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Caprine mortality profiles from prehistoric cave-sites of the northern Adriatic: Livestock strategies or natural death?

Francesco Boschin 

Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente, Università degli Studi di Siena, Siena, Italy

Correspondence

Francesco Boschin, Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente, Università degli Studi di Siena, Via Laterina 8, 53100 Siena, Italy.
Email: fboschin@hotmail.com

Abstract

This paper poses a question on the interpretation of caprine “kill-off patterns” in some prehistoric sites of the *Caput Adriae* (northern Adriatic region, Mediterranean area). In particular, caprine kill-off data from layers 2 (Late Neolithic-Copper Age) and 2a (Middle Neolithic) of Grotta dell'Edera (Trieste Karst, north-eastern Italy) are presented here and compared with those from two neighbouring sites. Distribution of age classes of domestic animals (in particular Caprinae) is generally discussed in terms of exploitation strategies adopted by past communities to obtain different products (e.g., milk, meat, and wool). Nevertheless, emphasis is rarely given to the possible meaning of the presence of foetal individuals and to their relation with neonatal ones. In this sense, it needs to be considered that causes of abortion (e.g., infections or ewe malnutrition) often can also lead to lamb mortality. The presence of a high proportion of neonatal (0–2 months old) and foetal sheep/goat individuals in the sites analysed raises an issue about the possible meaning of the mortality profiles: exploitation of dairy products or just premature death of ill individuals? This issue is important not only to better interpret subsistence strategies of past human communities but also to explore animal disease through time.

KEYWORDS

animal stabling, Adriatic, kill-off patterns, mortality of perinatal caprines, Neolithic

1 | INTRODUCTION

The analysis of mortality profiles is a powerful tool for zooarchaeologists to infer about animal management in the past. Methods based on dental eruption and wear and on epiphyseal fusion assessment have been the most widely used over the years to establish the age at death of individuals whose remains were found in archaeological sites. The literature is largely focused on the collection of reference materials, starting from the earliest methodological work (e.g., Habermehl, 1975, 1986; Silver, 1969) and going on with more accurate techniques, developed in the field of zooarchaeology and palaeobiology, for recording tooth ontogeny, eruption, and wear (e.g., Payne, 1973, 1987; Coy, Jones, & Turner, 1982; Grant, 1982; Mariezkurrena, 1983; Tomé & Vigne, 2003;

Carter, 2006; Greenfield & Arnold, 2008) as well as for measuring bone development (Bridault et al., 2000; Bull & Payne, 1982; Bullock & Rackham, 1982; Dammers, 2006; Zeder, 2006). At the same time, there is a fruitful discussion about the meaning of detected kill-off patterns, based both on theoretical models and on archaeological and ethnographic data (e.g., Payne, 1973; Halstead, 1996; Ervynk, 1997; Ervynk, 2005;). With the exception of isolated studies (e.g., Martín, García-González, Nadal, & Vergès, 2016), mortality profiles usually do not take fetuses into account, even if there are methods available for detecting them in archaeological sites (e.g., Ahmed, 2008; Habermehl, 1975; McDonald, Wenham, & Robinson, 1977; Prummel, 1987a, 1987b, 1988, 1989; Richardson, Herbert, & Terlecki, 1976); although this referential is based on present-day individuals, it leads to similar results notwithstanding the level of

improvement of the breed considered. This is because foetal development is less influenced by environmental factors than that of lambs (see Martín & García-González, 2015 and references therein). In addition, with regard to Caprinae, biometric methods give results in line with morphological ones (Martín & García-González, 2015).

The presence of foetal remains in zooarchaeological assemblages can be due both to abortion or to cultural practices and can be of great interest to infer about the health status of flocks or about periods of occupation of a site. Abortion related to natural phenomena can be the result of a mix of challenges that past herders had to face. It can be related to physical and nutritional stress, climatic conditions, carnivore attacks, type of ingested food, and hereditary problems. In recent times, spontaneous abortions affect caprine flocks in different percentages, from 2–3% as reported by Martín et al. (2016 and references therein), to higher percentages; van Heerden (1961), observed 25% abortion among angora goats in Southern Africa, possibly due to hereditary problems; Rafiq, Sultani, Munir, and Arshad (1990) observed a 16.67% abortion rate in a grazing sheep flock in Baluchistan, which was caused by malnutrition. Incidence of abortion reaches higher percentages when it is due to infections. A decrease in quantity or quality of pastures triggers a series of negative events in ewes, especially during the late pregnancy. Indeed, to supply for the low intake of energy, the mobilization of body reserves from the ewe to the foetus leads to a loss in ewe's body weight. Malnourished ewes become more susceptible to infections and parasitic disease, which can lead to abortion (Rafiq et al., 1990). A number of parasites can lead to abortion, such as the bacteria *Salmonella enteritidis* (Pardon et al., 1988), *Brucella ovis* (Poester, Samartino, & Santos, 2013) and *Chlamydia abortus* (Abd El-Razik, Al-Humiany, Ahmed, Barakat, & Elfadaly, 2011; Borel et al., 2004) or the protist *Toxoplasma gondii* (Abd El-Razik et al., 2011). In addition, all of these parasites are also responsible for zoonoses, resulting for instance in human abortion (e.g., Borel et al., 2004; Roberts, Grist, & Giroud, 1967). *Salmonella* can also be responsible for offspring mortality (Pardon et al., 1988), and generally, lamb born from malnourished ewes has less chances to survive. Adding a brief notice, fetotoxicity can also result from the ingestion of poisonous pastures, as it happens in North America when livestock feeds on plants such as *Astragalus lentiginosus* (Van Kampen & James, 1971).

Among cultural factors, which can lead to foetal mortality, it is well known in the culling of pregnant ewes for the production of astrakhan (e.g., Payne, 1973) or the use of foetuses in peculiar ritual contexts (e.g., Horváth, 2015). The habit of drinking amniotic liquid and of eating foetuses is usually widespread among hunter gatherers more than it is among herders (e.g., Silberbauer, 1981; Speth, 2017).

The aim of this work is to reanalyse caprine mortality profiles from a prehistoric site located in the northern Adriatic region (Grotta dell'Edera), considering how the presence of foetal and perinatal individuals can help us to better evaluate the meaning of zooarchaeological data.

2 | THE SITE

Grotta dell'Edera (Štenašca) opens at the bottom of a small sinkhole in the Trieste Karst (north eastern Italy). The site is located 3 km from the coastline at an altitude of about 230 m a.s.l. (Figure 1); first fieldworks were carried out by local amateurs in the 1970s and resumed from 1990 to 2001 by the Ca'Foscari University of Venice and the University of California at Berkeley (USA; Biagi, Starnini, & Voytek, 1993). The stratigraphy revealed by excavations is composed of Pleistocene and Holocene sediments (Boschian, 1997), but only Holocene archaeological evidence was detected at the site. In particular, the archaeological sequence embraces a period between the Preboreal and the Time of Migrations (Biagi & Spataro, 2001; Biagi, Starnini, & Voytek, 2008; Boschian & Riedel, 2011). Most of the remains are from layers 3b–c (Mesolithic, Sauveterrian) and from layers 2–2a (Neolithic and Copper Age). Late Mesolithic (Castelnovian) layer 3a, as well as uppermost layers 1b–1a (Bronze Age and age of migrations, respectively) yielded poor assemblages of both zooarchaeological and material culture finds (mainly stone artefacts and potsherds). The Neolithic phase is represented by layer 2a that is composed of six superimposed lenses of ash and charcoal. Uncovered potsherds are ascribed to the Vlaška group, considered as a local variant of Danilo Neolithic culture. Uncalibrated dates of this layer range from 6305 ± 285 (GX-19022) to 6615 ± 390 (GX-19568; Biagi et al., 2008). The superimposed layer 2 is a similar palimpsest dated from 5555 ± 35 (GrN-18968) to an early phase of the Copper Age (4680 ± 325 , GX-19019). Sedimentological features of layers 2–2a are those of a *fumier* (i.e., deposits related to animal husbandry, formed mainly by burnt animal dung and vegetal remains, as defined by Angelucci, Boschian, Fontanals, Pedrotti, & Vergès, 2009), being composed mainly of burned ruminant droppings (Boschian, 1997).

Caprine mortality profiles of this site, along with those from other sites of the same region, have been discussed in several works (e.g., Boschian & Riedel, 2000; Miracle & Pugsley, 2006; Mlekuž, 2005), sometimes giving different interpretations (Bonsall, Mlekuž, Bartosiewicz, & Pickard, 2013). At the moment, available data are not enough to fully understand the social setting of prehistoric herders and their stables in the north Adriatic Karst (i.e., relations with possible open air sites, nomadic or transhumant pastoralism, annual mobility etc.; Bonsall et al., 2013).

3 | MATERIALS AND METHODS

Caprine remains from layers 2 and 2a of Grotta dell'Edera are analysed in this paper. Following the field notes drawn by B. Voytek during the 1990–2001 excavations, materials from the squares excavated in the deepest side of the cave (squares 27–35) are not considered here, in order to avoid processing data from possibly reworked areas. For this reason, animal bones are only from squares 3,4,8, and 9 (Figure 1). Bones were identified by the author and by Dr. Alfredo Riedel at the Natural History Museum of Trieste. This paper results from a revision of the osteological material carried

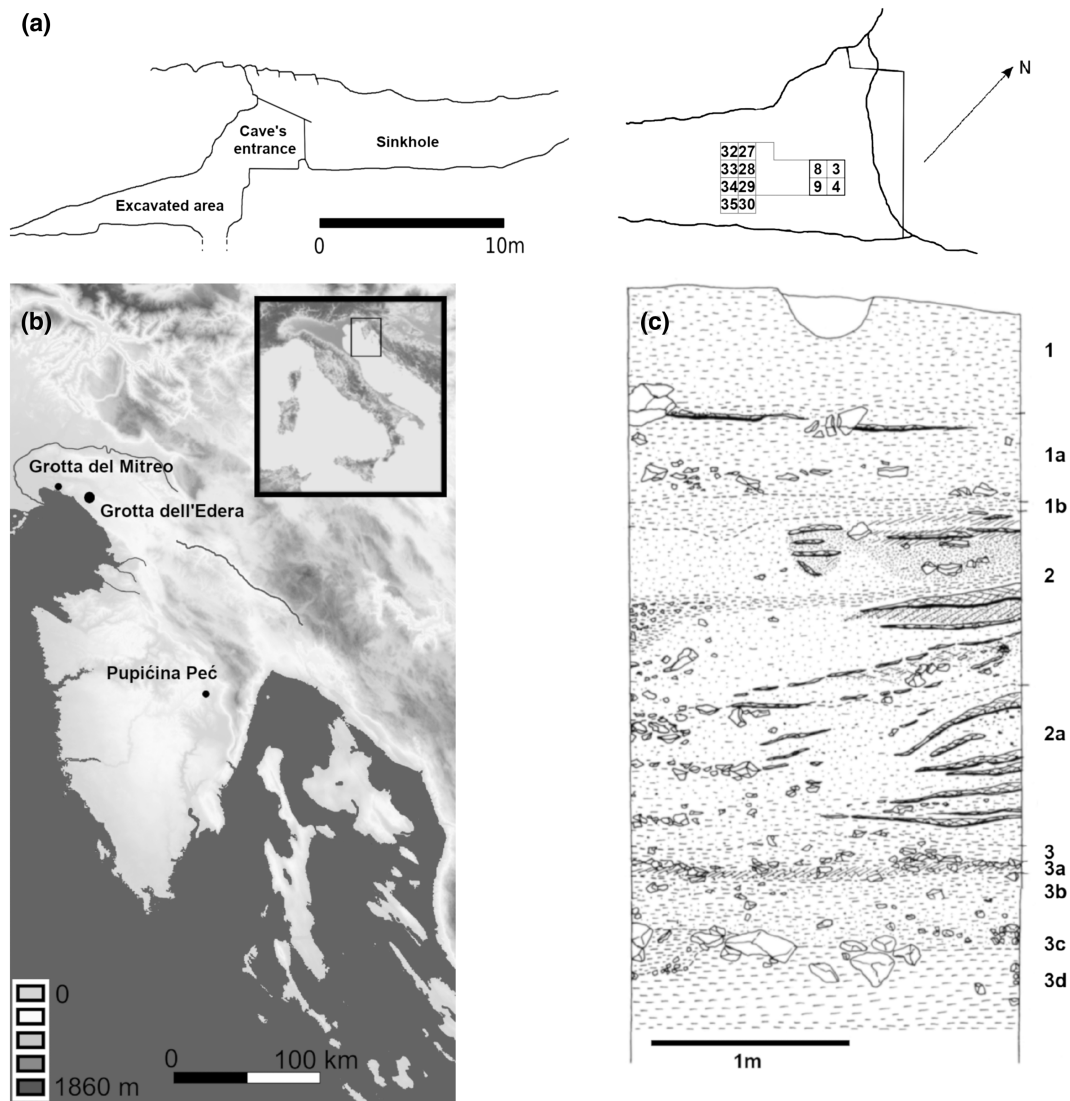


FIGURE 1 (a): cave section and plan. Numbers on cave plan indicate the squares where layers 2 and 2a were detected and excavated in the 1990–2001 fieldworks; (b): geographical location of sites; (c): site's stratigraphy (modified from the original drawing by Paolo Biagi). This stratigraphic scheme fits in the north-eastern side of squares 3 and 4

out by the author in 2008. Mortality profiles of Caprinae were calculated using teeth eruption and wear following Payne (1973). In this work, the age class “foetuses” was added to the other ones. In this regard, length of bones is used here for the first time to infer about ontogeny of the youngest individuals. Tables of concordance from Habermehl (1975), as well as those from Ahmed (2008), and equations proposed by McDonald et al. (1977) and Richardson et al. (1976) for sheep were used to calculate the age of foetuses expressed in days. Because McDonald et al. (1977) stated that the best mathematical model they found to describe the relation between bone size and gestational age was the one in which bone length was employed, bone breadth was not used in this work. This also enables to draw a better comparison between used methods. Ulna and innominate were prudently assigned only to foetus/neonatal category. Even if sheep is more abundant than goat at the site (Boschin & Riedel, 2000), the latter is surely present in the assemblage. This can be a problem in evaluating the age of

foetuses, which were identified as “*Ovis/Capra*.” Even if foetal development is similar between the two species, sheep foetuses appear to be larger in comparison with those of goat (Silvatchelvan, Ghali, & Chibuzo, 1996). Unfortunately, the only table of concordance proposed for goats (Habermehl, 1975) gives results for foetuses only until 131 days (against a gestation of at least 20 weeks). Complete remains that were aged were considered as belonging to both sheep and goat (Table 1), but due to the above mentioned bias for goat and to the fact that sheep was more common than goat at Grotta dell'Edera (Boschin & Riedel, 2000), foetuses are considered as sheep in Tables 3 and 4 and in Figure 2.

To assign fragmented specimens to foetal or neonatal categories, these were visually compared with the size of those already aged using the above mentioned references. Considering the possible uncertainty in age estimation, foetuses close to birth were assigned to the category “Foetus?”. number of identified specimens (NISP) was used for a first general evaluation of abundance of skeletal

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TABLE 1 Faunal composition (NISP) of layers 2 and 2a of Grotta dell'Edera, compared with layers 5 and 6 of Grotta del Mitreo (Trieste Karst, Italy) and layers H and I of Pupičina Peć (Istria, Croatia)

Layers	Grotta dell'Edera		Grotta del Mitreo		Pupičina Peć		
	2	2a	5	6	H	I	
domesticates	<i>Bos taurus</i>	22	10	4	-	204	31
	<i>Ovis/Capra</i>	386	852	62	32	1615	539
	<i>Ovis aries</i>	14	22	9	2	189	61
	<i>Capra hircus</i>	4	7	1	-	38	11
	<i>Sus domesticus</i>	44	4	-	-	-	-
	<i>Canis familiaris</i>	2	1	1	-	6	4
d/w	<i>Bos/Cervus</i>	12	9	1	-	-	-
	<i>Sus domesticus/scrofa</i>	4	-	-	-	46	14
wild	<i>Cervus elaphus</i>	9	3	4	-	19	19
	<i>Capreolus capreolus</i>	2	-	2	-	6	4
	<i>Sus scrofa</i>	2	-	1	-	-	-
	<i>Vulpes vulpes</i>	2	-	-	-	8	1
	<i>Meles meles</i>	1	-	-	-	1	2
	<i>Martes sp.</i>	-	-	-	-	34	1
	<i>Ursus arctos</i>	-	-	-	-	1	-
	<i>Felis sylvestris</i>	-	-	2	-	2	-
	<i>Lepus sp.</i>	2	1	1	-	8	6
	<i>Castor fiber</i>	-	-	-	-	1	-
	<i>Erinaceus sp.</i>	1	-	-	-	2	-
NISP	507	909	88	34	2180	693	

Abbreviation: NISP, number of identified specimens.

elements because most foetal/neonatal elements are complete or just fragmented into two halves, whereas bones of young or adult individuals were heavily fragmented, the minimum number of elements (MNE) was used to compare abundance of scapula, innominate and long bones among the different age categories. In addition, foetuses are represented only by long bones, whereas other age classes are mostly represented by teeth. For this reason, minimum number of individuals (MNI) was used to describe mortality patterns. MNI was recalculated according to a revision of teeth data (using Payne's, 1973 age classes) and an evaluation of foetal/neonatal post-cranial bones; individuals represented by shed deciduous teeth (dropped from mandibles of still living individuals) published in Table 5 in Bosch and Riedel (2000) are considered here as belonging to Payne's age classes E-I. Because the probability of each individual to belong to any of the five classes is the same, the MNI scored on the basis of shed deciduous teeth was divided by 5, and the result was added to the rest of MNI already calculated for each of the E-I age classes. This is the reason for the presence of decimals in Table 4. In addition, the Payne's (1973) age classes were used with the correction proposed by Helmer and Vigne (2007), who argued that the processing of quantitative data can be biased by the unequiprobability of the age classes. Because each age class covers a different time duration (from 2 months to ca. 4 years), its frequency is corrected as the inverse proportion of its probability (Helmer & Vigne, 2007). This allows preventing misinterpretations due to the different time duration of each class. Because foetal elements appear to belong to individuals that died between about the 90th day of gestation and birth, a time span of 1 month and a half was considered as the time duration of age category foetuses. Thus, following the same method proposed by Helmer and

Vigne (2007), a probability (p) of 1/8 was used as a correction to the rough frequency of this age class.

Evidence from Grotta dell'Edera is compared with those from spits 5 (Neolithic/Copper Age) and 6 (Middle Neolithic, Vlaška Group) of Grotta del Mitreo (province of Trieste, north-east Italy, Petrucci, 1997) and layers H and I (Middle Neolithic, Danilo/Vlaška Group) of Pupičina Peć in Istria (Croatia, Miracle & Pugsley, 2006). Data are fully comparable because age classes of offspring and of older individuals were calculated following Payne (1973), whereas the presence of foetuses was detected considering length measurements published by the authors for both sites (Miracle & Pugsley, 2006; Petrucci, 1997).

4 | RESULTS

Faunal composition of layers 2 and 2a points to a prevalence of Caprinae among domestic ungulates. Sheep is always more abundant than goat with a ratio of about 3:1. In general, sheep/goat count for 96.9% of total NISP in layer 2a and 79.7% in layer 2 (Table 1). Cattle and domestic pig are less abundant in the middle Neolithic layer 2a, whereas they increase during the late Neolithic/Copper Age layer 2, together with wild species (the latter represent only 0.4% of NISP in layer 2a and 3.7% in layer 2).

Caprine biometric data point to the presence of foetuses of various age, irrespective of them being considered as belonging to the genus *Ovis* or to the genus *Capra*. Most individuals are late-pregnancy foetuses, with an age comprised between 110 days and birth (if sheep) or 112 days and birth (if goat; Table 2). Results obtained with different methods correspond rather well between each other, with differences

TABLE 2 Age estimation for foetal/neonatal complete remains at Grotta dell'Edera

layer	Element	Length	Estimated age (days)					Estimated class	
			as sheep				as goat	as sheep	as goat
			Habermehl	McDonald	Richardson	Ahmed	Habermehl		
2	Scapula	27	90-100	-	-	91-98	90-112	Foetus	Foetus
2	Humerus	45	110-120	114	-	-	112-131	Foetus	Foetus
2	Humerus	42	110-120	110	-	-	90-112	Foetus	Foetus
2	Humerus	57.5	136-145	131	-	-	112-131	Foetus	Foetus
2	Humerus	65	136-145	142	-	-	131-140?	Foetus?	Foetus?
2	Radius	46	110-120	112	108	-	112-131	Foetus	Foetus
2	Radius	40	100-110	105	100	98-105	90-112	Foetus	Foetus
2	Metacarpal	65	136-145	130	-	-	-	Foetus	Neonatal
2	Tibia	105	145	144	146	-	-	Foetus?	Neonatal
2	Tibia	70	120-136	120	115	-	112-131	Foetus	Foetus
2a	Humerus	86	>145	144	-	-	-	Neonatal	Neonatal
2a	Humerus	51	110-120	122	-	-	112-131	Foetus	Foetus
2a	Humerus	45	110-120	114	-	-	112-131	Foetus	Foetus
2a	Humerus	27	90-100	91	-	-	90-112	Foetus	Foetus
2a	Radius	56	120-136	126	120	-	112-131	Foetus	Foetus
2a	Radius	54	120-136	123	118	-	112-131	Foetus	Foetus
2a	Radius	59	136-145	131	124	-	112-131	Foetus	Foetus
2a	Radius	57	136-145	127	121	-	112-131	Foetus	Foetus
2a	Radius	63	136-145	136	129	-	131	Foetus	Foetus
2a	Metacarpal	51	110-120	115	-	-	131	Foetus	Foetus
2a	Metacarpal	54	120-136	118	-	-	131-140?	Foetus	Foetus?
2a	Metacarpal	60	136-145	125	-	-	-	Foetus	Neonatal
2a	Metacarpal	64	136-145	129	-	-	-	Foetus	Neonatal
2a	Femur	66	136-145	131	-	-	131	Foetus	Foetus
2a	Tibia	54	100-110	105	101	-	90-112	Foetus	Foetus
2a	Tibia	81	136-145	132	125	-	112-131	Foetus	Foetus
2a	Tibia	92	136-145	144	135	-	-	Foetus?	Neonatal
2a	Tibia	37.8	90-100	90	86	-	90-112	Foetus	Foetus
2a	Metatarsal	53	110-120	120	-	-	112-131	Foetus	Foetus
2a	Metatarsal	54	110-120	121	-	-	131-140?	Foetus	Foetus?
2a	Metatarsal	61	110-120	129	-	-	-	Foetus	Neonatal
2a	Metatarsal	54	110-120	121	-	-	131-140?	Foetus	Foetus?
2a	Metatarsal	74.4	136-145	146	-	-	-	Foetus?	Neonatal
2a	Metatarsal	71.5	136-145	142	-	-	-	Foetus?	Neonatal
2a	Metatarsal	70	136-145	140	-	-	-	Foetus?	Neonatal

Note. Used referentials: Habermehl (1975), McDonald et al. (1977), Richardson et al. (1976), Ahmed (2008). Length is given in mm.

of a few days from one to the other. Differences increase when comparing results obtained for different species. Anyway, in most of the cases, bones classified as foetal sheep are classified also as foetal goats. One exception is represented by metapodials. In this case "Foetal" sheep often turns to Foetal? or even "Neonatal" goat. The number of skeletal elements (MNE) of foetal and neonatal individuals is quite high if compared with the frequency of those belonging to young,

subadult, or adult individuals. If only limb bones are considered, foetal ones represent 41.8% of total MNE in layer 2a and 36.6% in layer 2 (Table 3).

Also considering the MNI, foetal age class is the best represented one in both layers 2 and 2a. Age classes related to young and subadult animals with milk dentition (classes A–D) are represented by few individuals each in both layers, with the exception of class D, which was

TABLE 3 Minimum number of elements of sheep/goat in layers 2 and 2a according to age class

2	Foet.	Foet./Neo.	Juv./Ad.	Σ
Scapula	2	1	1	4
Humerus p	3	1	1	5
Humerus d	4	1	1	6
Ulna p	0	1	3	4
Radius p	2	0	1	3
Radius d	2	0	2	4
Metacarpal p	1	0	2	3
Metacarpal d	1	0	4	5
Innominate	0	1	1	2
Femur p	0	0	1	1
Femur d	0	0	2	2
Tibia p	1	1	0	2
Tibia d	1	1	1	3
Metatarsal p	2	0	6	8
Metatarsal d	2	0	2	4
Metapodial d	1	0	3	4
Σ MNE	22	7	31	60
2a	Foet.	Foet./Neo.	Juv./Ad.	Σ
Scapula	2	0	4	6
Humerus p	4	1	1	6
Humerus d	3	1	5	9
Ulna p	0	4	8	12
Radius p	5	0	1	6
Radius d	5	0	2	7
Metacarpal p	3	0	1	4
Metacarpal d	4	0	2	6
Innominate	0	0	5	5
Femur p	1	0	2	3
Femur d	1	0	2	3
Tibia p	4	1	2	7
Tibia d	3	1	2	6
Metatarsal p	3	2	4	9
Metatarsal d	3	2	3	8
Metapodial d	0	0	1	1
Σ MNE	41	12	45	98

Note. Class "Foetus?" in Table 1 was added to "Foetus/Neonatal". Foetal and Neonatal elements are considered as sheep.

Abbreviations: Foet, Foetus; Neo, Neonatal; Juv, Juvenile; Ad, Adult; p, proximal; d, distal.

TABLE 4 Sheep/goat minimum number of individuals according to age classes

Layer	Age classes										Σ
	foetal	A	B	C	D	E	F	G	H	I	
2	5 (3)	1	2	2	0	0.6	1.6	1.6	0.6	0.6	15 (13)
2a	5	2	2	2	2	1.4	3.4	1.4	2.4	1.4	23

Note. Foetuses considered as sheep (numbers in brackets indicate the MNI when foetuses are considered as goat). Age classes A–I are from Payne (1973) and are scored considering teeth data. Foetal MNI is based on long bone data.

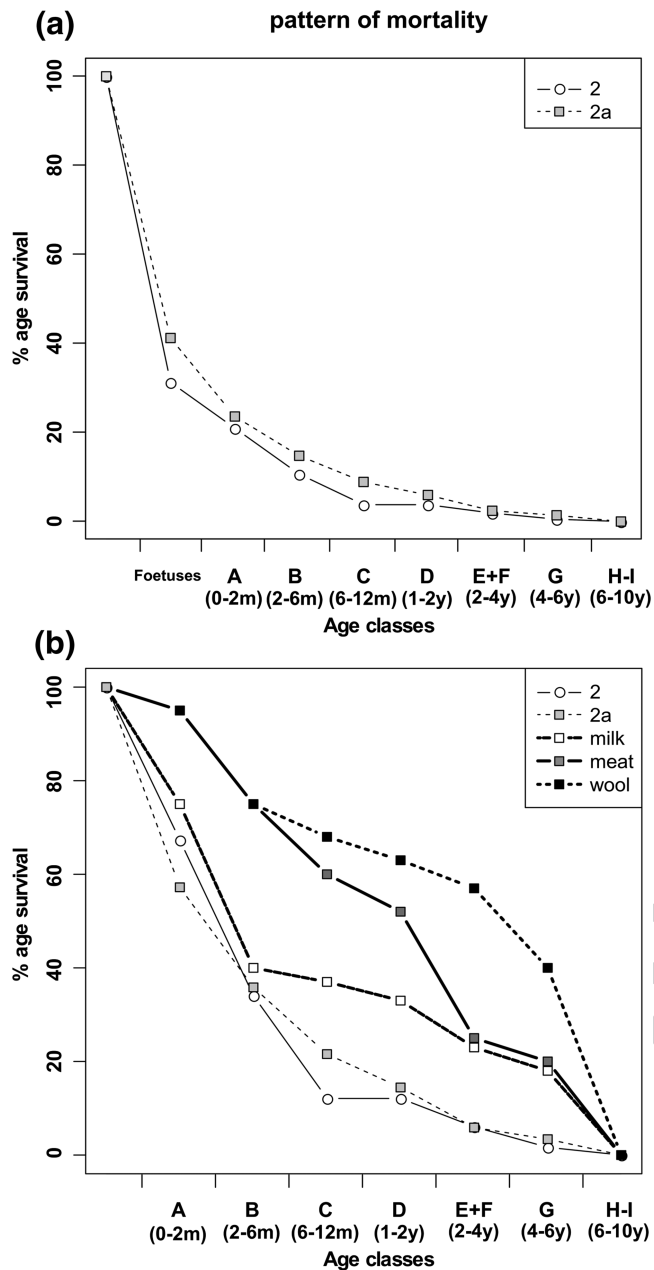


FIGURE 2 Pattern of mortality of Caprinae in layers 2 and 2a at Grotta dell'Edera according to Payne's (1973) age classes. Numbers in brackets show the approximate age in months (m) or years (y) proposed by Payne (1973). Abundance of age classes was corrected following Helmer and Vigne (2007). (a): mortality pattern with foetuses (here considered as sheep); (b): mortality pattern without foetuses. Evidence from layers 2 and 2a is compared with theoretical models proposed by Payne (1973) for meat, milk, and wool exploitation

not detected in layer 2. Individuals with permanent dentition (classes E-I) are quite rare, and some of them are represented by shed deciduous teeth (MNI is three in layer 2 and seven in layer 2a, respectively).

The caprine pattern of mortality is similar between layers 2 and 2a (chi-square test, $p = .94$). It is characterised by a high mortality among foetal and neonatal individuals (Payne's class A, 0-2 months), and it is followed by a survival rate that is similar for classes B, C, and D. Older

individuals are rare (Table 4, Figure 2). The high number of foetal and neonatal remains points to a cave occupation around the birth season, but the occurrence of individuals belonging to age classes B and C indicates human presence also in other periods of the year. If foetuses are not considered, neonatal mortality is higher than that expected in the three theoretical models (milk, meat, and wool exploitation) proposed by Payne (1973; Figure 2B), and the survival rate of the older age classes is much lower than that of the three above mentioned models. In general, the mortality profile of both layers 2 and 2a is more similar to the one proposed for milk exploitation.

5 | DISCUSSION AND CONCLUSIONS

Although Grotta dell'Edera did not yield large samples of sheep/goat data in terms of MNI, the characteristic of the bone assemblage is useful to stimulate the discussion about the presence of foetal and neonatal specimens. Although foetuses are distributed over quite a wide range of gestational ages, most of them are terminal ones, as it often happens in archaeological samples (Prummel, 1988). Individuals of uncertain classification between foetus and neonatal, as well as neonatal ones, often show a borderline body size, which nevertheless indicates a perinatal mortality or death that occurred in the first weeks of life. The quantity of foetal/neonatal skeletal elements in comparison with that of older individuals is high at Grotta dell'Edera (Table 3). This especially considering that bones of very young mammals are less ossified, with more porous cortical region and thinner trabeculae (e.g., Boschín, Bernardini, Zanolli, & Tuniz, 2015), and thus, they are expected to be more affected by decay and should normally be under-represented in archaeological assemblages. At Grotta del Mitreo, a cave located few kilometres away from Grotta dell'Edera, foetal and neonatal long bones count for 25% of all long bone remains both in the Neolithic (Vlaška) spit 6 and in the Late Neolithic spit 5. This is another impressive dataset because no sieving appears to have been carried out for collecting bones (unidentified specimens are almost absent, Petrucci, 1997). At Pupčina Peć in Istria, from where comes the most representative Neolithic faunal assemblage from a cave site in the *Caput Adriae*, evidence seems to be in line with this picture; mortality profiles, obtained both from dental and postcranial data, show a high mortality of individuals belonging to Payne's age class A (0-2 months; Miracle & Pugsley, 2006). Foetal and neonatal caprine skeletal elements are considered together when Miracle and Pugsley (2006) discussed the body part frequencies; thus, it is difficult to quantify the abundance of foetal individuals. However, it should be considered that (i) the number of post cranial elements of foetal/neonatal individuals is quite high in Neolithic layers H and I (e.g., Miracle & Pugsley, 2006, figure 7.10, p. 304; (ii) the authors report the complete list of measurable bones (Miracle & Pugsley, 2006, Appendix 7.1, pp. 365-379), indicating length (GL) and smallest width of the diaphysis (SD) also of the long bones of neonatal and foetal individuals. If the GL is used to infer about gestational age, the presence of foetuses of various age (between about the 80th day and the end of gestation, mostly died at late gestation) can be detected. A high number of

broken elements show SD measurements comparable or smaller than those of complete elements considered as foetuses (Miracle & Pugsley, 2006, Appendix 7.1, pp. 365–379). It emerges that in the Neolithic layer H, 83% of measured long bones of very young individuals (148 skeletal elements) seems to belong to animals that died due to abortion or at a perinatal age. In the Neolithic layer I (77 skeletal elements), this percentage is still high (66%).

Turning back to Grotta dell'Edera, geoarchaeological evidence testifies to the presence of animal stabling layers (*fumier*). Accumulation of these layers, rich in ruminant droppings, represents the main sedimentary pattern during the Neolithic. Other sediments brought into the cave by erosional phenomena (water and wind) are scarce, probably due to the presence of wooded vegetation that allowed soil preservation (Boschian, 1997). Animal stabling layers were burned by shepherds, as testified by the sequence of ash layers found at Grotta dell'Edera and also in other cave sites of the area. Thus, geoarchaeological data points to the use of the cave as a stable site, even if it is not clear whether such a function was continuous through time or if it alternated with other kinds of (ephemeral) frequentations (Boschian & Montagnari-Kokelj, 2000). Small ruminant penning at Grotta dell'Edera is also confirmed by the relatively large quantity of caprine shed deciduous teeth (Boschian & Riedel, 2000). Also the relative scarcity of other finds, such as potsherds (Biagi et al., 2008), should indicate reduced daily life activities by humans directly in the cave. This situation is shared by other cave sites of the North Adriatic region (i.e., Karst and Istria, Boschian, 1997, 2006; Boschian & Montagnari-Kokelj, 2000; Angelucci et al., 2009). The great abundance of foetal and perinatal individuals among sheep and goats possibly mirrors the cave's function: a more intense exploitation of the site during late pregnancy/birth season and a (perhaps sporadic) human presence during the other parts of the year, as testified by the presence of some individuals belonging to age classes B and C. Also the scarcity of adults can corroborate the picture: these animals were probably killed more frequently in other sites. The caprine mortality pattern resembles more the theoretic model proposed by Payne (1973) for milk exploitation, rather than those for meat and wool. Such scenario seems to be in agreement with the evidence of dairying coming from residue analysis carried out on Neolithic pottery of the area (Bonsall et al., 2013; McClure et al., 2018). However, two points have to be kept in mind: (i) mortality of class A individuals is quite high (it is twice the one predicted by the theoretic model in layer 2a) and (ii) the culling of perinatal individuals is unlikely because it is supposed that offspring of prehistoric caprine populations had to be kept alive to stimulate milk production by ewes, if milk was the target of production, or were culled at the reaching of their optimal body size if the target was meat (Halstead, 1996; Helmer & Vigne, 2004, 2007; Payne, 1973; Serjeantson, 2007).

Considering faunal composition, the scarcity of other exploited taxa, such as for instance wild game, points to the absence of episodes of food shortage for humans, differentiating Grotta dell'Edera from other contexts (e.g., Martín et al., 2016), where, for instance, the repetitive but occasional consumption of carnivore species was observed. This observation seems to rule out the possibility of culling pregnant females and neonatal individuals to face crises of food

availability. In this regards, the relative large quantity of foetal elements (or of those of individuals which died at perinatal age) at Grotta dell'Edera more likely represents failures of gestation, problems occurred at parturition or just after it. Abortion can be triggered by several, often interrelated, factors such as malnutrition, infections and parasitic disease, which can also be the reason for lamb mortality at perinatal age (Abd El-Razik et al., 2011; Pardon et al., 1988; Poester et al., 2013; Rafiq et al., 1990).

The presence of aborted individuals in these stable sites could be used to corroborate the idea that natural death is also the reason (at least partially) for the overwhelming presence of very young lambs (Payne's class A). Natural mortality of lambs, which was also considered as a possible explanation for the abundance of age class A at Pupicina (Miracle & Pugsley, 2006: 323), can affect a high proportion of individuals: Payne (1973) reported lamb losses as high as 50% in rural Turkey, Mukasa-Mugerwa et al. (2000) reported a mortality of 43.3% among lambs (from birth to 1 year old) in Debre Berhan (Ethiopia), during a period of data collection of 4 years, whereas Abdelqader et al. (2017) reported a mortality rate of 18.6% of lambs in the first 60 days of life among flocks in Jordan. Infection is always the most important cause of mortality followed by starvation. Trauma, accidents, or predation are rare causes of mortality (Abdelqader et al., 2017; Mukasa-Mugerwa et al., 2000).

Evidence from Grotta dell'Edera, corroborated by that from neighbouring sites, poses questions on the meaning of mortality profiles of cave sites used as stables. The abundance of very young individuals appears to be independent from livestock strategies and could represent the accumulation of failures over centuries. This does not mean that herders were not able to manage their flocks, it just means that the peculiar function of considered sites implies a more intense accumulation of skeletal elements related to selected age classes. In this perspective, the similarity between caprine age profiles and Payne's milk exploitation model, both characterised by a high mortality of younger individuals, can be the result of a bias, and milk exploitation could be better detected in such a site by chemical analysis of fatty residues on pottery (McClure et al., 2018). The aim of this brief contribution is just to stimulate the evaluation of foetuses in discussing mortality profiles of domesticates. The presence of foetuses is one of several datasets that have to be matched together to better contextualise sites used for stabling. This especially in order to understand if a zooarchaeological assemblage can be meaningfully used to infer about animal management in the past. Finally, even if the type of problem affecting herds cannot be detected by mortality profiles, the detection of natural mortality itself can be useful to select those sites where other analyses, such as for instance palaeogenetics from sediments or from teeth (e.g., Namouchi et al., 2018) can be carried out to detect the presence of zoonotic agents (be they bacteria, protozoists, or other parasites) in the past.

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ORCID

Francesco Boschini  <https://orcid.org/0000-0001-5795-9050>

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