso (2010); Dimitrijević and Vuković (2015); Gaudry and Boule (1892); Germonpré et al. (2009); Germonpré et al. (2012); Germonpré et al. (2015); Germonpré et al. (2017); Harrison (1973); Huxley (1880); Janssens et al. (2019); Jeteiles (1877); Jolicoeur (1959); Kurtén (1968); Lawrence and Reed (1983); Morey (2014); Musil (2000); Napierala and Uerpmann (2012); Nehring (1888); NMBE database n 2217 dogs; Ovodov et al. (2011); Pidoplichko et al. (2001); Pionnier-Capitan (2010); Pionnier-Capitan et al. (2011); Rüttimeyer (1861); Sablin and Khlopachev (2002); Sanchis and Sarrión (2004); Street (2002); Studer (1901); Tchernov and Valla (1997); Wolfgram (1894).

Postcranial measurements were taken and compared with a standard (a complete skeleton of a present-day female wolf from Italy, according to Boschini et al. 2020) using the log ratio methodology. The log ratio technique is used to

increase sample size and allow for comparisons to be made between assemblages (Simpson et al. 1960; Meadow 1999). The log ratio is a size index scaling technique, comparing our measurements to the measurements of a standard individual or population.

Taphonomic analysis

In order to conduct the taphonomic analysis, we considered all the domestic dog remains (*Canis l. familiaris*) recovered from the different archaeological levels at the site: Neolithic (NISP = 23), Chalcolithic (NISP = 26) and Bronze Age (NISP = 81). For the microscopic study, a Nikon SMZ800 Stereoscopic zoom microscope and a DINO-LITE digital microscope were used. Photographs were taken with the digital video microscope DINO-LITE AM-TFVW-A (*DinoCapture* 2.0 software). The taphonomic study includes anthropic traces, fracture patterns, carnivore modifications and post-depositional alterations.

Stone tool modifications were classified as cut marks (including incisions or slicing cut marks, scrape marks and

chop marks) and percussion marks (percussion pits, conchoidal scars and flakes, and adhered flakes) (Blumenschine et al. 1996; Blumenschine and Selvaggio 1988; Cáceres et al. 2007; Capaldo and Blumenschine 1994; Rodríguez-Hidalgo et al. 2015; Saladié et al. 2012; Shipman and Rose 1983). The location of cut marks was recorded—especially the muscle insertion areas or on tendons or ligaments—since these can be used as criteria for distinguishing different butchery activities (Binford 1981; Saladié et al. 2012; White 1992). In order to study the burned bones, we followed the stages defined by Stiner et al. (1995). Evidence of boiling was identified on the basis of the smoother, lighter and more transparent surfaces as opposed to the unboiled bones, as defined by Botella et al. (2000).

In order to analyse the breakage patterns, we focused on long bone fragments following the methodology proposed by Villa and Mahieu (1991) and Sala et al. (2015) in terms of fracture outline (longitudinal, transverse or oblique/curved), fracture angle (right or oblique), fracture edge (smooth or jagged), shaft circumference (1: less than half of the circumference; 2: more than half of the circumference; and 3: complete circumference) and shaft fragment (1: less than 1/4 of the total diaphysis; 2: between 1/4 and 1/2 of the total diaphysis; 3: between 1/2 and 3/4 of the diaphysis; and 4: increased from 3/4 of the diaphysis).

In addition to these features, the presence or absence of peeling was also considered. Peeling is defined as ‘a roughened surface with parallel grooves or fibrous texture’ (White 1992) produced when breaking the bone by bending the pieces with the hands or by cheek-tooth chewing the bones and bending with the hands (Fernández-Jalvo and Andrews 2011; Saladié et al. 2013). Pickering et al. (2013) distinguished three types of peeling: (i) *classic peeling* following the definition proposed by White (1992); (ii) *general peeling* defined as ‘an area of the whole dorsal or ventral cortex of a rib is peeled backed for some length, revealing the internal trabeculae of the rib’; and (iii) *incipient peeling*, a type of peeling ‘where a strip of

lamella is only partially peeled back against the rib shaft, not fully removed from the specimen’. Classic and general peeling are considered particular features of anthropogenic breakage (Pickering et al. 2013).

Tooth marks on bone surfaces were classified as pits, punctures, furrowing, scores and dissolution due to gastric acids. Punctures, scores and pits were measured (length and width) in accordance with previous studies (Domínguez-Rodrigo and Piqueras 2003; Sala and Arsuaga 2018; Sala et al. 2014a; Selvaggio and Wilder 2001). The length and breadth of tooth marks were measured using *DINO-LITE* digital microscope software tools. Tooth mark measurements were compared with neotaphonomic experimental assemblages of carnivores and humans (Delaney-Rivera et al. 2009; Fernández-Jalvo and Andrews 2011; Sala and Arsuaga 2018; Saladié et al. 2013). Recent studies (Andrés et al. 2012; Sala et al. 2014a, 2014b) show that tooth pit length on cortical surfaces is the best indicator of the taxa responsible for the tooth marks. For this reason, we will focus mainly on this variable when comparing the samples. For the univariate analysis, we performed a Welch test, comparing all possible pairs of samples to determine which differed significantly. Hominin tooth marks were identified following the criteria of Saladié et al. (2013), Fernández-Jalvo and Andrews (2011), Pickering et al. (2013) and Rodríguez Hidalgo et al. (2015), based on their morphological features, location and dimensions and their relationship with other anthropic modifications. In addition to the conspicuous marks, traces of the dissolution caused by gastric acids produced during the consumption of bone fragments are considered. Some carnivores (and also birds) are able to swallow bone fragments. These splinters can be recovered from faeces and they are also the product of regurgitation (Sala and Arsuaga, 2018). Bones affected by acid-etching display characteristic features described previously by Sutcliffe (1970), such as scalloping of the bone surface, presence of holes and/or fine and sharp edges.

Table 3 Metrical data (L , length = mesio-distal diameter) of M_1 and P^4 of *Canis* from the different levels of the El Portalón site

	M_1	Length (in mm)	P^4	Length (in mm)
Bronze Age	CMI.A6.48.4	21.54		
Early Bronze Age	CMI.B6.88.1	20.98		
	CMI.D2.87	18.8		
Middle Bronze Age	CMI.C4.53.2	21.06	ATP17.2003 N.825	16.9
	CMI.A8.51.1	20.03	CMI.B2.63.5	18.02
			CMI.C2.63.2	17.02
			CMI.C2.74	18.8
			CMI.B2.67	15.91
			CMI.B2.64.2	17.39
			CMI.A8.51.5	19.16
Neolithic	ATP16.UE516.37	15.23		

Results

Anatomical and taxonomic identification

The M_1 lengths of the canids from El Portalón (Table 3) fall within the metrical range of dogs from the different archaeological sites included in Janssens et al. (2019), within a variation ranging from 17 to 25.3 mm for the lower first molar.

The canid P^4 lengths from El Portalón (Table 3) also fall within the metrical range of archaeological dogs, with a variation ranging from 14 to 21.8 mm for the upper four premolars. There is no overlap with the P^4 mesio-distal diameter (22.5–29.2 mm) from fossil wolves and dogs, according to Janssens et al. (2019).

The data set of the postcranial elements is included in Supplementary Table S1 and Supplementary Figure S1. We can observe that the population of canids from the Neolithic, Chalcolithic and Bronze Age at El Portalón is smaller than the standard population (Supplementary Figure S1); therefore, the canid bone remains from the El Portalón site belong to *Canis l. familiaris*.

Thus, the morphology and metrical characteristics (Table 3; Supplementary Table S1 and Supplementary Figure S1) indicate that dogs were present in the Neolithic, the Pre-Beaker Chalcolithic (funerary and sheepfold

phases), the Beaker Chalcolithic (sheepfold) and the Early, Middle and Final Bronze Age levels at the El Portalón site.

Twenty-three dog remains were recovered from the Neolithic level, 26 from the Chalcolithic (14 from a Pre-Beaker Chalcolithic funerary context, 10 from a Pre-Beaker Chalcolithic stabling context and two from the Beaker Chalcolithic) and 81 from the Bronze Age (28 from the Early Bronze Age, 47 from the Middle Bronze Age and six from the Final Bronze Age) (Table 4). There is no context from which dog remains were recovered where they exceeded 6% of NISP (the identified species) (Table 4).

From the Neolithic, at least two adults (fused anatomical elements), including the burnt phalanx (ATP17.UE536.425), the mandible (ATP15.UE507.392) and one juvenile (unfused elements), were found. From the Pre-Bell Beaker Chalcolithic (sheepfold context), at least two individuals were recovered (one unfused distal part of a tibia: ATP'08.UE21.83, suggesting an individual less than 15 months of age, and one fused ulna ATP'08.UE23.F10 + ATP'08.UE23.101, suggesting an individual older than 15 months of age). From the Pre-Bell Beaker Chalcolithic (funerary context), at least two adult individuals were recovered, which were calculated using left humeri. From the Bell Beaker Chalcolithic habitational context, the humerus found belongs to an individual over 6 months old. From the Early Bronze Age, two cranium fragments (zygomatic bones: CMI-A8-73–10; CMI-B2-79–2) were identified

Table 4 Number of identified specimens (NISP) of each taxon at the El Portalón de Cueva Mayor site. Percentages of number of identified specimens (NISP%) indicated in parenthesis

NISP (%NISP)	Final Bronze Age	Middle Bronze Age	Early Bronze Age	Bell Beaker (habitat)	Pre-Bell Beaker (habitat)	Pre-Bell Beaker (funerary)	Neolithic
<i>Bos taurus</i>	99 (34.74)	309 (37.64)	245 (26.4)	285 (28.85)	217 (29.25)	184 (16.49)	146 (25.75)
Total ovicaprines	124 (43.51)	262 (31.91)	338 (36.42)	609 (61.64)	392 (52.83)	724 (64.87)	182 (32.1)
<i>Sus</i> sp.	29 (10.18)	58 (7.06)	84 (9.05)	39 (3.95)	78 (10.51)	112 (10.04)	66 (11.64)
<i>Equus</i> sp.	21 (7.37)	98 (11.94)	162 (17.46)	19 (1.92)	11 (1.48)	17 (1.52)	0
<i>Bos</i> cf. <i>primigenius</i>	0	1 (0.12)	0	1 (0.1)	3 (0.4)	0	8 (1.41)
<i>Sus scrofa</i>	0	0	3 (0.32)	1 (0.1)	3 (0.4)	0	0
<i>Equus ferus</i>	0	0	0	0	0	0	89 (15.7)
<i>Cervus elaphus</i>	0	15 (1.83)	11 (1.19)	5 (0.51)	1 (0.13)	11 (0.99)	24 (4.23)
<i>Capreolus capreolus</i>	0	1 (0.12)	1 (0.11)	0	3 (0.4)	2 (0.18)	4 (0.7)
<i>Canis familiaris</i>	6 (2.21)	47 (5.72)	28 (3.02)	2 (0.2)	10 (1.35)	14 (1.25)	23 (4.05)
<i>Vulpes vulpes</i>	0	0	6 (0.65)	0	1 (0.13)	1 (0.09)	0
<i>Mustela</i> sp.	0	0	0	0	0	2 (0.18)	0
Carnivora indet	0	0	0	0	4 (0.54)	4 (0.36)	0
Leporidae indet	6 (2.21)	30 (3.65)	50 (5.38)	14 (1.42)	14 (1.89)	23 (2.06)	11 (1.94)
Chelonia indet	0	0	0	0	1 (0.13)	5 (0.45)	0
Avian remains	0	0	0	12 (1.21)	4 (0.54)	14 (1.25)	14 (2.47)
Fish	0	0	0	1 (0.1)	0	3 (0.27)	0
	285	821	928	988	742	1116	567

as one juvenile (unfused) and one adult (fused) individual. From the Middle Bronze Age, six maxilla fragments with permanent teeth (CMI-B2-64-2; CMI-C2-63-2; CMI-B4-41; CMI-B2-63-5; ATP18.2003 N.825) were identified and determined to be from at least five adult individuals. A metapodial (CMI-C2-33-2) was recovered from the Final Bronze Age and was fused, so this individual was over 6 months of age. It may belong to the same individual whose other anatomical elements were found in this level (see Table 5).

Taphonomic analysis

Neolithic (Fig. 2)

From the Neolithic, a metacarpal III (AT16.UE524.302) has been documented with evidence of gastric acid dissolution (Table 6). One proximal phalanx (ATP17.UE536.425) and a mandible (ATP15.UE507.392) show evidence of burning on the proximal surface of the phalanx and the almost complete surface of the mandible. Following the burning damage categories of Stiner et al. (1995), the phalanx corresponds to stage 1 (less than half the surface is carbonised) and the mandible corresponds to stage 2 (more than half the surface is carbonised).

None of the bone remains from the Neolithic layers displays butchery evidence such as cut marks.

The reduced bone sample, together with the absence of conspicuous tooth marks, necessary for extrapolating useful metric data, hinders the accurate identification of the intervention of small carnivores and/or humans. Nevertheless, the intervention of later carnivores is demonstrated by the presence of bones with evidence of digestion.

Chalcolithic

The dog remain analysis from the Chalcolithic period was conducted in accordance with the archaeological context from which they were recovered: (i) Early (Pre-Bell Beaker) Chalcolithic corresponding to a funerary context; (ii) Early (Pre-Bell Beaker) Chalcolithic corresponding to a sheepfold and habitational context; and (iii) Late (Bell Beaker) Chalcolithic corresponding to a sheepfold. The results of the taphonomic analyses are detailed in Table 6 and Fig. 3.

Within the funerary context from the Pre-Bell Beaker Chalcolithic period, 10 dog remains were analysed and half of them display cut marks (slicing marks). In addition, tooth marks, burning and intentional breakage by humans (i.e. peeling) have been observed on these bone remains (Table 6). Only one bone displays conspicuous tooth marks that provided metric data (Table 7) and triangular-shaped morphology compatible with human tooth marks (Fernández-Jalvo and Andrews 2011; Saladié et al. 2013).

Similar frequencies of cut-marked bones are represented in combination with tooth marks and fresh bone breakage from the Pre-Bell Beaker Chalcolithic sheepfold and habitational contexts (Table 6). The tooth mark dimensions (Table 7), their triangular- or crescent-shaped morphology (Fig. 3), which was described previously as a diagnostic feature for human tooth marks by Fernández-Jalvo and Andrews (2011) and Saladié et al. (2013), together with other anthropic traces, all suggest that they are indeed human tooth marks, indicating that ‘sporadic’ consumption of dogs took place in funerary and sheepfold-habitational contexts during the Early Chalcolithic.

The locations of the cut marks from the Chalcolithic in both cases, the funerary and sheepfold contexts, are mainly concentrated in the diaphysis of long bone and ribs, though slicing marks have been identified additionally in the inter-tubercular groove of the humerus (Table 6). This indicates that defleshing, periosteum removal, evisceration and disarticulation took place amongst the butchering processes in these periods.

Evidence of fire modification is present on a burned surface of an ulna (ATP’08.UE23.101), which appears to be an isolated incident, as well as two dog remains that show characteristics typical of boiling (Table 6).

Within the herding and domestic habitat from the Bell Beaker Chalcolithic period, one bone shows fresh fractures compatible with human activity (Table 6).

Bronze Age

The material from the Bronze Age is the most abundant out of all the sequences. Separate analyses were performed for the three periods represented: the Early, Middle and Final Bronze. These provide frequencies of anthropic traces that are similar throughout the three periods. Cut marks mainly comprise slicing marks, but chop and percussion marks have been documented as well and are present in 25% and 27% of the Early and Middle Bronze Age periods, respectively. Fresh bone fractures, in some cases considered intentional breakage (i.e. peeling), have been documented in Early, Middle and Final Bronze Age periods in 35.7%, 25.5% and 25% of specimens, respectively. Tooth marks are only present in Early and Middle periods with frequencies of 21.4% and 17.6%, respectively, and in some cases are compatible with human tooth marks.

Lastly, by taking into consideration the burned and boiled bones, fire modification has been documented in the three periods as well, with a significantly higher frequency during the Middle Bronze Age period (25%, 81.25% and 25% for the Early, Middle and Final Bronze units, respectively). The detailed data regarding anthropic traces are portrayed in Table 6 and Fig. 4.

Table 5 NISP and brief description of dog bone remains within the different levels of the El Portalón de Cueva Mayor site. *AD*, adult (fused bones or permanent teeth); *JUV*, juvenile (unfused bones or decidual teeth)

N°	Cultural level	Dog bone code	Anatomical element	Age
1	Final Bronze Age	CMI-C4-13-6	Maxilla + P2 + canine	-
2		CMI-D2-11-4	Occipital bone	-
3		CMI-C2-33-2	Metapodial	AD
4		CMI-D2-22-2	Cuboid	AD
5		CMI-D4-35	Tooth	-
6		CMI-D4-38	Canine	-
1	Middle Bronze Age	CMI-D2-48-3	Atlas	AD
2		CMI-A8-65-1	Ulna	AD
3		CMI-A8-51-1	Hemimandible	AD
4		CMI-A8-65-2	Proximal phalanx	AD
5		CMI-A8-49-3	Atlas	-
6		CMI-243	Tooth	-
7		CMI-B2-64-2	Maxilla	AD
8		CMI-49	Atlas	-
9		CMI-A6-41-1	Ulna	AD
10		CMI-D4-50-1	Ulna	AD
11		CMI-A6-45-6	Tibia	AD
12		CMI-B2-64-3	Cranium	AD
13		CMI-C4-63-7	Vertebrae	AD
14		CMI-A6-46-2	Cervical vertebrae	AD
15		CMI-A6-48-4	Mandible	-
16		CMI-A6-58-5	Cervical vertebrae	AD
17		CMI-C4-53-4	Vertebrae	JUV
18		CMI-C4-63-10	Cervical vertebrae	AD
19		CMI-B2-63-6	Rib	AD
20		CMI-B2-64-4	Rib	AD
21		CMI-A4-54-3	Fibula	AD
22		CMI-B2-64-3	Atlas	AD
23		CMI-A4-48-2	Metacarpian II	AD
24		CMI-B2-63-7	Proximal phalanx	AD
25		CMI-C2-55-1	Proximal phalanx	AD
26		CMI-B2-64-6	Metacarpian III	AD
27		CMI-B2-64-8	Calcaneus	AD
28		CMI-A6-45-2	Scapholunar	AD
29		CMI-C4-47-3	Cuboid	AD
30		CMI-53	Mandible	-
31		CMI-C2-63-2	Maxilla	AD
32		CMI-B4-41	Maxilla	AD
33		CMI-B2-63-5	Maxilla	AD
34		CMI-B2-64-6	Proximal phalanx	AD
35		CMI-C6-43-2	Mt IV	AD
36		CMI-A4-53-5	Metapodial	AD
37		CMI-B4-70-4	Cranium	-
38		CMI-C2-74	Maxilla	AD
39		CMI-A6-41-1	Ulna	-
40		CMI-B2-64-9	Metatarsal	AD
41		CMI-A6-61-5	Tibia	AD
42		CMI-D2-69-4	Proximal phalanx	AD
43		CMI-A10-64-5	Metapodial	AD
44		CMI-A2-64-2	Ulna	-
45		ATP18.2003 N.825	Maxilla + P2, P3 left	AD
46		ATP17.2003 N.1514	Metapodial	AD
47		ATP18.2003 N.863	Tibia	AD

Table 5 (continued)

N°	Cultural level	Dog bone code	Anatomical element	Age
1	Early Bronze Age	CMI-B2-96-2	Metacarpian III	AD
2		CMI-A8-73-8	Occipital bone	-
3		CMI-A8-73-9	Cranium fragment	-
4		CMI-A8-73-10	Zygomatic bone (right)	JUV
5		CMI-A8-73-7	Parietal bone	-
6		CMI-A8-73-12	Cranium fragment	-
7		CMI-A8-80-2	Atlas	AD
8		CMI-83	Tooth	-
9		CMI-C2-96-1	Scapula	-
10		CMI-B6-87-3	Tibia	-
11		CMI-C2-92-1	Humerus	-
12		CMI-B2-78-9	Calcaneus	AD
13		CMI-A6-73-22	Medium phalanx	AD
14		CMI-B6-88-1	Hemimandible	AD
15		CMI-D2-87	Hemimandible	AD
16		CMI-B2-79-2	Zygomatic bone (right)	AD
17		CMI-A6-72-93	Cranium	-
18		CMI-104	Lumbar vertebra	JUV
19		CMI-B4-84-2	Vertebrae	JUV
20		CMI-B2-79-3	Metatarsian	AD
21		CMI-C4-77-7	Metapodial	-
22		CMI-B2-80-3	Metapodial	-
23		CMI-C2-99-1	Metapodial	-
24		CMI-C2-90	Proximal phalanx	AD
25		CMI-C2-79-1	Proximal phalanx	AD
26		CMI-A6-72-41	Ulna	AD
27		CMI-D2-104-10	Coxae	AD
28		CMI-A10-73-6	Coxae	AD
1	B-B-C habitat	ATP'07.L45.UE4.F1	Humerus	AD
2		ATP07-M45.UE4.F2	Tooth fragment	-
1	Pre-Bell Beaker Chalcolithic (funerary context)	ATP'10.UE26.466	Humerus	AD
2		ATP'10.UE26.62	Coxae	AD
3		ATP'10.UE26.254	Tibia	AD
4		ATP'10.UE26.287	Rib	-
5		ATP'08.UE20.F183	Humerus	AD
6		ATP'10.UE20.55	Femur	JUV
7		ATP13.UE79a.10	Metacarpian	-
8		ATP13.UE79.31	Femur	JUV
9		ATP.UE79.37c	Rib	-
10		ATP.UE79.37d	Rib	-
11		ATP.UE79.37f	Rib	-
12		ATP12.UE77.1180	Proximal phalanx	-
13		ATP12.UE77.1181	Metatarsian IV	-
14		ATP12.UE77.1211	Metatarsian V	-

Table 5 (continued)

N°	Cultural level	Dog bone code	Anatomical element	Age
1	Pre-Bell Beaker Chalcolithic (habitational context)	ATP'08.UE21.97	Maxilla	JUV
2		ATP'08.UE21.83	Tibia	JUV
3		ATP'08.UE23.F10 +	Ulna	AD
		ATP'08.UE23.101		
4		ATP'10.UE23.248	Long bone	-
5		ATP'10.UE52.15	Rib	-
6		ATP'12.capa212a.523	Mandible	-
7		ATP'12.capa212a.528	Rib	-
8		ATP'12.capa212a.570	Humerus	-
9		ATP'12.capa212b.593	Ulna	-
10	ATP'12.UE74.616	Tooth	-	
1	Neolithic	ATP15.UE507.392	Mandible	AD
2		ATP16.UE524.282	Proximal phalanx (half part)	-
3		AT16.UE524.302	Metacarpian III	AD
4		ATP16.UE530.549	Toracic vertebra	AD
5		ATP16.UE530.740	Proximal phalanx	AD
6		ATP17.UE530.2124	Metatarsian IV	AD
7		ATP17.UE530.2365	Cervical vertebra (VII)	JUV
8		ATP18.UE530.562	Thoracic vertebra	JUV
9		ATP19.UE530.437	Carpal bone	-
10		ATP17.UE530H2b.833	Caudal vertebra	JUV
11		ATP17.UE530H2b.1049	Proximal phalanx	AD
12		ATP17.UE532.40	Caudal vertebra	AD
13		ATP17.UE532.113	Distal metapodial + proximal part of phalanx	JUV
14		ATP17.UE534.137	Calcaneus and tarsals	JUV
15		ATP17.UE534.138	Metatarsian II + unfused epiphysis	JUV
16		ATP17.UE534.139	Metatarsian III + unfused epiphysis + proximal phalanx	JUV
17		ATP17.UE534.140	Metatarsian IV + unfused epiphysis + proximal phalanx + sesamoid	JUV
18		ATP17.534.141	Metatarsian V	JUV
19		ATP17.534.142	Medial phalanx	JUV
20		ATP17.UE536.425	Proximal phalanx	AD
21		ATP17.UE537.588	Metacarpian V	JUV
22		ATP17.UE543.2450	rib	JUV
23		ATP18.UE543.69	Atlas	JUV

The cut marks from the Bronze Age have been observed on all anatomical parts and are associated with the removal of soft tissues (flesh, periosteum, viscera and scalp), thus indicating butchering processes such as skinning, defleshing, evisceration and disarticulation (Table 7).

Tooth mark dimensions are represented in Table 7. The dimensions of tooth pits on the cortical surfaces corresponding to the Middle Bronze Age (the best represented period in terms of the number of measurements) do not differ statistically ($p < 0.05$) from the human tooth mark size data provided by Saladié et al. (2013), Delaney-Rivera et al. (2009), Romero et al. (2016) and Sala and Conard (2016). However, there are statistical differences regarding the large carnivore tooth pits, including for the wild canids (wolves), when compared with the data from Sala and Arsuaga (2018) and Sala et al. (2014a). Nevertheless, in

some cases we cannot rule out the secondary intervention of small carnivores, such as foxes or dogs. Actually, in cranial remain CMI-B2-64–3, it is possible to observe a tooth pit (perhaps created by a small carnivore) superimposed on a slicing mark (Fig. 4). Moreover, rodent activity has been documented for one occipital fragment (CMI-A8-73–8).

The fracture patterns are dominated by oblique angles and smooth surfaces, typical of fresh bone breakage (*perimortem*). Furthermore, in some cases, there are traces of intentional breakage by humans such as peeling and percussion marks (Table 6).



Fig. 2 The Neolithic dog remains from the El Portalón de Cueva Mayor site. Photography and different views of fire alterations on the proximal phalanx ATP17.UE536.425 (A) (photo taken by Javier Trueba and the mandible ATP15.UE507.392 (B)). Scale bars 2 cm

Discussion

The role of dogs throughout Prehistory has changed over time. Dogs probably had considerable symbolic significance in the lives of hunter-gatherers, at least from the Mesolithic onwards and from the Mesolithic onwards (Larsson 1990). This special role is confirmed in the Iberian Peninsula, where, for instance, an almost complete dog skeleton was found close to human skeletons at Cabeço da Arruda, the final Mesolithic Muge shell middens (Portugal), suggesting it was buried intentionally (Detry and Cardoso 2010). From the second half of the 5th millennium cal BC, dogs played a very important role in the symbolic world. Dogs in the Neolithic (Detry and Cardoso 2010) are abundant, mainly in funerary contexts (Moreno-García 2003; Albizuri et al. 2019) (see Fig. 5 for location of the sites). It is in the subsequent Chalcolithic that their occurrence in the archaeological record begins to be abundant enough to draw conclusions as to morphology and dimensions. Dogs in funerary contexts are also very frequent throughout the Chalcolithic and Bronze Ages (see Fig. 5). There is also evidence that they served as draught

animals, and on some occasions, they were consumed (Grandal-d'Anglade et al. 2019).

Evidences of dog consumption, including just cut and burn marks on dog bone remains, have been identified in European sites from the Upper Paleolithic (Pont d'Ambon; Pionnier-Capitan et al. 2011), the Neolithic and the Bronze Age in Hungary (Vretemark and Sten 2010) and the Iron Age in Slovakia (Chrószcz et al. 2013), the British Isles (Hambleton, 2008) and Gaul (Méniel 2006; Horard-Herbin 2014). In the Iberian Peninsula (Table 1; Fig. 5), these evidences (cut and burn marks) of dog consumption have been identified during the Neolithic (La Sarsa; López and Molero 1984), as well as during the Bronze Age at sites in Valencia (Sanchis and Sarrión 2004), Castellón Alto and Terrera del Reloj (Granada; Milz 1986), Los Palacios and Azuer (Ciudad Real; Driesch Von Den and Boessneck, 1980) and Cerro de La Encina (Granada; Friesch 1987) (Table 1; Fig. 5). Consequently, in the Iberian Peninsula it seems that a change occurred in the role of dogs from the Neolithic to the Bronze Age, since the consumption of dogs was rare during the Neolithic and became more frequent during the Bronze Age.

Table 6 Summary of the anthropic traces documented on dog bones from the El Portalón de Cueva Mayor site. Cut marks: *SL*, slicing marks; *SC*, scraping marks; *PM*, percussion marks; *CHM*, chop

marks. Tooth marks: *PT*, pits; *SC*, scores; *FW*, furrowing. Fire modification: *BR*, burned; *BL*, boiled. YES = presence; NO = absence

Cultural period	Level	Context	Dog bone code	Anatomical element	Cut marks	Fresh bone fracture	Tooth marks	Fire modifications	
Neolithic	Neolithic	Habitat context	ATP17.UE536.425	I phalanx	-	-	PT	BR	
			ATP15.UE507.392	Mandible	-	YES	-	BR	
			AT16.UE524.302	Metacarpal	-	YES	DG	BR	
Chalcolithic	Pre-Bell Beaker Chalcolithic	Funerary context	ATP10UE26.466	Humerus	SL	YES	PT, SC	NO	
			ATP10.UE20.62	Innominate	SL	YES	NO	NO	
			ATP10.UE26.287	Rib	SL,SC	PEELING	NO	NO	
			ATP10.UE20.55	Femur	SL	YES	FW	BL	
			ATP13.79a.10	Metapodial	SL	YES	PT	NO	
		Habitat context	ATP08.UE23.F10	Ulna	SL	YES	PT	BR	
			ATP08.UE23.101						
			ATP08.UE21.83	Tibia	SL	YES	PT, FW	BL	
			ATP10.UE52.15	Rib	SL	PEELING	NO	BL	
			ATP12.Layer 212b. 570	Humerus	SL	YES	NO	NO	
Bronze Age	Bell Beaker Chalcolithic Early Bronze Age	Habitat context	ATP07.UE4.F1	Humerus	NO	YES	NO	NO	
			CMI-A8-73-9	Cranial fragment	NO	YES	NO	BR	
			CMI-A8-73-8	Occipital	SL	NO	NO	BR	
			CMI-A8-73-10	Zygomatic	NO	YES	NO	BR	
			CMI-A8-73-7	Parietal fragment	NO	NO	NO	BR	
			CMI-A8-73-12	Cranial fragment	NO	YES	NO	BR	
			CMI-C2-96-1	Scapula	SL	YES	NO	NO	
			CMI-B6-87-3	Tibia	PM	YES	NO	NO	
			CMI-C2-92-1	Humerus	SL	YES	PT	NO	
			CMI-B2-78-9	Astragalus	NO	NO	NO	BR	
Middle Bronze Age			CMI-B4-84-2	Vertebra	NO	NO	NO	BR	
			CMI-A6-72-41	Ulna	SL	YES	NO	NO	
			CMI-D2-104-10	Innominate	SL	YES	PT, FW	NO	
			CMI-A10-73-6	Innominate	SL	YES	PT	NO	
			CMI-A8-65-1	Ulna	PM	YES	PT, FW	BL	
			CMI-A8-51-1	Mandible	SL, SM	PEELING	PT, SC	BL	
			CMI-A6-48-4	Mandible	SL	NO	NO	NO	
			CMI-A8-49-3	Atlas	CHM	NO	NO	NO	
			CMI-A6-41-1	Ulna	SL	YES	NO	BL	
			CMI-D4-50-1	Ulna	SL	YES	NO	BR	
			CMI-B2-64-3	Cranial -Frontal	SL	YES	PT	BL	
			CMI-C4-63-7	Vertebra	SL	PEELING	NO	BL	
			CMI-A6-46-2	Vertebra	SL	NO	NO	BL	
			CMI-C4-63-10	Vertebra	NO	NO	NO	BL	
			CMI-B2-64-4	Rib	SL	NO	NO	BL	
			CMI-B2-64-3	Atlas	SL	NO	NO	NO	
			CMI-C2-55-1	Phalanx	NO	NO	NO	BR	
			CMI-B2-64-8	Calcaneum	SL	NO	NO	BL	
			CMI-C4-47-3	Cuboid	NO	NO	NO	BR	
			CMI-D2-48-3	Atlas	SL	NO	NO	NO	
Late Bronze Age			CMI-B2-64-2	Ulna	SM	NO	NO	BL	
			CMI-C4-13-6	Maxilla	NO	YES	NO	NO	
			CMI-D2-11-4	Occipital	NO	NO	NO	BR	

In the Iberian Peninsula, the Holocene archaeological sites of El Portalón de Cueva Mayor and El Mirador, in the Sierra de Atapuerca (Burgos), are the only ones in which human tooth marks have been documented on dog bone remains (Martín et al. 2014), unlike the rest of the peninsular sites with evidence of anthropic processing of dog bone remains, in which cuts and butchering marks are identified, as well as cremation features. While this last evidence is compatible with ritual offerings, the cases of the Sierra de Atapuerca sites clearly confirm the consumption of dogs at

least from the Chalcolithic and probably from the Neolithic as well.

In the case of the Neolithic level from El Portalón, although the fire modifications on the phalanx and mandible do not constitute clear anthropic processing, they do suggest possible human consumption due to the character of the stratigraphical units where these bone remains (UE 507 and UE 536) were found; the burnt dog bones were recovered from activity floors, formed as the result of domestic

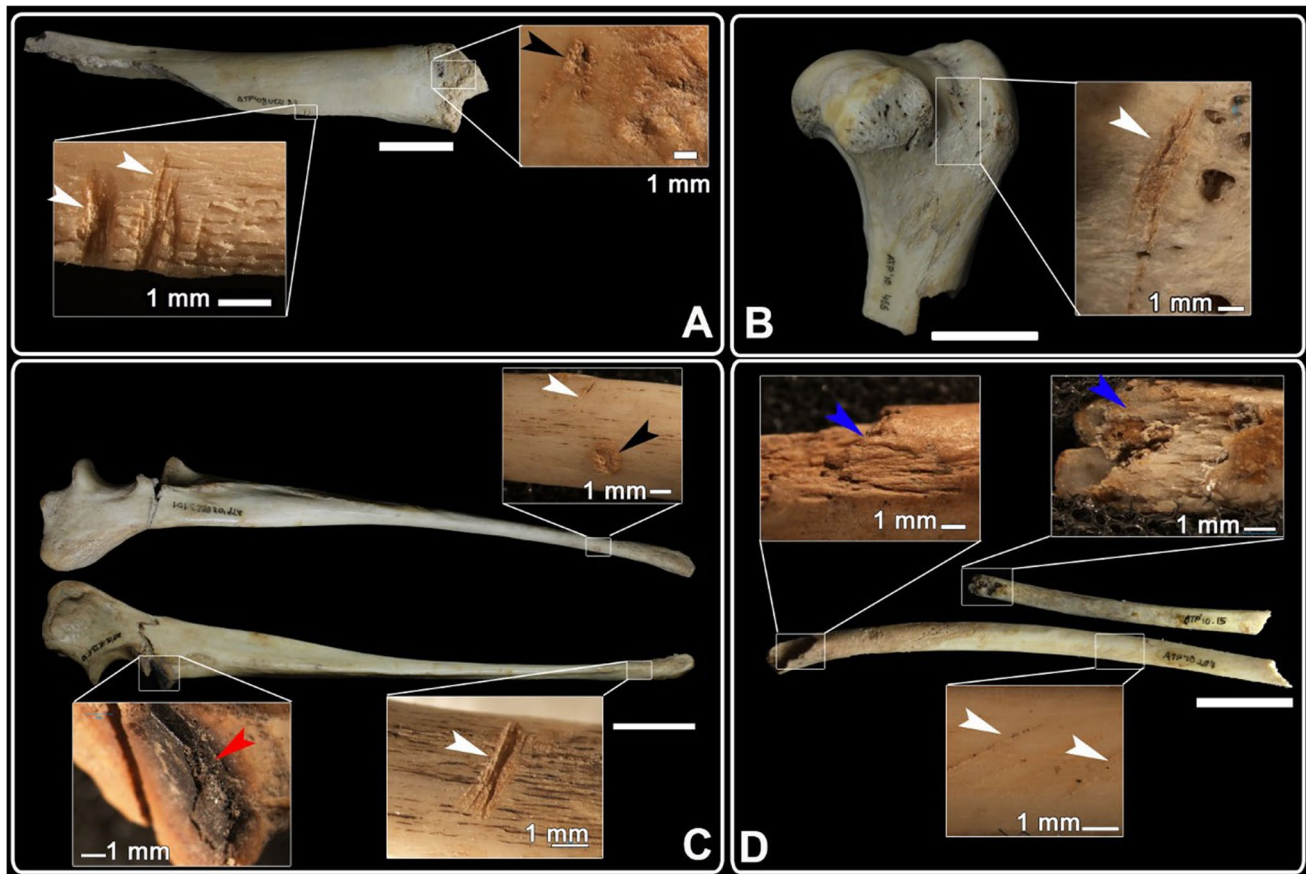


Fig. 3 Anthropogenic modifications on the Chalcolithic dog bone remains from the El Portalón de Cueva Mayor site. **A** Cut marks (white arrows) and human tooth marks (black arrow) on the tibia ATP08.UE21.83 from the Pre-Bell Beaker Chalcolithic sheepfold context. **B** Slicing marks on the humerus ATP10.466 from the Pre-Bell Beaker funerary context. **C** Slicing marks (white arrows) in combination with

human tooth marks (black arrow) and burning (red arrow) on an ulna (ATP08.UE23.F10+101). **D** Peeling (blue arrows) and slicing marks (white arrows) on two ribs from the Pre-Bell Beaker Chalcolithic funerary (ATP10.UE26.287) and sheepfold (ATP10.UE52.15) contexts. Scale bars 2 cm

activities inside the cave, cooking near several fireplaces and other consumed domestic animal bones.

The oldest Neolithic dog bone from the Neolithic level at the El Portalón site was found in UE 536 (Table 2) and dated 7240–7000 cal BP. This bone remain (ATP17.UE536.425) shows fire alteration and pits (Table 6) on its surface and is included within a domestic context. If these alterations are interpreted as indicative of human consumption, this bone, together with another one with similar evidence from the Neolithic at the nearby El Mirador site (MIR19: 7180–6970 cal BP) (Martín et al. 2014), would constitute the oldest Holocene evidence of cynophagy in the Iberian Peninsula.

The consumption of dogs at El Portalón is not decisive in terms of subsistence during the sequence of the El Portalón site, due to the low frequency of dog bones (less than 10% of NISP per level) in comparison with the high percentage of NISP of ovicaprines, bovines and pigs (Table 4) (Galindo-Pellicena et al. 2017, 2019, 2020; Francés-Negro et al.

2021). No faunal remains present pathologies that would indicate a health risk for the humans who lived there (just pathologies in cattle livestock from the Chalcolithic habitat context were detected due to the domestication process: Galindo-Pellicena et al. 2017). In terms of the age of the dogs when they were slaughtered, the vast majority of dogs from El Portalón are adults and not juveniles (11:3). Taking into account the variety and quantity of animals available at the site and the dogs' age of death (not appropriate for eating, according to the Preclassic Mayan site in Belize, where dogs were deliberately bred and slaughtered for consumption around the first year of life: Clutton-Brock 1994), the dogs do not appear to be an effective meat source. Our observations could indicate sporadic dog consumption at the El Portalón site.

Therefore, the cynophagy in the domestic, funerary and sheepfold context from the Neolithic, Pre-Bell Beaker Chalcolithic, Bell Beaker Chalcolithic and Bronze Age levels at the El Portalón sites could be caused by the provision

Table 7 Tooth mark dimensions of the domestic dog sample from the El Portalón de Cueva Mayor site. *N*, number of cases; *Min*, minimum; *Max*, maximum; *Std. Dev*, standard deviation

		<i>N</i>	<i>Min</i>	<i>Max</i>	<i>Mean</i>	<i>Std. dev</i>
Pre-Bell Beaker Chalcolithic-funerary						
Pits on cortical	Length	1	-	-	1.78	-
	Breadth	1	-	-	1.53	-
Pre-Bell Beaker Chalcolithic-habitat						
Pits on cortical	Length	4	1.1	1.91	1.6	0.4
	Breadth	4	1.02	1.64	1.4	0.3
Early Bronze Age						
Pits on thin cortical	Length	11	0.75	2.29	1.5	0.5
	Breadth	11	0.6	1.7	1.1	0.3
Scores on thin cortical	Breadth	3	0.3	0.66	0.5	0.2
Middle Bronze Age						
Pits on cortical	Length	18	0.76	2.86	1.5	0.6
	Breadth	18	0.53	2.28	1.1	0.4
Pits on thin cortical	Length	17	1.08	2.45	1.7	0.4
	Breadth	17	0.67	1.78	1.4	0.3
Scores on cortical	Breadth	1	-	-	0.94	-
Scores on thin cortical	Breadth	2	0.7	0.83	0.76	-
Scores on cancellous	Breadth	1	-	-	0.86	-

of extra food at sporadic periods of shortage or starvation (Beech 1995; Murphy 2001) or sporadic periods of dog consumption as a delicacy (Hayden 1990), as proposed in the nearby El Mirador site (Martín et al. 2014).

Nevertheless, in the case of the Pre-Bell Beaker Chalcolithic funerary context from El Portalón, a skeleton of a buried child was recovered with possible evidence of rickets and scurvy (Castilla et al. 2014). Three dog remains (IV and V metatarsals and one first phalanx) in anatomical connection (Pérez-Romero et al. 2017) were also found close to this burial. This possible association could suggest a symbolic offering in this funerary context (Pérez-Romero et al. 2017), with a portion of a dog either buried with the human or related to a ritual of commensalism (Larsson 1990).

The study of the Chalcolithic inhabitants' dental micro-wear from El Portalón (García-González et al. 2019) indicates that their diet was based mainly on meat consumption (higher relative frequency of enamel vertical scratches than horizontal ones). In this context, the observation of dog meat consumption at this level is not out of the ordinary. This heavy meat consumption could be due to the higher intensification of animal husbandry at the expense of agriculture, as suggested by García-González et al. (2019), and may be related with the climatic conditions during the Chalcolithic, which were relatively dry, and with a decrease in the woodlands and nitrophilous taxa, together with a slight increase in xeric taxa, documented by Martínez-Pillado et al. (2014). Perhaps, these arid conditions could have increased the frequency of shortage, famine and finally starvation events, making small and not very profitable dogs a necessary resource of food.

Although it is still difficult to give a satisfactory interpretation, it is obvious that dogs were consumed at El Portalón during most of the Holocene, as suggested by the anthropogenic marks on the dog bone surfaces found at the site. And together with El Mirador, cynophagy is confirmed at least from Neolithic to Bronze Age in the Sierra de Atapuerca and by extension in the Iberian Peninsula.

Conclusions

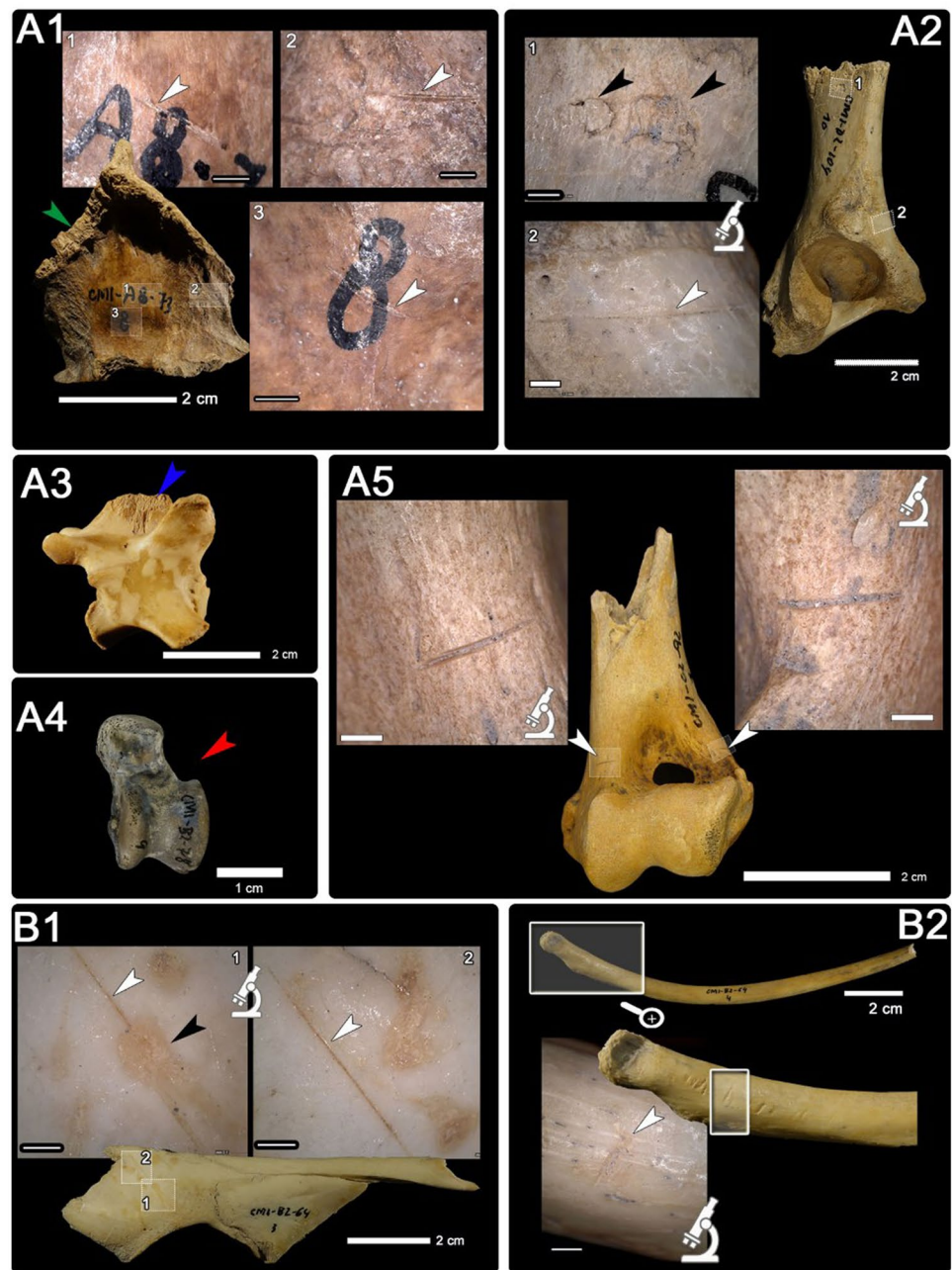
The taxonomical analysis indicates that 130 *Canis l. familiaris* bone remains were present from the Neolithic (23), Chalcolithic (26) and Bronze Age (81) units at the El Portalón de Cueva Mayor site.

Signs of anthropic activity, such as cut marks, human tooth marks, intentional breakage and fire modifications, suggest sporadic consumption of domestic dogs during the Chalcolithic and Bronze Age and probably during the Neolithic. These anthropic signs have been identified in bone remains recovered from different archaeological contexts, such as domestic, sheepfold and funerary contexts.

These taphonomic evidences suggest that domestic dogs were, at least occasionally, also part of the diet of the humans who inhabited the El Portalón site; fact could be due to shortage, famine or the consideration of dog meat as a delicacy.

The El Portalón de Cueva Mayor and El Mirador Holocene archaeological sites from Sierra de Atapuerca constitute the oldest evidence of cynophagy in the Iberian Peninsula, and record the continued consumption of dogs

Fig. 4 Anthropogenic modifications on the Early Bronze Age (A) and Middle Bronze Age (B) dog remains. **A1** Slicing marks (white arrows) on the occipital bone CMI-A8-73–8 where rodent activity is also recorded (green arrow). **A2** Innominate bone CMI-D2-104–10 with tooth pits (black arrow) and slicing marks (white arrows). **A3** Peeling (blue arrow) in the CMI-D2-104–11 lumbar vertebra. **A4** Astragalus CMI-B2-78–9 with partial calcination (red arrow). **A5** General and detailed views of the slicing marks on the humerus CMI-C2-92–1 where the typical features of fresh bone (*perimortem*) breakage can be observed. **B1** General and detailed views of the frontal and nasal remain CMI-B2-64–3 where slicing marks (black arrows) and tooth pits (black arrow) are marked. Note the superimposition of the tooth pit on the cut mark. **B2** Numerous parallel slicing marks on the rib CMI-B2-64–4. All the scale bars of the microscope views correspond to 1 mm



over an extensive period of time (from the Neolithic to the Bronze Age) in a single region within the Iberian Peninsula.

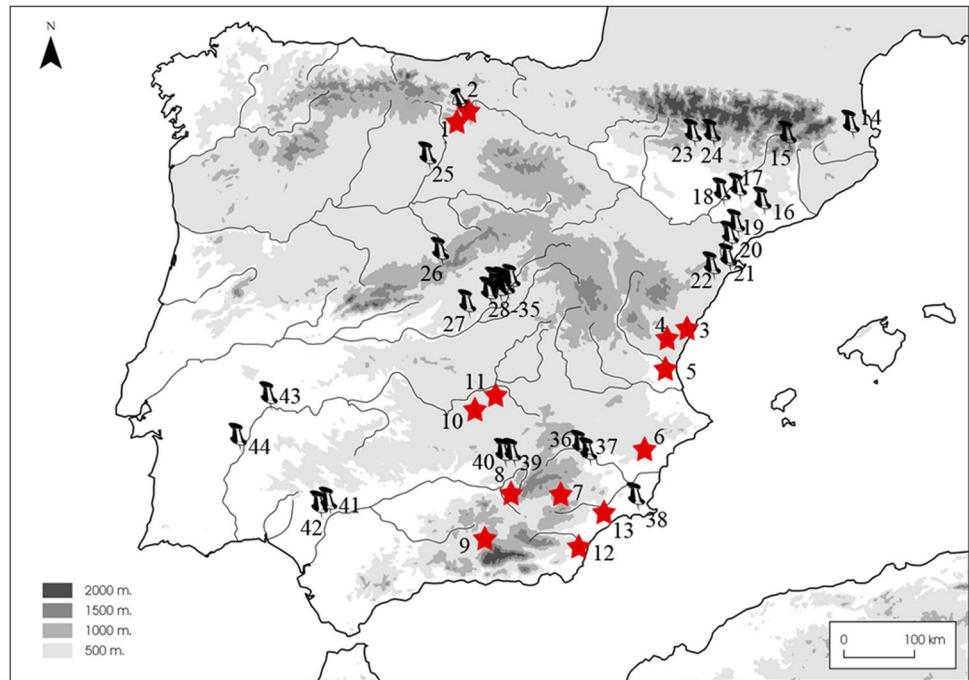
Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s12520-022-01522-5>.

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Fig. 5 Location of the archaeological sites with dog remains associated with human consumption evidence (red stars) and funerary context (black pins). See Supplementary Table S2 for map legend



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