Animal husbandry and Neolithic mining: new insights from the variscite mines at Gavà (Barcelona)*

Prácticas ganaderas y minería neolítica: nuevos datos de las minas de variscita de Gavà (Barcelona)

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ABSTRACT

Husbandry practices have played an important role in the socioeconomic organization of mining societies… This paper presents the results of a zooarchaeological and taphonomic analysis of the faunal remains recovered from Mine16 at Gavà (Barcelona). Analyses of the faunal remains were used to determine the importance of livestock in subsistence practices, the origin of the faunal assemblage and the depositional dynamics of the faunal assemblage in the fill inside Mine16. The mining activities at Gavà did not replace specialized subsistence production, but rather complemented it. The results suggest that the faunal remains found in the mines comprised production and consumption waste, providing new and complementary evidence of settlement activities associated with mining.

RESUMEN

Las prácticas ganaderas han jugado un papel importante en la organización socioeconómica de las sociedades mineras. Este trabajo presenta los resultados del análisis arqueozoológico y tafonómico de los restos de fauna recuperados en la Mina16 en Gavà (Barcelona). Los análisis de los restos de fauna se utilizaron para determinar la importancia ganadera en las prácticas de subsistencia, el origen y la dinámica de depósito del conjunto faunístico en el relleno de la Mina16. Las actividades mineras en Gavà no reemplazaron la producción especializada de subsistencia, sino que la complementaron. Los resultados sugieren que los restos de fauna encontrados en las minas fueron residuos de producción y consumo, lo que proporciona evidencia

nueva y complementaria del asentamiento asociado con las estructuras mineras.

Key words: Archaeozoology; Mining activity; Variscite; Post-cardial Middle Neolithic; Northeast Iberian peninsula; Taphonomy.

Palabras clave: *Arqueozoología; Actividad minera; Variscita; Neolítico Medio Post-Cardial; Noreste península ibérica; Tafonomía.*

1. INTRODUCTION

The Neolithic transition in the Western Mediterranean is characterized by major changes in economic strategies, including the development of exchange networks for the circulation of mineral resources as a consequence of the high degree of systematization, organization and specialization of mining production (Collet 2004; Consuegra *et al*. 2004; Galiberti 2005; Borrell y Bosch 2012; Borrell *et al*. 2015, 2019). The working of flint mines is well attested in the Neolithic: Casa Montero in Spain (Consuegra *et al*. 2004; Díaz-del-Río *et al*. 2008), Defensola in Italy (Galiberti 2005), Spiennes in Belgium (Collet 2004), and Jablines in France (Bostyn and Lanchon 1995). Quartz mines at Plancher-les-Mines in France (Pétrequin *et al*. 1993) and variscite mines at Gavà in Spain have also been documented (Villalba *et al*. 1986; Bosch and Estrada 1994).
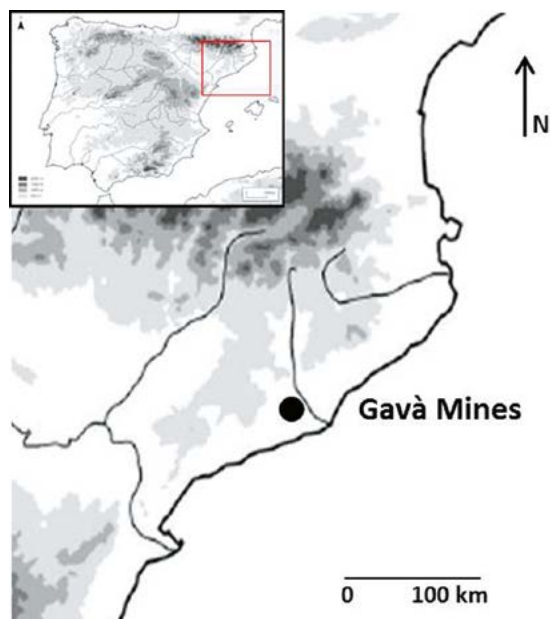
Fig. 1. Location of the Gavà Mines (Gavà, Barcelona) in Northeast Iberian peninsula.

The mining activities at Gavà took place mainly during the first half of the 4th millennium cal BC. The mines (Ferreres mountain range and Can Tintorer, Gavà, Barcelona) are on the eastern slope of the Garraf Massif, south of the mouth of the Llobregat River (Fig. 1), in what is nowadays the Parc Arqueològic Mines de Gavà (http://www.arqueoxarxa.cat/Jaciments/Parc-Arqueologic-Mines-de-Gava-Gava?).

They form a unique subterranean mining complex where variscite, a green aluminium phosphate mineral similar to turquoise, was extracted (Villalba *et al.* 1986; Bosch and Estrada 1994; Bosch *et al.* 1996, 1999; Bosch and Borrell 2009; Borrell and Bosch 2012; Bosch 2019). The mine structures vary in size, shape and complexity, reaching a maximum depth of up to 15 m (Bosch *et al.* 1999) (Fig. 2). The access shafts to the mines were backfilled with soil from their surroundings once they were abandoned. The amount of archaeological remains recovered in the mine shafts varies depending on their scale and structure, the type of backfilling, or their secondary functions (*i. e.* burials). Evidence of flint knapping and micro-perforators have been recovered in the fill of some mines, suggesting that variscite beads were produced on site (Villalba *et al.* 1986; Bosch and Estrada 1997; Bosch *et al.* 1999). Analysis of the spatial distribution of the
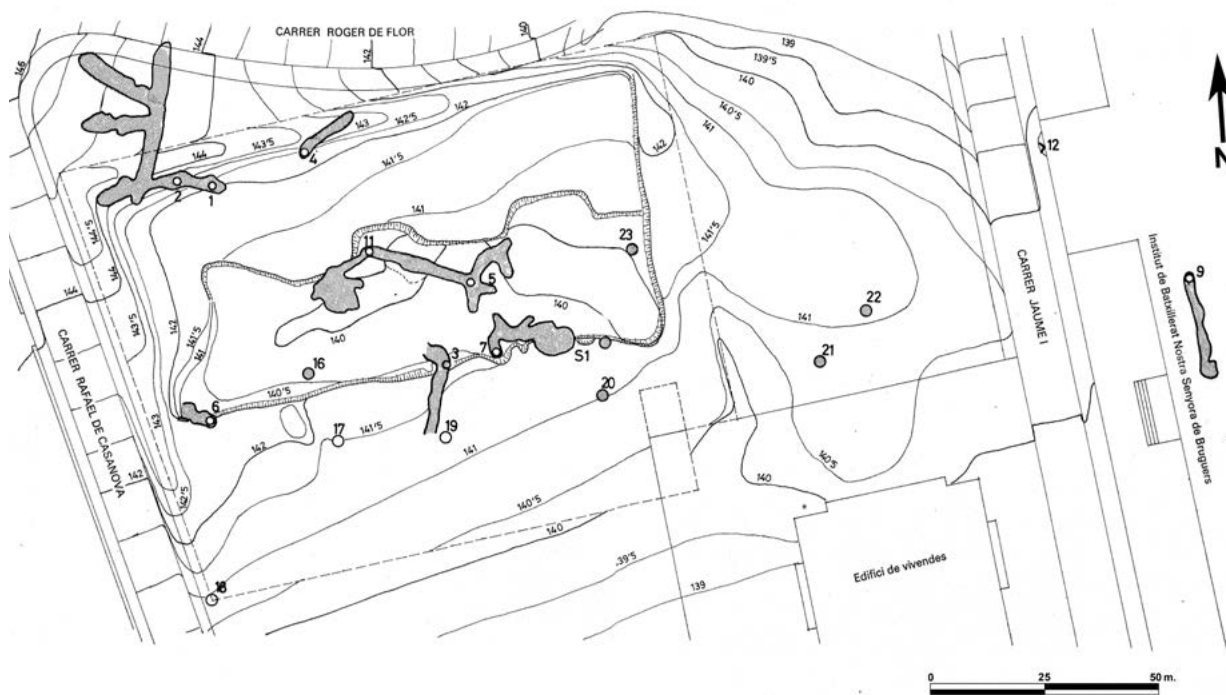

Fig. 2. Topography of the Gavà Mines (Gavà, Barcelona) (Villalba *et al.* 1986: 22-23). The plan represents what is nowadays the Parc Arqueològic Mines de Gavà.

Gavà variscite suggests that specialization in the extraction and processing of the mineral was for the production of beads for exchange (Villalba *et al.* 1986, 1997; Bosch and Estrada 1997; Edo *et al.* 1997; Blasco *et al.* 1998; Domínguez-Bella 2004; Weller and Fíguls 2007; Borrell *et al.* 2015, 2019; Bosch 2019). During the post-cardial Middle Neolithic, variscite beads circulated through complex distribution networks, and have been documented as prestige goods in Neolithic burials in the northeast of the Iberian peninsula and part of southern France (Bosch and Estrada 1997; Weller and Fíguls 2007; Borrell *et al.* 2015, 2019). In addition to this specialised activity, other subsistence activities have also been documented in the mines of Gavà, such as animal husbandry involving the four main domestic species: cattle (*Bos taurus*), sheep (*Ovis aries*), goat (*Capra hircus*) and pig (*Sus domesticus*). This livestock activity would have been mainly focussed upon the production of meat (Estévez 1986). Hunting was represented to a lesser degree by remains of red deer (*Cervus elephus*), fox (*Vulpes vulpes*), wild boar (*Sus scrofa*), rabbit (*Oryctolagus cuniculus*) and Mediterranean seal (*Monachus monachus*). The Iberian water turtle (*Mauremis caspica leprosa)* is also represented. Likewise, fish remains such as sea bream (*Pagrus pagrus*), common pandora (*Pagellus erythrinus*) and dentex (*Dentex dentex*) have been recovered (Bosch *et al.* 1999); and four different classes of malacological remains were recorded : bivalves (Glycymerididae, Veneridae, Cardiidae, Mactridae, Ostreidae, Mytilidae and Spondylae), gastropods *(*Patellidae, Thaididae, Muricidae, Cancellariidae, Cassidae and Cymatiidae), scaphopods (Dentaliidae) and cephalopods (Sepiidae) (Oller 1986; Estrada and Nadal 1994; Bosch *et al.* 1999). Malacological studies show that marine molluscs were collected for food, except for Glycymerididae and Dentaliidae (Bosch *et al.* 1999). Agriculture is represented by such cereals as dressed (*Hordeum vulgare*) and naked barley (*Hordeum vulgare nudum*), einkorn wheat (*Triticum monococcum*), spelt wheat (*Triticum dicoccum*), and common wheat (*Triticum aestivum*), and by legumes such as broad beans (*Vicia* sp.) (Buxó *et al.* 1991). No clear evidence of an associated settlement has been recorded to date. This may be due to a combination of factors, such as the fragility of dwellings, natural erosion and the modern urbanization suffered by the area (Bosch *et al.* 1996; Bosch and Estrada 1997). However, the settlement must have existed nearby as indicated by the archaeological remains recovered in the fill of some mines: *i. e.* faunal remains, pottery sherds, lithic artefacts, daub fragments with impressions of branches and building material (Villalba *et al.* 1986; Bosch and Estrada 1994, 1997; Bosch *et al.* 1996, 1999; Villalba 1999; Bosch and Borrell 2009; Bosch

2010). In addition to the great economic importance of Gavà Mines during the Post-Cardial Neolithic, they might also have possessed great symbolic meaning (Bosch and Estrada 1994; Bosch 2010). The discovery of the Gavà Venus, a fragment of an anthropomorphic figure-vessel, and the burials found in various mines are characteristic of a special space (Bosch and Estrada 1994; Villalba 1999). Anthropological studies have shown that the individuals buried in these mines participated in the mining to a greater or lesser degree over a long period of time; men, women and children all took part in the mining and bead production tasks (Villalba 1999; Casas and Majó 2009).

Traditionally, mining complexes have been studied from economic and technological perspectives, focusing on the forms of extraction, manufacture and exchange of the final product. Thus, the study of background subsistence practices, such as agriculture and husbandry, has been uncommon despite their importance in underpinning the socio-economic organization behind the use of mining complexes (Topping and Lynott 2005). In this sense, the study of animal management is a cornerstone to characterizing how animals were used at extraction sites. For example, during the Bronze Age at Great Orme Mines (Wales, United Kingdom), animals were not slaughtered at the mining complex. Only the joints with the most meat were transported to the mines. Here, the presence of cut marks on the animal bones and the absence of skeletal remains with low meat content evidence the transport of joints, perhaps from a distant settlement, which were destined for consumption at the copper mines (James 2011). In contrast, in the Neolithic mines at Spiennes (Belgium) domestic animals for consumption were processed at the mine complex and the whole carcass was discarded producing both processing and consumption waste (Collet 2004). The same pattern is documented at the Bronze Age copper mines at Ross Island (Ireland). O'Brien and Brindley (2004) have suggested that the animals would have been kept at the mining complex. Also, the survival of all skeletal elements of domestic species on-site has been interpreted as representing consumption waste (van Wijngaarden-Bakker 2004). In the same way, in some mining complexes, faunal remains were also used as tools. At the Neolithic mines of Grime's Graves (United Kingdom), a large collection of red deer antlers were used as picks and wedges to dig the flint mines (Clutton-Brock and Grigson 1984). Remains of bone tools associated with copper mining tasks such as polishers, spatulas, drilling tools, bone cylinders and shovels have been documented in the Bronze Age mine at Gorny (Russia) (Antipina 2001). Finally, faunal remains have also been recorded in burial contexts (*i. e.* burials within mines). For example, in Gorny mine,

Sample	Level	Material	¹⁴C yr BP	¹⁴C yr cal BP (2σ)	¹⁴C yr cal BC (2σ)	Reference
Beta 268776	1002	Charcoal	5190 ± 40	6172-5773	4223-3824	Bosch 2010
Beta 268777	1003	Charcoal	5030 ± 40	5896-5661	3947-3712	Bosch 2010
Beta 268778	1006	Charcoal	5090 ± 40	5918-5743	3969-3794	Bosch 2010
Beta 268779	1007	Charcoal	5080 ± 40	5915-5736	3966-3787	Bosch 2010
Beta 268780	1008	Charcoal	5160 ± 40	5995-5755	4046-3806	Bosch 2010
Beta 268781	1009	Charcoal	5110 ± 40	5930-5746	3981-3797	Bosch 2010

Tab. 1. Mine16 (Gavà, Barcelona). Conventional radiocarbon date along with calibrated radiocarbon ages using OxCal 4.3 software (IntCal 13; Reimer *et al.* 2013).

cattle and dog neonate and young individuals in anatomical connection were identified as grave goods (Antipina *et al.* 2002); or in Grime's Graves, cattle remains associated with a human skull were recorded (Clarke 1915). Animal remains arguably relating to magico-cosmological beliefs or meanings have also been studied. In Easton Down (England, United Kingdom) a dog skull was found in the upper fills and was interpreted as a possible offering to mitigate the impact of mining (Stone 1931).

Husbandry practices at the Gavà Mines were carried out for food production. The composition of the herds was rather mixed and orientated towards producing meat. This highlights the greater relative importance of cattle during the Middle Neolithic, followed by ovicaprines, pig and dog (Estévez 1986). Estévez (1986) and Saña (1994)[1] have proposed that the faunal remains recovered in the mines were production and consumption waste. Estévez (1986) pointed out that one of the major problems in interpreting the faunal assemblages from the mining complex is the difficulty in characterizing the origin of these animals since no habitation area or settlement has been found.

One of the main issues to be addressed by the present paper is the role that husbandry practices played in the socioeconomic system at Gavà Mines, focusing on animal management and exploitation. Secondly, it will determine the origin of the faunal assemblages recovered in the fill in Mine16, focusing on whether the animals were butchered at the mining complex or whether only joints with most meat were destined for consumption at the mine. Finally, the depositional dynamics of the faunal assemblage in the fill in Mine16 will be characterized.

[1] M. Saña. "Estudi Arqueozoologic de les unitats estratigrafiques 1000, 2000, 4000 I 5000 del jaciment de Can Tintorer (Gavà). Excavacions 1991-1993". Servei d'analisis arqueologiques. Universitat Autònoma de Barcelona, inédito.

2. MATERIALS

2.1. Mine16

Mine16, with a semi-vertical entrance and a depth of almost 9 m, has provided abundant archaeological evidence that enable a better understanding of the organisation of mining activities (Bosch and Estrada 1994; Bosch 2010). The shaft was filled with clay/
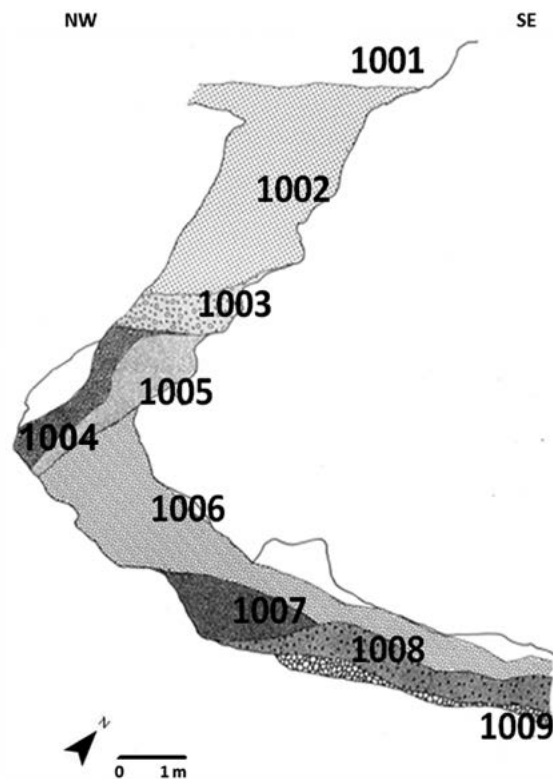

Fig. 3. Stratigraphic layers identified in the Mine16 (Gavà, Barcelona). Rewritten from Bosch (2010: 26, Fig. 4).

silt-based anthropogenic deposits that included abundant archaeological material (pottery, lithic picks and maces, tools for jewellery, broken variscite beads, building materials, faunal and botanical remains). The iconic anthropomorphic figure-vessel, known as the Gavà Venus, was recovered in the shaft of this mine (Bosch and Estrada 1994; Bosch 2010). Nine stratigraphic layers were identified during the excavations of Mine16; dating from ca. 4000 to 3800 cal. BC, they constitute the fill of the mine (Fig. 3 and Tab. 1). It has been proposed that this backfill could be the result of a process of intentional dumping of waste inside the mines after their abandonment in order to remove residue from other active mines, but it could also have originated by the natural erosion of surrounding areas (Bosch 2010).

2.2. Faunal remains from the Mine16

A total of 2.425 faunal remains from the nine stratigraphic levels in Mine16 have been analysed, and eight different animal species have been identified. A total of 903 animal bones have been classified at a specific and anatomical level, while 1,522 bones could not be specifically classified because of the degree of fragmentation.

3. METHOD

All the fauna remains found in Mine16 were recovered and analysed. In order to recover even the smallest remains, all the sediment extracted from the mine was screened through a 2mm mesh. Each bone was classified anatomically and taxonomically using the reference collection in the *Laboratori d'Arqueozoologia* of the Autonomous University of Barcelona. Sheep and goats were distinguished based on the following studies: Boessneck 1980; Payne 1985; Prummel and Frisch 1986; Halstead *et al*. 2002; Zeder and Lapham 2010; Zeder and Pilaar 2010; Gillis *et al.* 2011; Salvagno and Albarella 2017.

The archaeozoological analysis has focused on the study of taxonomic and anatomical representation frequencies, estimates of the age of death of the main domestic taxa (*Ovis aries, Capra hircus, Sus domesticus* and *Bos taurus*), the study of butchering processes and techniques, and the characterization of natural processes on bone surfaces. The quantification of the assemblages was based on the Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI) of each species. The MNI was calculated by considering the estimated age, anatomical representation and laterality. Taxonomic variability

was estimated by the relative frequency or presence/absence of taxa. The anatomical variability for each taxon was based on the relative frequency or presence/absence of skeletal elements grouped in anatomical parts. The anatomical parts have been classified according to their greater or lesser contribution to meat production: head, trunk, fore limb, hind limb, and distal parts of the extremities. In the anatomical representation of the domestic species, the minimum number of elements (MNE), from diagnostic areas (Stiner 1991), and the minimum number of anatomical units (MAU) were estimated. The MAU was obtained by dividing the MNE by the number of times an element appears in the skeleton (Mengoni-Goñalons 1999). The percentage values standardized to the MAU higher (% MAU) was obtained from the MAU, dividing the MAU obtained for each anatomical unit by the highest of the assemblage and multiplying the result by one hundred (Lyman 1994). The age of the animals was estimated according to the stages of tooth wear (Grant 1982; Payne 1985, 1987; Jones 2006; Lemoine *et al.* 2014), eruption sequences and epiphyseal fusion in postcranial elements (Silver 1969; Barone 1976, Amorosi 1989; Zeder 2006). As it was possible to associate several skeletal elements to the same animal, either through refits or anatomical connections, a new unit was used, called IES (individualised elements of the same individual). The criteria used for this attribution, in cases with no refits or direct connections, were the age of the animals, the size, spatial distribution of the remains and taphonomic characteristics.

The location and orientation of each butchering mark were recorded, differentiating between processing and cutting marks, to identify the different culinary processes and techniques (Lyman, 1987, 1994; Gifford-Gonzalez 1989, 2008; Greenfield 2000; Egeland *et al.* 2004). Thermally altered bones can provide information on meat preparation. Thermal alterations were recorded according to colour, distinguishing between brown, black, grey and white, as evidence of intensity and/or exposure to fire (Nicholson 1993; Outram *et al.* 2005; Asmussen 2009; Avido 2012). Different types of fractures were identified based on particular morphotypes defined by origin, morphology and location (Villa and Mahieu 1991; Lyman 1994). The analysis was carried out on the basis of the delineation with respect to the longitudinal axis of the bone (longitudinal, transverse or oblique fracture) and the fracture surface (smooth or irregular).

Regarding the characterisation of processes produced by natural agents on bone surfaces, alterations produced by biological agents of animal origin (action of carnivores and rodents) have been recorded on the basis of the presence/absence of the modification of the bone surface (Binford 1981; Domínguez-Rodrigo

and Barba 2006; Delany-Rivera *et al.* 2009). Alterations produced by physicochemical agents were also recorded (action of atmospheric agents and the sedimentary context). The action of atmospheric agents has been specified by the degree of weathering defined by Behrensmeyer (1978): 0 = no weathering; 1 = presence of cracks; 2 = presence of exfoliation; 3 = fibrous texture and rounded edges; 4 = fibrous texture and splintered edges; and 5 = disintegration of the bone *in situ*. At the same time, the degree of fragmentation of the faunal assemblage has been evaluated by measuring the length of each piece and grouping them by measurements in millimetres in order to document trampling or sedimentary compaction (Shipman 1981; Yravedra 2006; Domínguez-Rodrigo *et al.* 2009). The impact of physicochemical alteration produced by the sedimentary context (pH) has been evaluated by bone survival in relation to the estimation of the age of individuals based on bone development (Binford and Bertram 1977; Behrensmeyer 1978; Ioannidou 2003; Jans *et al.* 2004; Symmons 2005; Smith *et al.* 2007; Fernández-Jalvo and Andrews 2016).

4. RESULTS

4.1. Faunal assemblage composition

903 animal bones from Mine16 were analysed. The remains of domesticated animals make up more than 99.4 % of the recovered assemblage and wild species represent only 0.6 %. Wild species comprise deer (NISP=1), wild goat (NISP=1) and fox (NISP=1). The composition of the herds was rather mixed. Cattle (NISP=295) are more important quantitatively than ovicaprines (o/c NISP=288; goat NISP=25; sheep NISP=11), followed by pig (NISP=186) and dog (NISP=131). The results of the frequencies of representation of domestic species are similar in all levels, except for L.1004 and L.1005 where pigs and dogs predominate in quantitative importance. The MNI indicates that 27 different individuals are represented: seven cattle (six adults over 36 months of age and one from 2 to 7 months), four adult ovicaprines over 24 months old, ten pigs (two adults over 24 months old and eight neonates from 0 to 1 month) and six neonate canids from 0 to 1 month of age. According to the MNI by level, L.1002, L.1004 and L.1005 have a higher MNI of pig and dog neonates (Tab. 2).

The representation of the anatomical frequencies of all anatomical parts of domestic species, except for pig and dog, for which the trunk and distal part of the extremities are not represented (SF1). The NISP trend is corroborated when considering the MNE. There is no marked preference for certain anatomical parts. All skeletal elements, with the exception of the lumbar vertebrae and axis, are represented for cattle. Ovicaprines have a high level of integrity, with all elements represented. The predominance of skull and rib bones, in both species, is due to their frequent fracturing because of their low structural density. MAU and % MAU values coincide with previous trends, although an important proportionality in the representation of all long bones is accentuated. The absence of most vertebrae, metapodials, carpal and tarsal bones, and phalanges of pig and dog may be related to the size and structural density of these skeletal elements, as

Taxa	L.1001 NISP	L.1002 NISP	L.1003 NISP	L.1004 NISP	L.1005 NISP	L.1006 NISP	L.1007 NISP	L.1008 NISP	L.1009 NISP	TOTAL NISP	TOTAL MNI
Bos taurus	16	184	29	7	17	13	2	27	0	295	7
Sus domesticus	6	90	5	38	36	5	1	5	0	186	10
Capra hircus	0	15	0	2	0	5	0	3	0	25	–
Ovis aries	1	3	1	2	0	3	0	1	0	11	–
Ovis/Capra	6	195	20	5	12	7	2	4	1	252	–
tt.OC	7	213	21	9	12	15	2	8	1	288	4
Canis familiaris	0	40	0	38	53	0	0	0	0	131	6
Capra pyrenaica	0	1	0	0	0	0	0	0	0	1	1
Cervus elephus	0	1	0	0	0	0	0	0	0	1	1
Vulpes vulpes	0	1	0	0	0	0	0	0	0	1	1
TOTAL	29	530	55	92	118	33	5	40	1	903	27

Tab. 2. Taxonomic representation of animal remains recovered in each level of the Mine16 (Gavà, Barcelona) (tt.OC= total ovicaprines; NISP= Number of Identified Specimens; MNI= Minimum Number of Individuals).

they correspond to neonate individuals. The percentage of anatomical connections is 14.1 % (NISP=127). It has been possible to refit and connect five pig neonates (NISP=60) and six dog neonates (NISP=77).

4.2. Faunal assemblage condition

Modifications related to butchering and cooking activities are observed in 60.9 % (NISP=556) of the faunal remains recovered from Mine16 (Fig. 4). Intentionally fractured remains are distributed evenly throughout the levels. Fresh bone fractures predominate, attributable to butchering activities such as cutting, on 59.0 % (NISP=519) of the remains. They display holes or striations associated with percussion (NISP=5), presence of shallow flakes (NISP=5), and oblique (NISP=253), longitudinal (NISP=265) and transversal (NISP=31) fractures (Fig. 4 and SF1). The comparative analysis between taxa and the type of fracture shows that there are differences at taxonomic level. Most butchery fractures are recorded in ovi-caprines (NISP=359) and cattle (NISP=133), and to a lesser extent in pigs (NISP=27). On the contrary, dogs (NISP=113) do not present anthropic fractures. Cut marks are found in 4.1 % (NISP=37) of the remains, marks related to meat extraction (NISP=25) are documented on ribs, scapulae, femora, humerus and tibia, and those associated with the disarticulation of the animal carcass (NISP=12) are found on the skull, jaw, metapodials, calcaneus, phalanges and pelvis (Tab. 3). Alterations due to exposure to fire have also been documented (% NISP=4.5). The comparative analysis between taxa and butchery marks shows that there are differences at taxonomic level. Most butchering marks are recorded on cattle (NISP=27), to a lesser extent on ovicaprines (NISP=7) and pigs (NISP=3), while dogs do not show butchery marks. A total of 3.2 % (NISP=29) of the faunal remains present total thermal alterations in black on the mandible, maxilla, femora, metapodials and radius, and in brown on the skull and femora. Only three skull fragments show total thermal alteration in grey. Similarly, a total of 1.3 % (NISP=12) of the remains present partial thermal alterations in
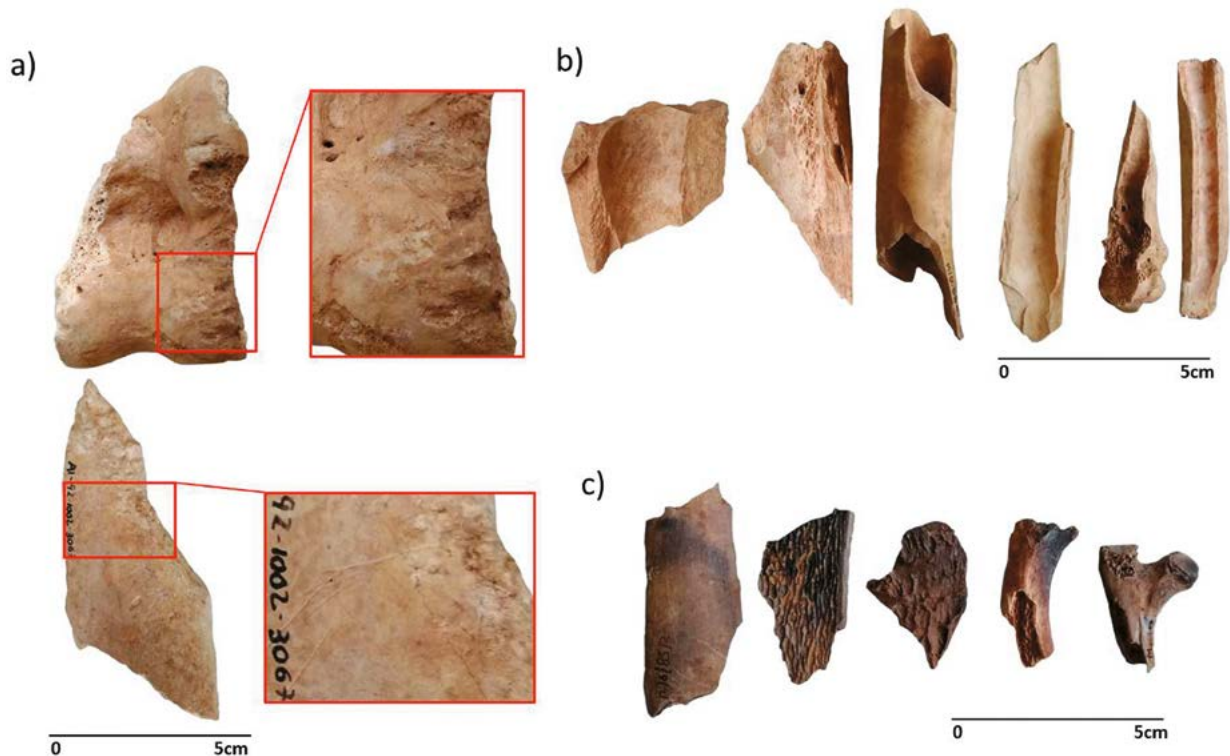

Fig. 4. Bone modifications related to butchering and cooking activities recovered in Mine16 (Gavà, Barcelona): a) Cut marks of the remains related to meat extraction on humerus (down) and marks associated with the disarticulation on the calcaneus (up); b) Fresh bone fractures (oblique, longitudinal and transversal); and c) total thermal alterations in black-brown on the ribs and femora (in colour in the electronic version).

	Bos taurus	Sus domesticus	Ovis/ Capra
NISP	295	186	288
%NISP longitudinal fractures	46	10	179
%NISP oblique fractures	67	16	170
%NISP transversal fractures	20	1	10
%NISP cut marks	27	3	7

Tab. 3. Mine16 (Gavà, Barcelona). Frequencies of bone modifications related to butchering activities in cattle (*Bos taurus*), pig (*Sus domesticus*) and ovicaprines (*Ovis/Capra*) (%NISP= Frequencies Number of Identified Specimens).

black on metapodials, and in black-brown on ribs and skull. Taking into account the black/brown colour and the location of these thermal alterations, they could be indicating the roasting of these anatomical parts. The dog is the only species for which no thermal alterations have been observed.

4.3. The formation of the faunal assemblage

There is no correlation between the recovered skeletal elements and their structural density. Moreover, the recovery in Mine16 of low-density structural skeletal elements, such as ribs and vertebrae of neonate individuals, suggests that differential preservation processes among skeletal elements due to taphonomic factors do not exist.

The assessment of the impact of natural agents on bone surfaces has been carried out by recording the degree of weathering of the remains and the action of biological agents, particularly carnivores. A total of 107 faunal remains have been recorded with some

Fig. 5. Faunal remains recovered in Mine16 (Gavà, Barcelona) with cracks in the surface tissue of the bone (weathering stage 1). In colour in the electronic version.

signs of weathering, consisting of cracks in the surface tissue of the bone (stage 1) (Fig. 5). The degree of weathering of the remains does not display differences among taxa, age groups and skeletal parts. Similarly, waste with stage 1 weathering is distributed evenly across the levels. The action of carnivores on mammal remains is low. A total of 69 faunal remains exhibit bites from carnivores on the bone surface. The mammal remains that could not be classified specifically (NR=1522) have an average length of 20 mm, with homogeneous patterns among the levels.

5. DISCUSSION

The results of the archaeozoological analysis of the faunal remains from Mine16 show that husbandry practices could have been completely integrated in the mining activities. There is a clear predominance of domestic species. Therefore, the data obtained from the analysis do not support hunting as a significant activity at Gavà Mines. The domestic species documented in Mine16 are characteristic of herds in the northeast of the Iberian peninsula during the post-cardial Neolithic: *Bos taurus, Ovis aries, Capra hircus* and *Sus domesticus* (Saña 1998; Colominas *et al.* 2008; Saña *et al.* 2015; Saña and Navarrete 2016). Moreover, it is worth emphasizing that the frequency of cattle in Mine16 is similar to that documented in the post-cardial Middle Neolithic Mines 1-8 (Estévez 1986). The MNI shows a similar trend, indicating the presence of seven cattle, four ovicaprines and ten pigs, of which eight are neonate individuals. The slight quantitative importance of cattle in open-air settlements during the post-cardial Middle Neolithic in the northeast of the Iberian peninsula has been documented (*i. e.* Can Sadurní, Reina Amalia sites). The domestic species occupied a central position, dominating the different strategies of animal exploitation with the increasing importance of pigs and cattle compared with ovicaprines[2]. If Gavà Mines are compared with other prehistoric mining complexes, a similar dynamic is observed. Indeed, at Grime's Graves (Legge 1992), Great Orme Mines (James 2011) and Ross Island (van Wijngaarden-Bakker 2004) more than 80 % of the faunal remains correspond to domestic species, with a higher quantitative importance of cattle over other domesticates.

The selection of individuals in Mine16 does not seem to be *ad hoc*. A significant proportion of domesticates were killed at their meat-producing optimum. Consequently, meat was probably the main product

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[2] *Vide* footnote 1.

obtained from domestic animals. Trace element analysis of human remains revealed a diet with high levels of animal protein and low levels of vegetable protein. In addition, the study of oral pathologies such as tartar and periodontitis also indicated a food intake rich in animal proteins (Villalba 1999). Specialist meat production has also been identified at the Spiennes mines (Collet and Van Neer 2002), Great Orme Mines (James 2011) and Ross Island (van Wijngaarden-Bakke 2004).

No specific butchering pattern documented in Mine16 was any different from the processes observed in the other mines in the Gavà complex (Estévez 1986) or is representative of the specific treatment of animals sacrificed as votive deposits (Antipina *et al.* 2002; Morales and Antipina 2003). The butchery marks and nearly all the fractures recorded are the direct result of human activity and occurred when the animal was processed and prepared for human consumption. Similarly, the few remains with thermal alteration suggest that some portions of meat were roasted. The total anatomical and skeletal representation of the domestic species and the abundant butchering marks on the bone surfaces provide evidence that the animals were processed and consumed, and then the waste was discarded in the mine. This is significant, because the animals could have been kept and exploited in the surroundings of the Gavà mining complex. This pattern was also recognised at the Spiennes and Ross Island mines. The settlement was documented immediately adjacent to the mining complex at Spiennes (Collet 2004), where the faunal assemblage is characterized by the representation of all the skeletal elements and anatomical parts of domestic species, with multiple butchery marks and fractures resulting from animal carcass processing and consumption (Collet and Van Neer 2002). This is also the case at Ross Island, where management practices and exploitation of domestic animals were carried out at the mine (van Wijngaarden-Bakker 2004; O'Brien and Brindley 2004). In addition, the faunal remains recovered at this mining complex are characterized by a great variety of skeletal elements with disarticulation and cut marks, the product of processing and consumption waste (van Wijngaarden-Bakker 2004).

A significant number of pig (MNI=8) and dog (MNI=6) neonates have been recovered in the faunal assemblage from Mine16. Other neonate individuals had previously been recorded in the mining complex at Gavà; for example, in Mine7 where four pig neonates were also documented (Estévez 1986), and ten pig and nine dog neonates were recovered in sector A1[3]. The evidence of neonate individuals in the fill of the mine could indicate that the animals were kept

close to the mining complex at the time of birth. Moreover, it is possible that a high percentage of neonate mortality may indicate the existence of unsuitable conditions for the breeding and reproduction of these species. It should be noted that it has not been possible to document the cause of death or any specific butchering activity through the qualitative study of marks on different skeletal elements of neonate individuals. The existence of neonates in the fill at Gavà mines is not exceptional: ovicaprine and cattle neonates were documented at Spiennes. Those individuals were equally not interpreted as grave goods (Collet and Van Neer 2002). Regarding neonatal dogs, their use as votive deposits or ritualised activity in burial practices during the Middle Neolithic in the northeast of the Iberian peninsula is documented. In these burials, young and neonate individuals predominate. Dog skeletons were normally deposited partially, without evidence of cut marks and fractures (Albizuri *et al.* 2019).

Finally, the good conditions of preservation of the faunal assemblage have allowed the depositional dynamics to be characterized. The bone surfaces show little or no signs of weathering and limited carnivore activity; these characteristics would indicate only a short period of exposure on the surface (Behrensmeyer 1978; Binford 1981; Lyman 1994). The recovery of almost all skeletal elements of domestic species and a high MNI suggest a process of rapid deposition over time. Furthermore, if we take into account the amount of biomass that each individual can provide, the recovered assemblage is representative of a considerable amount of food, which would have been consumed and deposited continuously. The rapid and continuous deposition of the faunal remains is reinforced by the six dates obtained for the backfill in Mine16, which indicate a short interval between the depositions of the different levels (Tab. 2).

6. CONCLUSION

Mining at Gavà can be interpreted as a specialized activity carried out in combination with other economic activities, such as animal husbandry and agriculture. Most of the archaeological remains recovered in the mines are of a specialized nature: mining tools, culinary and butchery remains, ceramic containers (Villalba 1999). All this suggests that mining specialization (miners and craftspeople) did not replace specialized subsistence production, but rather complemented it.

The faunal remains recovered in the backfill of Mine16 are the result of the processes of food production and consumption by the communities that worked in the Neolithic Mines at Gavà. The faunal assemblage informs us of the existence of different processes:

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[3] *Vide* footnote 1.

butchering, which would include the processing of the animal carcasses, the consumption of the meat and the subsequent disposal of the waste. The degree of selection of animal species, skeletal elements and anatomical parts, and the age of the animals, are all key to determining that the faunal assemblage was the result of a set of intentional anthropogenic events, possibly related to the cleaning and maintenance of the working spaces. In addition, the abundant cut marks on the bone surfaces, the type of bone fracturing, thermal alterations and the skeletal and anatomical representation of domesticated species attest that the animals were processed and consumed at the mining complex. The good level of preservation of the faunal assemblage suggests a rapid and continuous process of deposition.

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SUPPLEMENTARY FILE

In the online version of this paper is available as supplementary file SF1: Elements representation of cattle, pig, ovicaprines and dog for each level of the Mine16 (Gavà, Barcelona).

BIBLIOGRAPHY

Albizuri, S.; Nadal, J.; Martín, P.; Gibaja, J. F.; Cólliga, A. M.; Esteve, X. and Subirà, M. E. 2019: “Dogs in funerary contexts during the Middle Neolithic in the northeastern Iberian Peninsula (5th-early 4th millennium BCE)”. *Journal of Archaeological Science: Reports* 24: 198-207. doi.org/10.1016/j.jasrep.2019.01.004

Amorosi, T. 1989: *A postcranial guide to domestic neo-natal and juvenile mammals: the identification and aging of old world species (No. 533-534).* British Archaeological Reports International Series 1533, Archaeopress. Oxford.

Antipina, E. 2001: “Bone tools and wares from the site of Gorny (1690-1410 BC) in the Kargaly mining complex in the south Ural part of the east european steppe”. In A. M. Choyke and L. Bartosiewicz (eds.): *Crafting bone: skeletal technologies through time and space. Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group (Budapest 1999).* British Archaeological Reports International Series 937, Archaeopress. Oxford: 171-178.

Antipina, E.; Lebedeva, Y. and Chernykh, N. 2002: “Stock-breeding and agriculture in Gorny?”. *Kargaly International Field Symposium-2002. Earliest stages of mining and metallurgy in northern part of Eurasia: Kargaly complex (Kargaly-Orenburg 2002). Proceedings of Symposium:* 27-29. Moscow.

Asmussen, B. 2009: “Intentional or incidental thermal modification? Analysing site occupation via burned bone”. *Journal of Archaeological Science* 36 (2): 528-536. doi: 10.1016/j.jas.2008.10.005

Avido, D. 2012: “Conceptos y métodos para el estudio zooarqueológico de la cocción de los alimentos”. In M. P. Babot (ed.): *Las manos en la masa: arqueologías, antropologías e historias de la alimentación en Suramérica.* Museo de Antropología. Córdoba, Argentina: 553-575.

Barone, R. 1976: “Anatomie comparée des mammifères domestiques”. *Ostéologie* 1: 179-185.

Behrensmeyer, A. K. 1978: “Taphonomic and ecologic information from bone weathering”. *Paleobiology* 4 (2): 150-162. doi: 10.1017/S0094837300005820

Binford, L. R. 1981: “Behavioral archaeology and the ‘Pompeii premise’”. *Journal of Anthropological Research* 37 (3): 195-208.

Binford, L. R. and Bertram, J. B. 1977: “Bone frequencies and attritional processes”. In L. R Binford (ed.): *For theory building in Archaeology: Essays on faunal remains, aquatic resources, spatial analysis, and systemic modeling.* Academic Press. New York: 77-153.

Blasco, A.; Villalba, M. J. and Edo, M. 1998: “Explotación, manufactura, distribución y uso como bien de prestigio de la ‘calaita’ en el Neolítico: el ejemplo del complejo de Can Tintorer”. In G. Delibes (ed.): *Minerales y metales en la prehistoria reciente: algunos testimonios de su explotación y laboreo en la Península Ibérica.* Secretariado de Publicaciones e Intercambio Editorial. Valladolid: 41-70.

Boessneck, J. 1980: “Diferencias osteológicas entre las ovejas (*Ovis aries* Linné) y cabras (*Capra hircus* Linné)”. In D. Brothwell and E. Higgs (eds.): *Ciencia en arqueología.* Fondo de Cultura Económica. México: 338-366.

Borrell, F. and Bosch, J. 2012: “Las minas de Variscita de Gavà (Barcelona) y las redes de circulación en el Neolítico”. Actes. Xarxes al Neolític. Circulació i intercanvi de matèries, productes i idees a la Mediterrània occidental (VII-III mil·lenni aC) (Gavà / Bellaterra, 2011). *Rubricatum: revista del Museu de Gavà* 5: 315-322. https://www.raco.cat/index.php/Rubricatum/article/view/269767 (accessed: 19-6-2020).

Borrell, F.; Bosch, J.; Gibaja, J. F.; Schmidt, P. and Terradas, X. 2019: “The status of imported Barremian-Bedoulian flint in north-eastern Iberia during the Middle Neolithic. Insights from the variscite mines of Gavà (Barcelona)”. *PloS one* 14 (11): 224-238. doi: 10.1371/journal.pone.0224238

Borrell, F.; Bosch, J. and Majó, T. 2015: “Life and death in the Neolithic variscite mines at Gavà (Barcelona, Spain)”. *Antiquity* 89 (343): 72-90. doi: 10.15184/aqy.2014.30

Borrel F. and Orri, E., 2009: “Excavació de les mines neolítiques 83, 84, 85 i 90 de Gavà: estructura, ús, reutilització i rebliment”. *Rubricatum: revista del Museu de Gavà* 4: 15-45.

Bosch, J. 2010: “Representaciones antropomorfas muebles del Neolítico en Cataluña: primeros ídolos oculados”. In C. Cacho, R. Maicas, E. Galán and J. A. Martos (eds.): *Ojos que nunca se cierran, ídolos en las primeras sociedades campesinas.* Museo Arqueológico Nacional. Madrid: 13-38. http://www.man.es/man/dam/jcr:46784216-ae06-476e-bb28-01c51074e185/man-2009-ojos-cierran.pdf

Bosch, J. 2019: “Gavà (Barcelone), mine et atelier au Néolithique”. En G. Querré, S. Cassen and E. Vigier (eds.): *La parure en callaïs du Néolithique européen.* Archaeopress Publishing Limited. Oxford: 43-58.

Bosch, J. 2020: “Venus de Gavà. Señora de la callais (Minas de Gavà, Can Tintorer, Barcelona)”. In P. Bueno Ramírez y J. A. Soler Díaz (eds.): *Ídolos miradas milenarias. Guía catálogo.* Museo Arqueológico Regional, Comunidad de Madrid. Madrid: 56-57.

Bosch, J. and Estrada, A. 1994: “El Neolític postcardial a les mines prehistoriques de Gava (Baix Llobregat)”. *Rubricatum: revista del Museu de Gavà* 0.

Bosch, J. and Estrada, A. 1997: “Las minas neolíticas de Gavá: un intento de explicación ideológica”. In R. de Balbín Berhmann and P. Bueno Ramírez (eds.): *II Congreso de Arqueología Peninsular (Zamora 1996):* 123-128. Zamora.

Bosch, J.; Estrada, A. and Juan-Muns, N. 1999: “L’aprofitament de recursos faunístics aquàtics, marins i litorals, durant el neolític a Gavà (Baix Llobregat)”. *Saguntum-PLAV* extra 2: 77-83.

Bosch, J.; Estrada, A. and Noain, M. J. 1996: “Minería neolítica en Gavá (Baix Llobregat, Barcelona)”. *Trabajos de Prehistoria* 53 (1): 59-71. doi: 10.3989/tp.1996.v53.i1.405

Bostyn, F. and Lanchon, Y. 1995: "The Neolithic flint mine at Jablines, le Haut-Château (Seine et-Marne)". *Archaeologia Polona* 33: 297-310.

Buxó, R.; Cátala, M. and Villalba, M. J. 1991: "Llavors i fruits en un conjunt funerari situât a la galería d'accès a la mina 28 del complex miner de Can Tintorer (Gava)". *Cypsela* IX: 65-72.

Casas, A. and Majó, T. 2009: "Estudi arqueoantropològic de les restes humanes neolítiques de les mines 84 i 90 de Gavà (Baix Llobregat)". In J. Bosch and F. Borrell (eds.): "Intervencions arqueològiques a les Mines de Gavà (sector serra de les Ferreres). Anys 1998-2009. De la variscita al ferro: neolític i antiguitat". *Rubricatum: revista del Museu de Gavà* 4: 209-223.

Clarke, W. G. 1915: *Report on the Excavations at Grime's Graves, Weeting, Norfolk, March-May, 1914*. HK Lewis. London.

Clutton-Brock, J. and Grigson, C. 1984: *Animals and archaeology (Vol. 3)*. British Archaeological Reports International Series 1163, Archaeopress. Oxford.

Collet, H. 2004: "Les mines néolithiques de Spiennes: état des connaissances et perspectives de recherché". *XIVth UISPP Congress, University of Liege (Belgium 2001). Section 9: the Neolithic in the Near East and Europe. Section 10: the Copper Age in the Near East and Europe. General Sessions and Posters*: 129-133. Belgium.

Collet, H. and Van Neer, W. 2002: "Stratigraphie et faune d'un puits d'extraction de silex néolithique à Petit-Spiennes". *Anthropologica et praehistorica* 113: 73-104.

Colominas, L.; Lladó, E.; Saña, M. and Tornero, C. 2008: "La gestió dels recursos animals durant les ocupacions de l'assentament de la caserna de Sant Pau". *Quarhis* 4: 55-61.

Consuegra, S.; Gallego, M. M. and Castañeda, N. 2004: "Minería neolítica de sílex de Casa Montero (Vicálvaro, Madrid)". *Trabajos de Prehistoria* 61 (2): 127-140. doi: 10.3989/tp.2004.v61.i2.47

Delaney-Rivera, C.; Plummer, T. W.; Hodgson, J. A.; Forrest, F.; Hertel, F. and Oliver, J. S. 2009: "Pits and pitfalls: taxonomic variability and patterning in tooth mark dimensions". *Journal of Archaeological Science* 36 (11): 2597-2608. doi: 10.1016/j.jas.2009.08.001

Díaz-del-Río, P.; Consuegra, S.; Capote, M.; Castañeda, N.; Criado, C.; Vicent, J. M.; ... y Terradas, X. 2008: "Estructura, contexto y cronología de la mina de sílex de Casa Montero (Madrid)". In M. S. Hernández Pérez, J. Soler Díaz y J. López Padilla (eds.): *IV Congreso del Neolítico peninsular (Alicante 2006)* I: 200-207. Alicante.

Domínguez-Bella, S. 2004: "Variscite, a prestige mineral in the Neolithic-Aeneolithic Europe. Raw material sources and possible distribution routes". *Slovak Geological Magazine* 10 (1-2): 147-152.

Domínguez-Rodrigo, M. and Barba, R. 2006: "New estimates of tooth mark and percussion mark frequencies at the FLK Zinj site: The carnivore-hominid-carnivore hypothesis falsified". *Journal of Human Evolution* 50 (2): 170-194. doi: 10.1016/j.jhevol.2005.09.005

Domínguez-Rodrigo, M.; De Juana, S.; Galán, A. B. and Rodríguez, M. 2009: "A new protocol to differentiate trampling marks from butchery cut marks". *Journal of Archaeological Science* 36: 2643-2654. doi: 10.1016/j.jas.2009.07.017

Edo, M.; Blasco, A.; Villalba, M. J.; Gimeno, D. and Fernández Turiel, J. L. 1997: "La caracterización de la variscita del complejo minero de Can Tintorer. Una experiencia aplicada al conocimiento del sistema de bienes de prestigio durante el Neolítico". In J. Bernabeu, T. Orozco y X. Terradas (eds.): *Los recursos abióticos en la prehistoria*. Col.lecció Oberta, Sèrie Història 2, Universidad de Valencia. Valencia: 83-109.

Egeland, C. P.; Rayne Pickering, T.; Domínguez-Rodrigo, M. and Brain, C. K. 2004: "Disentangling Early Stone Age palimpsests: Determining the functional independence of hominid- and carnivore- derived portions of archaeofaunas". *Journal of Human Evolution* 47 (5): 343-357. doi: 10.1016/j.jhevol.2004.08.004

Estévez, J. 1986: "Estudi de la fauna". In M. J. Villalba: *Les mines neolítiques de Can Tintorer: Gavà: excavacions 1978-1980*. Excavacions Arqueològiques a Catalunya 6, Departament de Cultura de la Generalitat de Catalunya. Barcelona: 171-184.

Estrada, A. and Nadal, J. 1994: "Les restes malacològiques d'origen marí". In A. J. Bosch and A. Estrada (eds.): El Neolític Postcardial a les Mines Prehistòriques de Gavà (Baix Llobregat). *Rubricatum: revista del Museu de Gavà* 0: 186-189.

Fernández-Jalvo, Y. and Andrews, P. 2016: *Atlas of taphonomic identifications: 1001+ images of fossil and recent mammal bone modification (Vertebrate paleobiology and paleoanthropology)*. Springer. Dordrecht.

Galiberti, A. 2005: *Defensola. Una miniera di selce di 7000 anni fa. Siena*. Protagon Editore. Siena.

Gifford-Gonzalez, D. 1989: "Ethnographic analogues for interpreting modified bones: some cases from East Africa". In R. Bonnichsen and M. Sorg (eds.): *Bone modification*. Institute for Quaternary Studies. Orono, EE. UU.: 179-246.

Gifford-Gonzalez, D. 2008: "Thoughts on a method for zooarchaeological study of daily life". In S. Montón and M. Sánchez (eds.): *Engendering social dynamics: The archaeology of maintenance activities*. British Archaeological Reports International series 1862, Archaeopress. Oxford: 15-23.

Gillis R; Chaix L. and Vigne, J. D. 2011: "An assessment of morphological criteria for discriminating sheep and goat mandibles on a large prehistoric archaeological assemblage (Kerma, Sudan)". *Journal of Archaeological Science* 38 (9): 2324-2339.

Grant, A. 1982: "The use of tooth wear as a guide to the age of domestic animals". In B. Wilson, C. Grigson and S. Payne (eds.): *Ageing and sexing animal bones from archaeological sites. British Archaeological Reports*. International Series 1109, Archaeopress. Oxford: 91-108.

Greenfield, H. J. 2000: "The origins of metallurgy in the central Balkans based on the analysis of cut marks on animal bones". *Environmental Archaeology* 5 (1): 93-106. doi: 10.1179/env.2000.5.1.93

Halstead, P.; Collins, P. and Isaakidou, V. 2002: "Sorting the sheep from the goats: morphological distinctions between the mandibles and mandibular teeth of adult *Ovis* and *Capra*". *Journal of Archaeological Science* 29 (5): 545-553. doi:10.1006/jasc.2001.0777

Ioannidou, E. 2003: "Taphonomy of animal bones: species, sex, age and breed variability of sheep, cattle and pig bone density". *Journal of Archaeological Science* 30 (3): 355-365. doi: 10.1006/jasc.2002.0847

James, E. 2011: *The economic, social and environmental implications of faunal remains from the Bronze Age copper mines at Great Orme, North Wales*. University of Liverpool. Liverpool.

Jans, M. M. E.; Nielsen-Marsh, C. M.; Smith, C. I.; Collins, M. J. and Kars, H. 2004: "Characterisation of microbial attack on archaeological bone". *Journal of Archaeological Science* 31 (1): 87-95. doi: 10.1016/j.jas.2003.07.007

Jones, G. G. 2006: "Tooth eruption and wear observed in live sheep from Butser Hill, the Cotswold Farm Park and five farms in the Pentland Hills, UK". In D. Ruscillo (ed.): *Recent advances in ageing and sexing animal bones. Proceedings of the 9th Icaz Conference, Durham 2002*. Oxbow Books. Oxford: 155-178.

Legge, A. 1992: *Excavations at Grimes Graves, Norfolk, 1927-1976. Fascicule 4, Animals, Environment and the Bronze Age Economy*. British Museum Publications Ltd. London.

Lemoine, X.; Zeder, M. A.; Bishop, K. and Rufolo, S. 2014: "A new system for computing dentition-based age profiles in *Sus scrofa*". *Journal of Archaeological Science* 40: 179-193. doi: 10.1016/j.jas.2014.04.002

Lyman, R. L. 1987: "Archaeofaunas and butchery studies: a taphonomic perspective". *Advances in archaeological method and theory* 10: 249-337. doi: 10.1016/B978-0-12-003110-8.50008-6

Lyman, R. L. 1994: *Vertebrate taphonomy*. Cambridge University Press. Cambridge.

Mengoni-Goñalons, L. M. 1999: *Cazadores de guanacos de la estepa patagónica*. Sociedad Argentina de Antropología, Colección Tesis doctorales. Buenos Aires.

Morales, A. and Antipina, E. 2003: "Srubnaya faunas and beyond: a critical assessment of the archaeozooological information from the east european steppe". In M. Levine, C. Renfrew y K. Boyle (eds.): *Prehistoric steppe adaptation and the horse*. McDonald Institute Monographs 9. Cambridge: 329-351.

Nicholson, R. A. 1993: "A morphological investigation of burnt animal bone and an evaluation of its utility in archaeology". *Journal of Archaeological Science* 20 (4): 411-428. doi: 10.1006/jasc.1993.1025

O'Brien, W. and Brindley, A. L. 2004: *Ross Island: mining, metal and society in early Ireland*. Department of Archaeology, National University of Ireland. Galway.

Oller, J. 1986: "Estudi malacologic". In A. M. J. Villalba, L. Bañolas and M. Alonso (eds.): *Les mines neolítiques de Can Tintorer: Gavà: excavacions 1978-1980*. Departament de Cultura de la Generalitat de Catalunya. Barcelona: 185-187.

Outram, A. K.; Knüsel, C. J.; Knight, S. and Harding, A. F. 2005: "Understanding complex fragmented assemblages of human and animal remains: a fully integrated approach". *Journal of Archaeological Science* 32 (12): 1699-1710. doi: 10.1016/j.jas.2005.05.008

Payne, S. 1985: "Morphological distinctions between the mandibular teeth of young sheep, *Ovis*, and goats, *Capra*". *Journal of Archaeological Science* 12 (2): 139-147.

Payne, S. 1987: "Reference codes for wear states in the mandibular cheek teeth of sheep and goats". *Journal of Archaeological Science* 14 (6): 609-614

Pétrequin, P.; Jeudy, F. and Jeunesse, C. 1993: "Neolithic quarries, the exchange of axes and socialcontrol in the Southern Vosges". In C. Scarre and F. Healy (eds.): *Trade and exchange in Prehistoric Europe*. Oxbow Monograph 33, Oxbow Books. Oxford: 45-60

Prummel, W. and Frisch, H. J. 1986: "A guide for the distinction of species, sex and body size in bones of sheep and goat". *Journal of Archaeological Science* 13: 567-577.
doi: 10.1016/0305-4403(86)90041-5

Reimer, P. J.; Bard, E.; Bayliss, A.; Beck, J. W.; Blackwell, P. G.; Ramsey, C. B.; … and Grootes, P. M. 2013: "IntCal13 andMarine13 radiocarbon age calibration curves 0-50,000 years cal BP". *Radiocarbon* 55 (4): 1869-1887.

Salvagno, L. and Albarella, U. 2017: "A morphometric system to distinguish sheep and goat postcranial bones". *PLOS ONE* 12 (6): e0178543. doi: 10.1371/journal.pone.0178543

Saña, M. 1998: "Arqueozoologia i faunes neolítiques a Catalunya. Problemàtica plantejada entorn a la dinàmica del procés de domesticació animal". *Cypsela* 12: 99-110.

Saña, M. 2013: "Domestication of animals in the Iberian Peninsula". In S. Colledge, J. Conolly, K. Dobney, K. Manning and S. Shennan (eds.): *The origins and spread of domestic animals in southwest Asia and Europe*. Left Coast Press. Walnut Creek, EE. UU.: 195-220.

Saña, M.; Antolín, F.; Zapata, M.; Castells, L.; Craig, O. E.; Benaiges, M. E. and Spiteru, C. 2015: "Prácticas agropecuarias durante el Neolítico antiguo y medio en la cueva de Can Sadurní (Begues, Barcelona)". In V. Gonçalves, M. Diniz and A. C. Sousa (eds.): *5° Congresso do Neolítico Peninsular (Lisboa 2011)*: 57-66. Lisboa.

Saña, M. and Navarrete, V. 2016: "Gestió ramadera al pla de Barcelona durant la prehistòria". In M. Molist and A. Gómez (eds.): *La prehistòria al pla de Barcelona. Nous documents per a una síntesi*. Museu d'Història de Barcelona (MUHBA), Ajuntament de Barcelona. Barcelona: 97-104.

Shipman, P. 1981: *Life history of a fossil: An introduction to Taphonomy and Paleoecology*. Harvard University Press (No. 56.012 SHI). Cambridge.

Silver, I. A. 1969: "The ageing of domestic animals". In R. Brothwell and E. S. Higgs (eds.): *Science in archaeology: A survey of progress and research*. Thames & Hudson. London: 283-302.

Smith, C. I.; Nielsen-Marsh, C. M.; Jans, M. M. E. and Collins, M. J. 2007: "Bone diagenesis in the European Holocene I: Patterns and mechanisms". *Journal of Archaeological Science* 34 (9): 1485-1493. doi: 10.1016/j.jas.2006.11.006

Stiner, M. C. 1991: "The faunal remains from Grotta Guattari: a taphonomic perspective". *Current Anthropology* 32 (2): 103-117.

Stone, J. F. S. 1931: "Easton Down, Winterslow, S. Wilt, Flint Mine Excavation, 1930". *Wiltshire Archaeological Magazine* 45: 365-72.

Symmons, R. 2005: "New density data for unfused and fused sheep bones, and a preliminary discussion on the modelling of taphonomic bias in archaeofaunal age profiles". *Journal of Archaeological Science* 32 (11): 1691-1698. doi: 10.1016/j.jas.2005.05.011

Topping, P. and Lynott, M. J. 2005: *The cultural landscape of prehistoric mines*. Oxbow Books Limited. Oxford.

Van Wijngaarden-Bakker, L. H. 2004: "The animal remains". In W. O'Brien and A. L. Brindley (eds.): *Ross Island: mining, metal and society in early Ireland*. Department of Archaeology, National University of Ireland. Galway: 367-385.

Villa, P. and Mahieu, E. 1991: "Breakage patterns of human long bones". *Journal of Human Evolution* 21 (1): 27-48.
doi: 10.1016/0047-2484(91)90034-S

Villalba, M. J. 1999: "Las sepulturas neolíticas del complejo de Can Tintorer y el modelo social de la población minera". *Revista d'arqueologia de Ponent* 91: 41-73.

Villalba, M. J.; Bañolas, L. and Alonso, M. 1986: *Les mines neolítiques de Can Tintorer: Gavà: excavacions 1978-1980*. Excavacions Arqueològiques a Catalunya, 6, Departament de Cultura de la Generalitat de Catalunya, Barcelona.

Villalba, M. J.; Edo, M.; Gimeno, D. and Fernandez-Turiel, J. L. 1997: "Can Tintorer mining complex, Gavá: The Latest Results". In R. Schild and Z. Sulgostowska (eds.): *Man and Flint*. Institute of Archaeology and Ethnology, Polish Academy of Sciences. Warszawa: 143-147.

Weller, O. and Fíguls, A. 2007: "L'intercanvi com a dinamitzador econòmic del Neolític mitjà a Catalunya i la primera explotació minera de sal gemma d'Europa: la vall Salina de Cardona (Barcelona)". *Cota zero: revista d'arqueologia i ciencia* 22: 101-111.

Yravedra, J. 2006: *Tafonomía aplicada a Zooarqueología*. UNED Ediciones. Madrid.

Zeder, M. A. 2006: "Reconciling rates of long bone fusion and tooth eruption and wear in sheep (*Ovis*) and goat (*Capra*)". In D. Ruscillo (ed.): *Recent advances in ageing and sexing animal bones*. Oxbow. Oxford: 87-118.

Zeder, M. A. and Lapham, H. A. 2010: "Assessing the reliability of criteria used to identify postcranial bones in sheep, *Ovis*, and goats, *Capra*". *Journal of Archaeological Science* 37: 2887-2905.
doi: 10.1016/j.jas.2010.06.032

Zeder, M. A. and Pilaar, S. E. 2010: "Assessing the reliability of criteria used to identify mandibles and mandibular teeth in sheep, *Ovis*, and goats, *Capra*". *Journal of Archaeological Science* 37: 225-242.
doi: 10.1016/j.jas.2009.10.002