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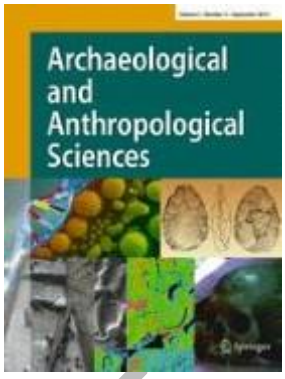
What happened in the highlands? Characterising Pyrenean livestock practices during the transition from the Iron Age to the Roman period



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Abstract

Abundant literature shows that on Western European lowlands, the transition from the Middle Iron Age to the early Roman period involved major changes in livestock practices, with the emergence of specialised and selective animal husbandry. Very little information is available about how the Roman conquest affected mountain livestock practices, despite them being of crucial importance for understanding the integration of mountain regions in the economy of the Roman Empire. To characterise this activity and evaluate its economic importance, we applied a combined archaeozoological and field survey approach to the eastern Pyrenees as a study case. The interrelation of these data was also contextualised with the available palaeoenvironmental record. This interdisciplinary approach allowed us to document an intensive and specialised animal husbandry in the mountains, probably focused on sheep, that would have involved a more intensive use of the highlands and the creation and maintenance of pastoral grasslands. We propose that these changes should be linked to greater pressure on the lowland pastures and an increased demand for wool as a result of the incorporation of eastern Pyrenees into the Roman market economy.

Keywords

Mountain areas ; Animal husbandry ; Roman conquest ; Archaeozoology ; Landscape archaeology

Introduction

Growing interest in the occupation and exploitation of European mountains has shown that human impact has been intense and that these areas constitute true cultural landscapes shaped over time. The pioneering work of Ch. Rendu in the Cerdanya valley and G. Barker in the Apennines in the 1990s; of E. Gassiot in the western Catalan Pyrenees; of Norwegian archaeologists in Scandinavia and that coordinated by Ph. Leveau in the Western Alps (Bjørgo 1986; Barker and Grant 1991; Rendu 2003) constitute the starting point of a research line in Europe that has developed into new projects enriched by the methods and techniques of landscape archaeology (Orengo et al. 2014a, b; Palet et al. 2013, 2014; Walsh et al. 2014; Gassiot et al. 2014; Gassiot 2016; Carrer et al. 2016; Reitmaier et al. 2018) and palaeoenvironmental studies (Galop 1998; Miras et al. 2007, 2010; Ejarque et al. 2009, 2010; Ejarque 2013).

These studies have shown that exploitation of the highlands was multipurpose and diversified. Activities related to mining, metallurgy and pitch production would, in addition stockbreeding, have played an important part in the shaping of mountain landscapes from the Neolithic onwards (Rendu 2003; Walsh et al. 2005; Gassiot and Jiménez 2006; Walsh et al. 2007; Segard 2009; Palet et al. 2010, 2013, 2014, 2016; Ejarque 2013; Orengo et al. 2013, 2014a, b).

The historical use of high mountains as pastures in medieval and modern times has involved that this economic activity had not been studied in depth from an archaeological perspective. Most projects focusing on the study of high-mountain areas look at animal husbandry through the palaeoenvironmental record that offers a long-term view of the activity in terms of its human impact and socio-environmental interactions. Another approach is through ethnographic studies, although the information derived from them is becoming increasingly scarce, due to the rapid disappearance of this economic activity. Therefore, the animals that grazed in these spaces or the products that were exploited, among other aspects, have just been taken for granted.

Taking into account these considerations, our aim with this paper is to shed light on animal husbandry in the highlands, characterising it and evaluating its economic importance as a high-mountain activity. To do this, we present a study that encompasses archaeozoological data and landscape archaeology research which involve field survey documentation of livestock structures. The interrelation of these data is also contextualised in the palaeoenvironmental record to present an integrated study of the evidence currently available on past mountain livestock practices.

In this study, we focus on the period between the fourth century BC and the fourth century AD, which represents the transition from the Iron Age to the Roman period. This is a widely researched period in which several studies show that important changes took place in animal husbandry. There was a shift from a more diversified range of livestock intended for self-sufficiency to a more specialised and selective range, the purpose of which was to supply animal products to consumer populations (Grant 1989; Columeau 1993; Leguilloux 1994; King 1999; Oueslati 2006; Colominas 2017a; Deschler-Erb 2017; Trixl et al. 2017; Pigière 2017). Local improvements to the existing stock (Noddle 1984; Lepetz 1996; Mackinnon 2004; Colominas

2013) and the introduction of breeding animals (Albarella et al. 2008; Gudea 2007; Colominas and Edwards 2017) have also been documented with the Roman conquest.

All these studies, however, refer to animal husbandry practiced on the lowlands. What happened in the highlands? Did the Romans also modify animal husbandry? Few data are available and this information is of crucial importance for understanding how mountain areas were integrated into the economy of the Roman Empire.

We investigate this subject in the eastern Pyrenees as a case of study. More concretely, we focus on the Cerdanya Pyrenean plain and the immediately adjacent high-mountain areas. In this Pyrenean zone, animal husbandry has fulfilled first-order roles (social, economic, environmental and spatial planning), leaving a strong cultural stamp on the population and the territories up to the present day. At the same time, the Cerdanya plain is connected to the highlands by historic animal tracks that show the land use of this area as livestock pastures since at least the medieval period (Miralles and Tutusaus 2005). The area also stands out for the presence of the Roman colony of Iulia Libica (Llívia), the urban and economic centre of this Pyrenean region in antiquity.

Therefore, with this paper, for the first time, we characterise livestock practices in the Pyrenean mountains during the Iron Age and the Roman period, providing invaluable knowledge on the integration of high-mountain areas into the study of the economy of the Roman Empire.

Materials and methods

The materials described here are from the Cerdanya Pyrenean plain and the immediately adjacent high-mountain areas: the Madriu, Perafita and Claror valleys in Andorra, the Cadí mountain range and the Núria, Coma de Vaca valleys in El Ripollès (Fig. 1, Table 1). This region is located on the Spanish-French border, immediately south of the Catalan Pyrenees Regional Natural Park in France. High-mountain areas have been studied in depth by the Landscape Archaeology Research Group (GIAP-ICAC) since 2004 (Ejarque et al. 2009, 2010; Ejarque 2013; Orengo et al. 2013, 2014a, b; Palet et al. 2013, 2014, 2016, 2017). Sites on the Cerdanya plain have been studied by the Autonomous University of Barcelona under the direction of O. Olesti (Morera et al. 2011; Guàrdia et al. 2017; Morera 2017; Olesti and Mercadal 2017).

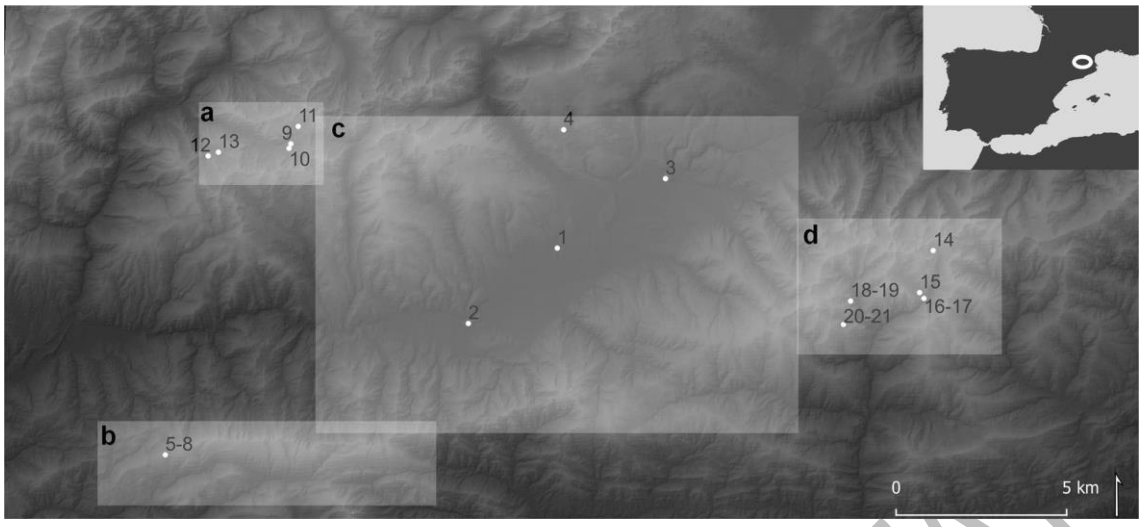

Figure 1. Location of the sites cited in the text. (a) Madriu-Perafita-Claror valley; (b) Cadí mountain range; (c) Cerdanya plain; (d) Núria-Coma de Vaca valley. See Table 1 for complementary information

Table 1. Archaeological information of the sites cited in the text. Altitude is in metres. See Fig. 1 for complementary information

Site name	No. of map	No. of structure	Chronology	Site type	Area	Altitude
Bolvir	1		Fourth c. BC–end first c. BC.	Village	Cerdanya plain	1140
Baltarga	2		Fourth c. BC–end first c. BC.	Village	Cerdanya plain	1158
Llívia	3		End first c. BC–third c. AD	Municipium	Cerdanya plain	1224
Orri d'en Corbill	4	92–83	Fourth–second c. BC/first c. AD	Shepherd hut and palaeo soil	Cerdanya plain	1900
El Goleró	5	42	First–second c. AD	Reduction kiln	Cadí mountain range	2030
El Goleró	6	2	Third–fourth c. AD	Livestock enclosure	Cadí mountain range	2020
El Goleró	7	46	Seventh c. BC	Livestock enclosure	Cadí mountain range	2020
El Goleró	8	16	Second–first c. BC	Livestock enclosure	Cadí mountain range	2020
Riu dels Orris I	18	M086	First c. AD	Livestock enclosure	Madriu-Perafita-Claror valley	2390
Basses de Setut III	10	M135	First c. AD	Livestock enclosure	Madriu-Perafita-Claror valley	2313
Pleta de les Bacives I	11	M152	Fifth c. AD	Shepherd hut	Madriu-Perafita-Claror valley	2517
Pleta de Claror I	12	P082	Middle of the fourth c. AD	Milking corridor	Madriu-Perafita-Claror valley	2250
Planells de Perafita I	13	P072	Middle of the third c. AD	Shepherd hut	Madriu-Perafita-Claror valley	2217
Aigols Podrits II	9	346	Second–first c. BC	Shepherd hut	Núria-Coma de Vaca valley	2470
Coma de Vaca I	14	114	End first c. AD–second c. AD	Shepherd hut	Núria-Coma de Vaca valley	2112
Jaça del Mig	17	191	Third–fourth c. AD	Shepherd hut	Núria-Coma de Vaca valley	2080
Jaça del Mig	21	190	Sixth–seventh c. AD	Livestock enclosure	Núria-Coma de Vaca valley	2080
Coma de Gombrén	19	307	Second–third c. AD	Livestock enclosure	Núria-Coma de Vaca valley	2150
Coma de Gombrén	20	430	Third–fourth c. AD	Shepherd hut	Núria-Coma de Vaca valley	2150
Fontalba V	15	332	First–third c. AD	Livestock enclosure	Núria-Coma de Vaca valley	2130
Fontalba V	16	333	Fourth–sixth c. AD	Shepherd hut	Núria-Coma de Vaca valley	2100

Archaeozoological material

The archaeozoological data available from the Iron Age come from the Bolvir and Baltarga sites (Colominas 2017b) on the Cerdanya plain (Table 1). They are the only two sites to have been extensively excavated to date in the area. Bolvir is an oppidum on a 1114-m-high promontory where domestic, productive and storage activities were carried out (Morera et al. 2011). Ten kilometres to the south and at a height of 1158 m is Baltarga, a small village at a strategic territorial control point (Morera 2017). Both of these sites were occupied from the fourth c. BC to the end of the first c. BC.

The archaeozoological data available from the Roman period also come from two sites: Llívia (Colominas 2017b) and El Goleró (in this paper) (Table 1). Llívia is on the Cerdanya Pyrenean plain at 1224 m. It is the only Roman municipium known to date in the eastern Pyrenees. It was built at the end of the first c. BC and occupied until the third c. AD (Guàrdia et al. 2017). El Goleró is at an altitude of 2030 m in the Cadí mountain range. The Roman phase of the site is related to mining and metallurgical activities (Palet et al. 2013, 2014). Faunal remains were recovered from two structures: structure 42 that corresponds to an iron ore reduction kiln from the first–second c. AD and structure 02 corresponding to palaeo-soil that could be linked to an enclosure and is dated to between the third and fourth c. AD (Palet et al. 2013, 2014).

The preservation of faunal remains in mountain environments is generally very poor (Antolín et al. 2018; Bréhard and Campmajó 2005) and explains the low samples presented here. However, they are the only well-dated mountain sites with faunal assemblages of the area.

All the samples are the remains of meat consumption. Despite the small number of remains that compose some of them, they are representative of the whole assemblage. The archaeozoological analysis focused on the study of taxonomic representation frequencies and age-at-death estimations for the main domestic animals (Ovis aries, Capra hircus, Sus domesticus and Bos taurus). The osteological reference collection from the Catalan Institute of Classical Archaeology was used for identification. Sheep and goat differentiation was carried out following Boessneck (1969), Payne (1985) and Prummel and Frisch (1986). Equid remains were studied following Peters (1998) and Armitage and Chapman (1979). The taxonomic variability was based on the relative frequency (NISP) and the minimum number of individuals (MNI). Age-at-death was recorded on the basis of fusion of the eruption and wear of mandibular teeth. For cattle and pigs, the tooth wear stages followed Grant (1982), and these were grouped into the age stages suggested by O'Connor (1988). For caprines, both tooth wear stage and age stages followed Payne (1973). Kill-off pattern interpretation followed the works of Tresset (1996), Payne (1973), Helmer (2000) and Oueslati (2006).

Landscape survey data: intensive survey and test pit digging

A large number of total coverage surveys in the three high-mountain areas have been carried out since 2004 as part of a landscape research programme funded by the ICAC, the Andorran

government and the Spanish Ministry of Science, Innovation and Universities (HAR2015-64636-P, HAR2012-39087-C02-02 and CGL2009-12676-C02).

Geographic Information System (GIS) software was used to incorporate high-resolution orthophotographs (0.25 m/pixel), 1:5.000 digital maps, 1:25.000 vegetation maps, 1:25.000 digital geomorphological maps and a 5 m/cell digital terrain model of the study area. These data were used in an initial assessment of the study areas using photointerpretation procedures (Orengo 2010). In a second stage, field walking allowed the verification of these structures and the incorporation of new ones. Field walking was also useful in assessing preservation issues and the typological diversity of the structures. These criteria were essential in selecting those structures suitable for test pit digging. The information collected during photointerpretation and field walking was incorporated in several vector layers linked to a database where the georeferenced plans of the structures and information related to typology, construction techniques, surface material and geographical setting could be queried.

Structures of different chronologies and typologies related to livestock activities, mining, metallurgy and the exploitation of forest resources were recorded. Sites linked to livestock practices were made up of dry stone enclosures and huts of varying complexity. In some cases, they were characterised by the simple association of an enclosure and a small shepherd's hut, but in other cases, sites were more complex, with the presence of different enclosures and huts of various sizes, sometimes associated with structures such as milking corridors, caves or storage structures.

The most representative structures in terms of typology and preservation were selected for archaeological excavation. In this selection, it was also taken into account that the geographical distribution of the structures selected for test pit digging covered the entire study area and that they were statistically representative. The archaeological trenches covered an area of at least 2 m2. Their purpose was to record the typology of the excavated structure, to recover information relating to the human use of the landscape and to obtain suitable samples for radiocarbon dating. The excavations followed the standard stratigraphic excavation procedures (Palet et al. 2013, 2014). In addition to the standard recording of all materials, the recording methodology included the sieving of all the sediment from the occupation levels. From each excavated unit, a minimum of 4 L of sediment was preserved for environmental sampling. Some natural soils located close to the archaeological structures were also excavated in order to correlate the natural sedimentation with that documented inside the structures.

In these environments, the presence of faunal remains is very scarce. In the high mountain studied areas, just one site, el Goleró (Cadi Range), has provided bones from the Roman period. The sieving of all sediments from the occupation levels has produced mainly charcoal remains, and to a lesser extent, artefacts and small fragments of bones from different periods. Therefore, for most of the sites where landscape survey has been done, livestock activities were deduced from the structures typology.

Results

Archaeozoological data

The majority of the species recovered at the sites during the whole sequence under study were domestic animals (Table 2). Wild mammals only represented 2.01% and 1.28% of the total NISP during the fourth–third c. BC and the second–first c. BC respectively; they were rarely present during the first–third c. AD (1.28% of the total NISP) and totally absent from the third–fourth c. AD assemblage. Among the domesticates, Ovis aries, Capra hircus, Sus domesticus and Bos taurus were the main species represented (Table 2). The relative frequencies for these four main species show fluctuations over time. During the fourth–third c. BC, cattle remains predominate (43%), followed by those of caprines (34%) and pigs (16%). No substantial changes are documented during the second–first c. BC: cattle remain the most frequent (50%), followed by caprines (27%) and pigs (18%). A clear change in comparison with the previous periods is documented during the first–third c. AD. Sheep and goats predominate (40%), followed by pigs (26%) and cattle (21%). All the identified faunal remains are from sheep and goats in Goleró structure 02 (third–fourth c. AD).

Table 2. Presence of mammal taxa, birds, fish and marine shells in the different sites under study

TAXA	Fourth–third c. BC	Second–first c. BC		First–third c. AD		Third–fourth c. AD
	Bolvir	Bolvir	Baltarga	Llívia	Goleró 42	Goleró 02
Sheep/goat (Ovis/Capra)	100	36	70	172	16	46
Pig (*Sus domesticus*)	48	10	60	118	0	0
Cattle (*Bos taurus*)	125	73	120	95	1	0
Equid (*Equus* sp.)	19	4	7	48	0	0
Dog (*Canis familiaris*)	0	4	3	12	0	0
Rabbit (*Oryctolagus cuniculus*)	3	1	2	1	0	0
Red deer (*Cervus elaphus*)	1	1	0	1	0	0
Birds	1	0	1	4	0	0
Fish	1	0	0	0	0	0
Marine shells	0	0	0	24	0	0
NISP	298	129	263	475	17	46
NR	450	176	475	699	32	92

If we focus only on sheep and goat remains, there is a slight predominance of goat during the fourth–third c. BC (11% of the caprine remains are identified as goat and 8% as sheep). No substantial changes are documented during the second–first c. BC (32% of the caprine remains are identified as goat and 22% as sheep). This predominance of goat decreases drastically during the first–third c. AD at Llívia, with a clear prevalence of sheep remains (24% of sheep

remains and 12% of goat). This predominance is also observed in the structure 42 from El Goleró, in which only sheep were documented (19% of the caprine remains). A similar presence of both species is documented in structure 02 at El Goleró, although of the 46 identified remains, we have only been able to identify 3 as sheep and 5 as goat, due to their fragmentation and poor preservation.

The kill-off patterns also vary over time (Fig. 2). Those from the fourth–third c. BC show a clear predominance of sheep slaughtered before maturity (between 6 and 12 months) and at adult 1 stage age (2–4 years), with a lower proportion of sheep slaughtered between 12 and 24 months. In contrast, goats were predominantly slaughtered at adult ages (between 48 and 72 months), although we document some sacrifices prior to those ages. Pigs show a specific pattern, being predominantly slaughtered at sub-adult ages (between 14 and 21 months). Cattle kill-off patterns present different results, in which most were slaughtered between their fifth and eighth year or even older.

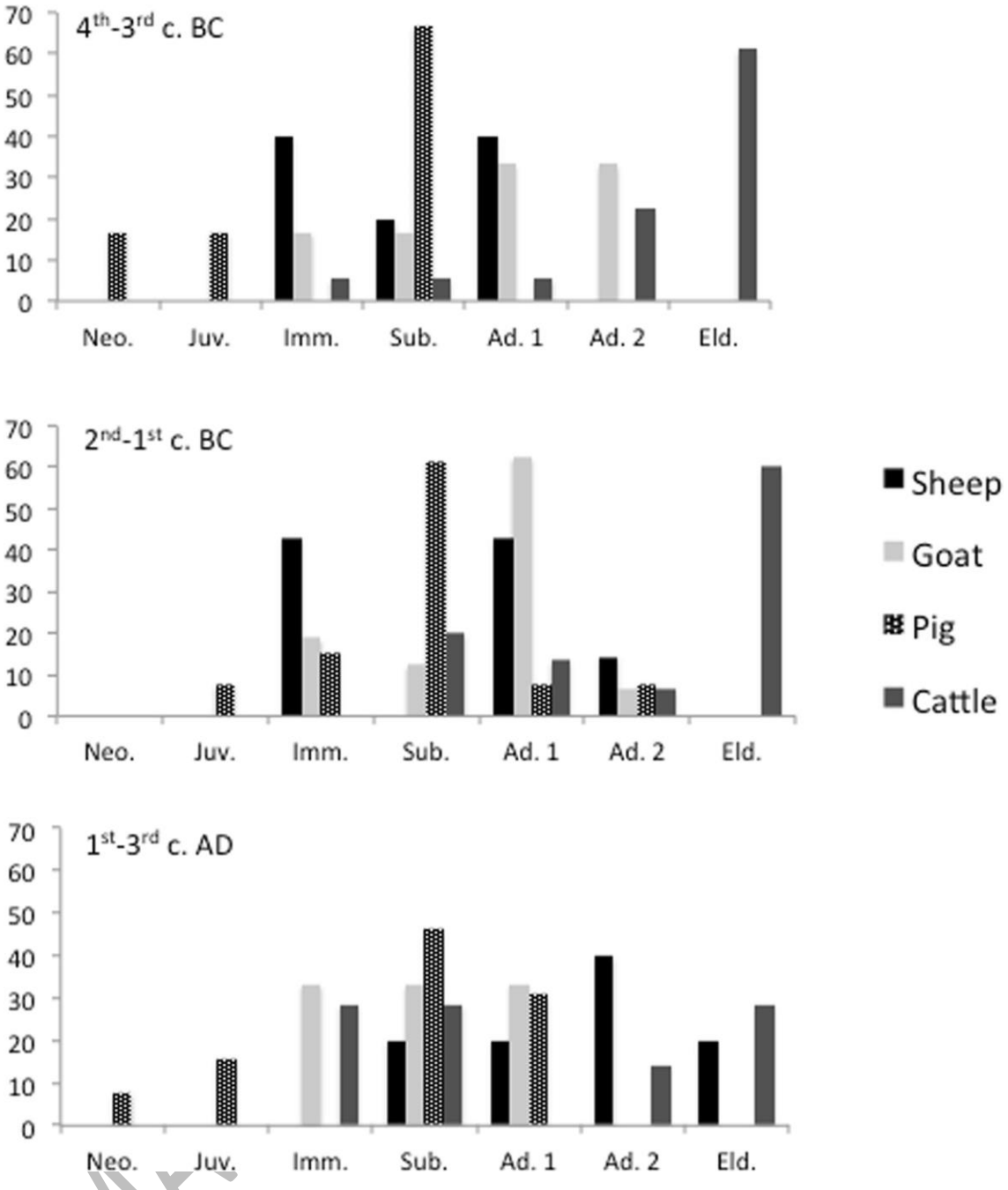

Figure 2. Relative percentages of mandibles by age stage and periods for sheep and goat (neo., 0–2 months; juv., 2–6 months; imm., 6–12 months; sub., 12–24 months; ad.1, 24–48 months; ad.2, 48–72 months; eld., + 72 months); pig (neo., 0–2 months; juv., 2–7 months; imm., 7–14 months; sub., 14–27 months; ad.1, 27–36 months; ad.2, 36–48 months; eld., + 48 months) and cattle (neo., 0–1 months; juv., 1–8 months; imm., 8–18 months; sub., 18–30 months; ad.1, 30–36 months, ad.2, 36–60 months; eld., + 60 months) where neo., neonatal; juv., juvenile; imm., immature; sub., sub-adult; ad.1, adult 1; ad.2, adult 2; eld., elderly

Some changes are documented during the second–first c. BC (Fig. 2). Although most sheep continued to be slaughtered at immature ages (6–12 months), a large proportion was also slaughtered as adults (between 24 and 36 months) and up to 72 months. In contrast, goats were clearly slaughtered at adult ages (between 24 and 48 months old), although some individuals slaughtered around the optimum age for meat consumption (immature and sub-

adult categories) are also documented. Pig kill-off patterns are similar to the previous period, with a minor presence of slaughtering at adult ages. Cattle kill-off patterns also show similar results to the previous period, with an increase in slaughtering at sub-adult ages.

A clear change in the kill-off patterns of the main domestic animals is also observed during the first–third c. AD (Fig. 2). Most sheep were slaughtered at adult and elderly ages (between their fourth and eighth years) and no individuals slaughtered at immature ages are documented. In contrast, goats were mainly slaughtered at immature and sub-adult ages (between 6 and 24 months). Only few individuals were slaughtered later and no older individuals are documented. Pig age-at-death shows a similar pattern, with an increase in slaughtering as adults. We have also documented the presence of neonatal pigs. The analysis of cattle kill-off patterns show that they were slaughtered at a relatively young age during that period, as the peak in age-at-death occurred at immature and sub-adult ages (during the first and second years of life), although elderly specimens are also present (60–96 months old). All the sheep remains in the El Goleró assemblage of structure 02 (third–fourth c. AD) are from adult individuals, whereas two immature individuals and two adult individuals aged 2–4 represent goats.

Archaeological data

A total of 990 structures of different chronologies and typologies related to livestock activities, mining, metallurgy and the exploitation of forest resources were recorded. Of these structures, 105 were subjected to test pit digging and 130 AMS radiocarbon dates were obtained in archaeological sequences. The chronological model obtained from radiocarbon dates indicates the first evidence of early Neolithic grazing activities in the Madriu-Perafita-Claror valleys and from the end of the Middle Neolithic in the upper Ter and Cadí mountain range.

The evidence linked to livestock practices for the Iron Age is found in the Cadí mountain range (El Goleró site) and the Núria-Coma de Vaca valleys (the Aigols Podrits II site) (Table 1, Fig. 1). Two large 30-m-diameter livestock enclosures (structure 46) were attested at El Goleró and dated to the 8th–6th and second–first c. BC. A set of 9 circular enclosures (structure 16) were also documented in the same area. They had a circular or ovoid shape and were delimited by a slope of compacted earth, with diameters ranging between 10 and 30 m (Palet et al. 2010, 2013). In the Núria-Coma de Vaca area, a quadrangular shepherd's hut, characterised by a dry stone basement and a posthole in the interior to support the roof, was excavated. The occupation levels yielded a long iron nail, cookware and Iberian pottery, consistent with their radiocarbon dating in the second–first c. BC (Palet et al. 2017).

Another punctual occupation was attested at the Orri d'en Corbill site (France) at 1900 a.s.l. in the Enveig mountains, in the northern sector of the Cerdanya plain. It is characterised by an occupation level with a hearth dated to the fourth–second c. BC (Rendu 2003).

On the other hand, several structures linked to livestock practices were documented for the Roman period (Table 1, Fig. 1).

In the Madriu-Perafita-Claror valleys, the research attested the importance and intensity of pastoral activities reflected in the presence of several livestock structures. A group of three small, oval livestock enclosures dated to the first c. AD was found in the Basses de Setut III site, in the Madriu valley. They were at 2313 m a.s.l. on a moraine ridge overlooking an area of small ponds and peatbogs. In this same valley, a livestock enclosure was found at Riu dels Orris I at 2390 m a.s.l. dated at the first c. AD. In addition, a shepherd's hut was found at the Pleta de les Bacives I site in a glacial basin forming an enclosed area at 2517 m a.s.l. The structure was small and oblong shaped; the occupation layer was excavated on the ground and the abandonment level was radiocarbon dated to the fifth c. AD. In the Perafita valley (Pleta de Claror I site), a milking corridor at 2250 m a.s.l. was radiocarbon dated to the middle of the fourth c. AD (Fig. 3). This structure, about 50 m long, was the most sedimented corridor in the study area. It was constructively linked to a shepherd's hut and an enclosure, both of small size. These structures formed an "orri" and delimit a fenced area against the slope. The test pit digging was located at the north end of the structure, at the point where it was in contact with the shepherd's hut. The excavation allowed us to prove the Roman origin of the whole complex. It is the oldest milking structure documented to date in the eastern Pyrenees. In addition, a shepherd's hut was also documented at the Planells de Perafita I site and dated to the middle of the third c. AD (Orengo 2010; Palet et al. 2013, 2015).

Figure 3. Plan of the milking corridor P082 at Pleta de Claror I site (Madriu-Perafita Claror valley) (@ Hèctor A. Orengo). See Fig. 1 and Table 1 for complementary information

Livestock activities were also attested on the western side of the Cadí range at around 2030 m a.s.l. in El Goleró. At this site, the archaeological excavation of structure 02 attested a palaeo-soil pre-dating the dry stone structure, and probably linked to an enclosure dated between the third and the fourth c. AD (Palet et al. 2013, 2014).

The Núria-Coma de Vaca valleys show an intensive livestock occupation from the first c. AD to late Roman and Visigoth period (seventh c. AD). Especially noteworthy is a dry stone shepherd's hut at the Coma de Vaca I site at 2112 m a.s.l. and dated by pottery between the end of the first c. and the second c. AD (terra sigillata, African cooking ware). The structure defines a rectangular area of about 20 m2 and it is slightly overexcavated (Fig. 4). On the Puigmal Massif, at the Coma de Gombrén site (2150 m a.s.l.), a shepherd's hut and a large livestock enclosure were dated at the second–third c. AD. In this same massif, at the Fontalba

V site (2100 m a.s.l.), a livestock enclosure (structure 332) also yielded abundant Roman pottery (terra sigillata, African cooking ware). The intensity of pastoral activities in late antiquity is also remarkable. Several remains have been attested at two relevant sites from this period, Fontalba (2100 m a.s.l.) and Jaça del Mig (2080 m a.s.l.). Both sites consist of a set of huts and livestock enclosures occupied in different phases between the fourth and the seventh c. AD (Fig. 5).

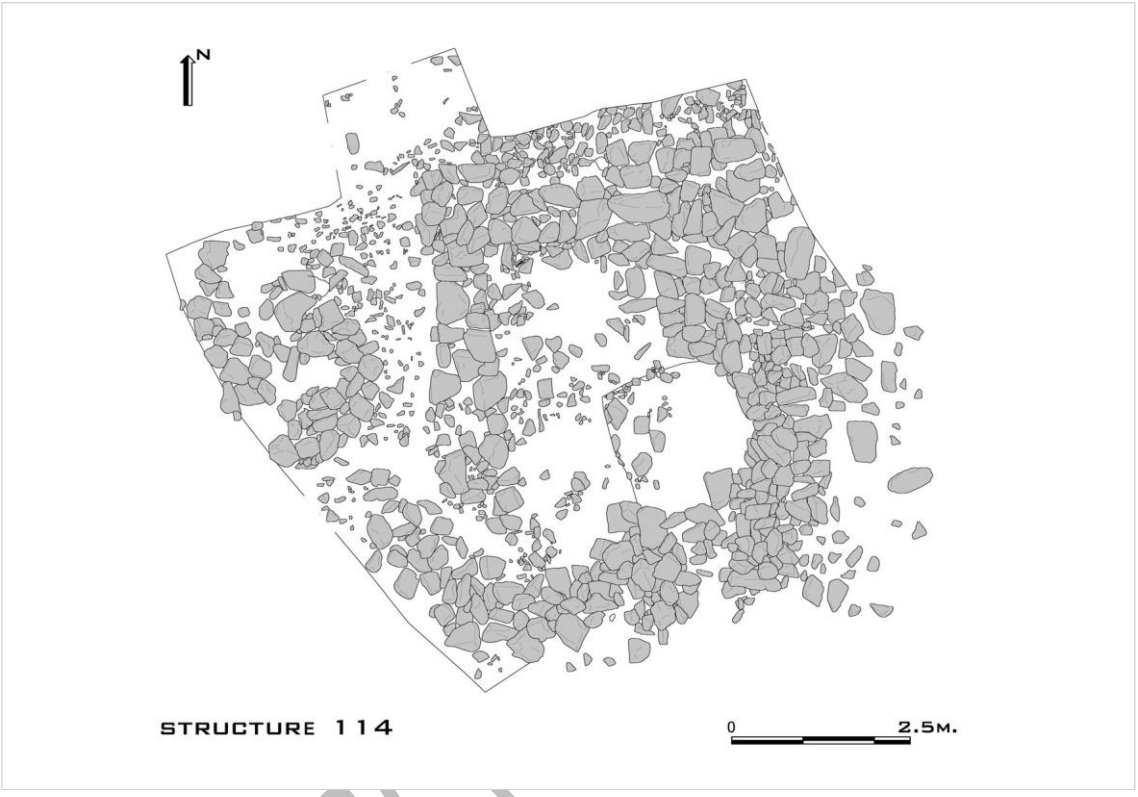

Figure 4. Plan of shepherd's hut 114 at Coma de Vaca I site (Núria-Coma de Vaca valley). See Fig. 1 and Table 1 for complementary information

Figure 5. Plan of livestock structures (enclosure 190 and hut 191) at Jaça del Mig site (Núria-Coma de Vaca valley). See Fig. 1 and Table 1 for complementary information

Discussion

With the aim of characterising and evaluating the economic importance of animal husbandry in the eastern Pyrenees from the Iron Age to the Roman period, in this section, we integrate and interpret the archaeozoological data and highland field survey information linked to livestock structures presented before. We contextualise and discuss them in relation to the available palaeoenvironmental record.

Archaeozoological data (NISP and kill-off patterns) show an animal husbandry focusing on cattle, which were mainly used for milking and possible traction during the Middle and Late Iron Age. Regarding this last point, several evidence from the Cerdanya plain such as the documentation of silo fields and barley and wheat seeds, suggest the existence of a remarkable agricultural production in this area (Olesti 2014). Cattle husbandry was complemented by that of goats, which were primarily used to obtain milk. In contrast, sheep and pigs were mainly for meat production. We must take into account that goat is traditionally considered the animal that produces the most quantity of milk in proportion to its weight: a goat of 30 kg can give 300 to 400 L of milk a year, 12 to 13 times its weight, whereas a cow produces only 5 to 6 times (Lavin et al. 1993). Therefore, we document a diversified animal husbandry, but with specific strategies for each domestic animal during that period in the settlements presented here.

During the early Roman period, sheep became the most common animals and were primarily bred for wool, as well as breeding animals. At the same time, cattle and goats were mainly used for meat. An increase in the economic importance of pigs focusing on meat production is also documented during that period at Llívia.

These changes, both in the relative frequency of the main domestic animals and in the kill-off patterns, suggest a clear change in the animal husbandry strategies of the communities living on the Cerdanya plain and in the surrounding mountains from the Roman period.

This change in livestock strategies in the early Roman period, focusing on sheep breeding, could have triggered the changes that are also observed in the absence/presence of livestock structures. Whereas few structures are documented from the Iron Age in the highlands, thirteen structures linked to animal husbandry are attested for the Roman period. These structures include shepherd's huts (Pleta de les Bacives I, Planells de Perafita I, Coma de Vaca I, Coma de Gombrén and Jaça del Mig), livestock enclosures (Basses de Setut III, Riu dels Orris I, structure 02 in Cadí mountain range, Fontalba V, Coma de Gombrén), a milking corridor (Perafita valley) and more complex sites made up of huts and enclosures (Fontalba V and Jaça del Mig).

The relative absence of Iron Age structures across our study zone is also attested in other areas of the Pyrenees (Gassiot 2016). This hiatus probably does not mean the abandonment of human activities in the highlands, but rather a change in settlement and socio-economic patterns. In relation to livestock practices, it could be showing not only a reduction in activity at high altitudes during that period and an increase from the Roman period onwards but also a change in animal husbandry strategies that needed different and/or more permanent stone structures than before. In that respect, it is worth highlighting the milking structure of the Madriu-Perafita-Claror valley, as it shows the recurrent exploitation of sheep and goats to obtain milk for producing cheese during the Roman period in that valley. It was thought that these structures were from the medieval period (ninth–tenth c. AD), which their continuous use has been documented in these valleys until modern times. The profusion of pottery (specifically terra sigillata) found in some of the huts (Coma de Vaca I and Fontalba V sites) also suggests a trading activity in these high-mountain environments that would have brought those areas within the Roman trade networks (Palet et al. 2016). The situation of the shepherd's hut at the Coma de Vaca I site, on the edge of a path that crosses this sector of the Pyrenees from east to west, also supports this hypothesis, as it could have served as a rest stop or control point on the trade routes (Palet et al. 2014, 2016).

Therefore, the archaeozoological and highland field survey data suggest not only a change in livestock practices but also an increase in the activity and complexity of the livestock practices undertaken there from the Roman period onwards. The palaeoecological evidence from the area supports this interpretation.

There are four palynological sequences availabe for the Madriu-Perafita-Claror valley (Miras et al. 2007; Ejarque et al. 2010), one palynological sequence available for the Cadí range (Ejarque et al. 2009) and two palynological sequences availabe for the Cerdanya plain (Galop 1998, 2005). They suggest a continuity of the pastoral activities established between the Bronze and Iron Ages and changes in land use in the highlands from the Roman period onwards. These

changes can be linked to a general process of forest clearance affecting the upper areas as a result of increasing anthropic pressure.

Specifically, the palynological data available from the surrounding mountains of the Cerdanya plain show an increase in the frequency of plants indicative of human activity and an increase in carbonised particles between the first c. BC and the fifth c. AD as a result of the expansion of agriculture and livestock practices during that period (Galop 1998, 2005). In the Madriu-Perafita-Claror valley, more significant grazing pressure is documented from the first to the fifth c. AD at the highest altitudes. The data reflect a general woodland regeneration in the valley during the Iron Age in comparison with the Bronze Age and a local presence of livestock and grassland expansion during the Roman phase (Miras et al. 2007; Ejarque et al. 2010). The data recorded in the Cadí range suggest the prevalence of relatively open pine woodland in the subalpine belt, at the same time as they show the existence of grazing activities (Ejarque et al. 2009). Therefore, there was relatively open woodland from 525 to 850 AD in that area, which was only moderately affected by the farming, grazing and mining activities that can be traced back to Roman times.

Thus, the interrelationship of the archaeozoological and livestock structure data and their contextualisation in the palaeoenvironmental record suggest a more intensive and specialised animal husbandry focusing on sheep. This would imply a more intensive use of the highlands with the reinforcement or construction of livestock structures and the creation and maintenance of pastoral grasslands from the Roman period.

These results are highly relevant as they show the economic importance of animal husbandry in the eastern Pyrenees during a period in which landscape archaeology studies show that activities related to mining, metallurgy or pitch would have had a greater weight in these high areas than in previous periods (Galop 2005; Palet et al. 2010, 2013, 2014, 2016; Orengo et al. 2013, 2014a, b; Ejarque 2013). Here we have demonstrated that animal husbandry would also have played a fundamental role.

We propose that this role should be related to lowland livestock practices and, therefore, to the incorporation of the mountain areas into the Roman economy. Before Roman conquest, animal husbandry in the eastern Pyrenees was focused on cattle. On the contrary, livestock practices in the eastern lowlands were focused on sheep, as the representation of this animal reaches 50% of the spectrum in most of the sites (Colominas et al. 2011; Colominas 2013). It has been proposed that these differences would be linked with environmental conditions. The northern areas of the peninsula would provide favourable conditions for the proliferation of pastures, suitable for cattle herds, in contrast to the Mediterranean strip, with an arid environment (Blasco 1999). But after the Roman conquest (and with the data available until now), sheep also predominate in the highlands. At the same time, a similar specialised and selective animal husbandry with the same orientation in the exploitation of domestic animals in the eastern Pyrenees and in the northeast Iberian lowlands is observed for the first time (Colominas et al. 2019).

Therefore, the changes documented in highland livestock practices could have been caused by changes in lowland livestock practices. The intensification of lowland agriculture (Burch et al. 2010; Nolla et al. 2010) and the specialised and selective animal husbandry could have

resulted in greater pressure on the existing pasture lands and in the necessity to integrate for the first time the Pyrenean areas into the lowland livestock management.

Conclusions

This paper presents the first account of Roman livestock practices in high-mountain areas. The integration of archaeozoological and archaeological data and their contextualisation in the available palaeoenvironmental record has allowed providing a first trend about the characterisation of this practice and the evaluation of its economic importance.

We have documented intensive and specialised animal husbandry in the highlands that would imply a more intensive use of the mountain areas and the creation and maintenance of pastoral grasslands beginning in the Roman period. We propose that these changes can be linked to the integration of mountain areas into the lowland livestock practices and, therefore, into the Roman economy. The eastern Pyrenees would have been transformed from an area with a predominantly local economy during the Iron Age to one that was fully integrated for the first time into the global market economy of the Roman Empire. The Pyrenean communities would have participated through the exploitation and trade of pitch, wood or minerals (Leveau and Palet 2010; Orengo et al. 2013; Olesti 2014), as well as the different products obtained from livestock, such as wool, milk to produce cheese and meat. In this respect, the studied valleys were well connected through an old Pyrenean road network linking Gallia Narbonense to Hispania Tarraconense. In the middle of these valleys is the Cerdanya plain, where the Roman town of Iulia Libica would have made it the focal point of an important road network connecting with the surrounding mountains.

This study case has shown that interdisciplinarity is a very effective, even indispensable tool for studying livestock farming in mountain areas, where preserved archaeological remains are scarce and studying this subject through a single discipline is very difficult. However, further research is needed. As a first consideration, an interesting aspect would be to include all the information from ethnographic studies in a study of shepherd's huts and enclosures. Secondly, it would be of prime interest to have more archaeozoological samples to properly contrast the data presented here. We hope that future excavations will provide sufficiently well-preserved samples to allow this.

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