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# Animal husbandry in Sicilian prehistory: The zooarchaeological perspective from Vallone Inferno (Scillato, Palermo)

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ABSTRACT

Starting in the mid-6th millennium cal BCE, Neolithic groups occupied the midlands of Sicily. The economy of these groups was based primarily on livestock farming. Archaeological and archaeobotanical data indicate an intensification of livestock practices during the Early Bronze Age, leading to a change in the landscape in the form of more open forests.

The Vallone Inferno rockshelter in the Madonie massif is one of the few sites that has been systematically excavated in these midlands, and has yielded evidence of Middle Neolithic and Early Bronze Age occupations. This work focuses on the study of prehistoric husbandry in the Sicilian midlands and highlands through the analysis of the Vallone Inferno faunal remains. Although the Middle Neolithic and Early Bronze Age faunal assemblages of Vallone Inferno are mixed, the paucity of information from other sites in this area makes their study worthwhile. The faunal remains were analysed by means of a zooarchaeological and taphonomic study.

Prehistoric Sicilian shepherds adapted to the conditions and resources of the Madonie massif midlands and highlands through husbandry and hunting practices. Husbandry was based on raising sheep and goats for meat and milk and exploiting their derivatives. Cattle, pigs and hunted animals were also exploited for their meat. The hunting of deer, leporids and, most probably, wild boar for meat and skins complemented livestock farming.

Although mortality profiles should be interpreted with caution, the rockshelter was probably occupied seasonally as a sheepfold during the breeding months and most likely served as an intermediate settlement between herd movements across the Madonie massif. These occupations coincide with a period in which the forests were opened up in the Madonie mountains, which is related to the practice of livestock farming.

## 1. Introduction

The islands of the Mediterranean played a fundamental role in the spread of agriculture and animal husbandry starting with the earliest population dispersals from the Near East around 12,000 BP (Zeder, 2008). This is the case, for example, in Cyprus, where the arrival of the four main domestic animal species has been dated to around 10,500–9,000 BP, along with several wild species, including the fox and fallow deer (Vigne and Guilaine, 2004, Vigne et al., 2016). The Neolithic lifeway continued its spread across the Aegean around 9,000–8,000 BP until it reached the coasts of Sicily and southern Italy approximately 7,000 BP (end of the 7th millennium cal BCE), associated with *Impresse Arcaiche* pottery (Natali and Forgia, 2018). Herding was practised in these regions, but with some differences in exploitation: cattle was predominant at some sites and domestic caprines at others. At the same time, hunting and fishing were still practised, although they generally played a secondary role (Vigne, 2003; 2006; Tagliacozzo and Pino Uría, 2009). Early Neolithic occupations in Sicily were concentrated near the coast (e.g., Grotta dell'Uzzo, Grotta d'Oriente, Grotta Geraci) and in the lowlands, whereas the first systematic colonisation of the inlands and midlands (700–1000 m.a.s.l.), as in peninsular Italy (Morandi and Branch, 2018), date to the Middle Neolithic (mid-6th millennium cal

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BCE) (Forgia, 2009; Forgia et al., 2012; Lo Vetro and Martini, 2012; Tiné and Tusa, 2012; Mannino et al., 2015; Natali and Forgia, 2018).

The first herders settled on the coast and bred domestic animals, but the exploitation of marine molluscs and fish continued to be an important part of their economy and their diet (Tagliacozzo, 1993; Martini et al., 2012; He Yu et al., 2022). The establishment of animal husbandry as a primary economic activity began in the Middle Neolithic and is better documented in the lowlands. Evidence of this is found in Grotta dell'Uzzo, which also began to be used as a sheepfold (Brochier et al., 1992; Tagliacozzo, 1993), as well as different sites in eastern Sicily, where the percentage of domestic animals is higher than that of wild animals, and the four main domestic species are represented (Villari, 1995).

The characteristics of early husbandry practices in the inlands of northern Sicily are unknown, as no systematic zooarchaeological studies have yet been conducted. However, there is evidence of progressive land occupation and use. The use of caves, rockshelters and open-air sites in the midlands began to expand starting in the Middle Neolithic (Brochier et al., 1992; Forgia, 2009; Belvedere and Forgia, 2019; Forgia et al., 2012). An example of this is Grotta di Bommartino, where the occupations date from the Middle Neolithic to the Early Bronze Age, and from which remains of *Tricromica* and *Castellucio* pottery have been recovered (Forgia et al., 2012). The presence of various facies of prehistoric ceramics in the Madonie mountains, particularly since the Early Bronze Age, have been interpreted as substantiating the presence of different cultural groups, all interested in exploiting the same mountain environment for farming (Forgia et al., 2012). Archaeobotanical studies have documented the earliest evidence of forest disruption in the Madonie and Nebrodi mountains in northern Sicily, related to an intensification of husbandry activities in the area and little evidence of agricultural practice (Tinner et al., 2016). After a recovery of the woodlands during the Early-Middle Copper Age, a new process of open grassland expansion occurred from the Early Bronze Age onwards (Tinner et al., 2016). This may have been due to a population increase and an intensification of agriculture and husbandry in central and western Sicily (Maniscalco et al., 2015a, 2015b; Speciale et al., 2020).

Vallone Inferno is one of the few midland sites with faunal remains that has been systematically excavated. Prehistoric occupations of Vallone Inferno date from the Middle Neolithic and Early Bronze Age, but occasional episodes of erosion have made distinguishing the remains originating from each of these occupations difficult, limiting the interpretability of the assemblage. Nevertheless, the site's good contextualisation and the degree of preservation of the faunal remains make this one of the only sites that, at least for now, can provide information on the evolution of husbandry practices and the occupation and exploitation of natural resources. As such, this paper aims to contribute to the discussion on the development of prehistoric husbandry in the midlands and highlands of northern Sicily and the Madonie massif.

## 2. The site: Vallone Inferno

The site is a rockshelter near the Vallone Inferno ravine located on the Madonie massif, the second highest mountain in Sicily, extending from an elevation of 200 m.a.s.l. (Imera River valley) to 1979 m.a.s.l. (Pizzo Carbonara). The rockshelter falls within the municipality of Scillato (coordinates: 37° 52′ 17.74″ N and 13° 55′ 58.97″ E) at ca. 770 m.a.s.l. (Fig. 1) (Forgia, 2008; Forgia et al., 2013; Forgia et al., 2021).

The rockshelter is more than 10 m long and 6 m deep and is oriented to the north. Archaeological excavations were carried out between 2008 and 2021 over an area of about 30 $m^2$ (Forgia et al., 2013), and four main stratigraphic complexes were identified (Fig. 1).

Different phases of occupation of the rockshelter have been documented, from the Middle Neolithic to the Mediaeval period (Forgia et al., 2013). This work focuses on prehistoric layer 3.4, comprising several sublayers (3.4.a-n) corresponding to different and repeated occupations. These originated in two cultural phases, the first dated to the

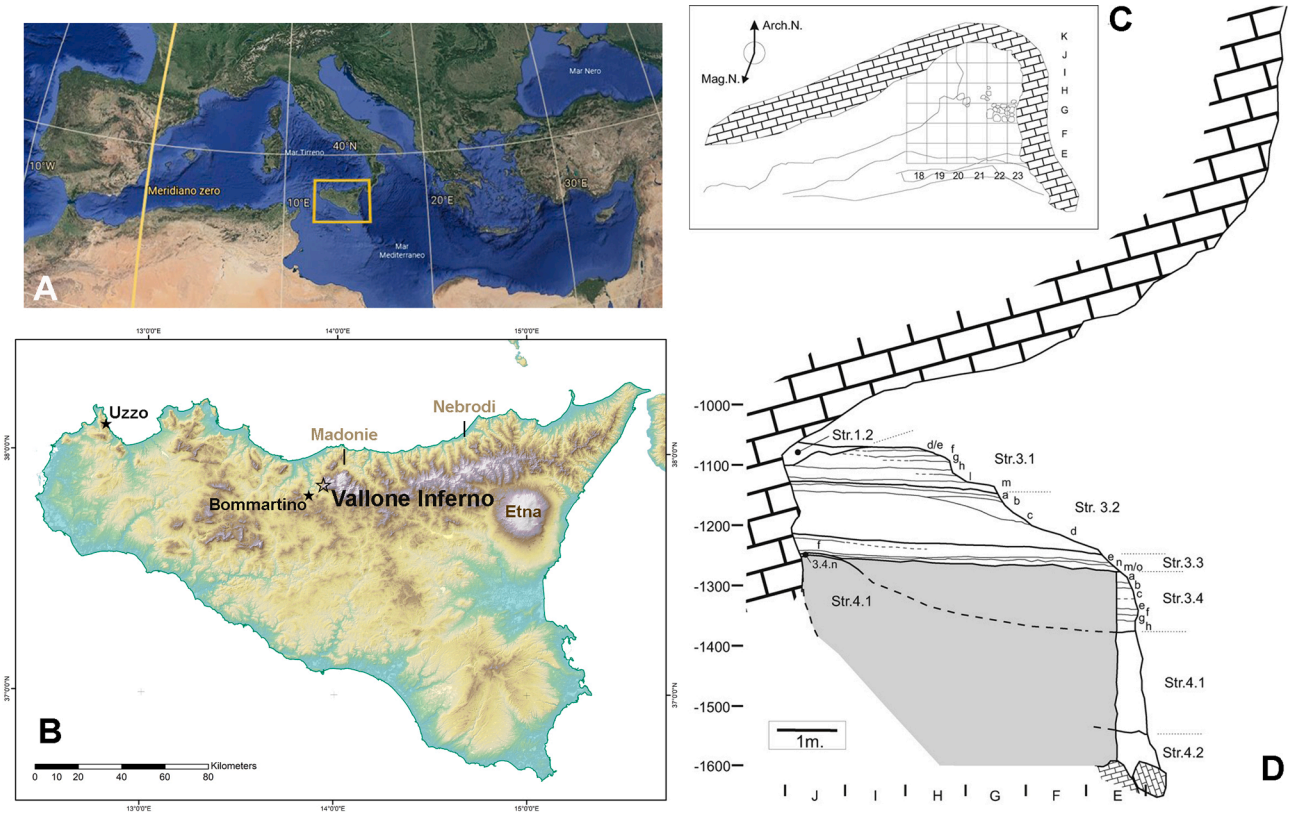


**Fig. 1.** A and B. The location of Vallone Inferno within the Madonie massif. C. General layout of the Vallone Inferno excavation area. D. Synthetic stratigraphic sequence (A from Google Earth, modified, C and D modified from Forgia et al., 2013).

Middle Neolithic (MN) period (5460–5220 cal BCE), represented by *Tricromica* pottery. The second phase is made up of several occupations dated to the Early Bronze Age (EBA) (1620–1420 cal BCE), identified by the presence of *Castelluccio* pottery. These Bronze Age levels were formed simultaneously with the partial destruction of the MN occupation due to periodic severe erosion processes caused by the Inferno stream and the use of the shelter and reworking of previous sediments by EBA communities, which scattered the archaeological material onto more recent layers following the natural slope of the deposit (Forgia et al., 2013; 2021).

The pottery is very fragmented, but both MN and EBA fragments correspond to closed forms associated with food storage and liquid collection (Forgia et al., 2021). This is the case of MN *figulina* pottery, used to contain milk in coeval sites in Croatia (McClure et al., 2018).

Flint and obsidian lithic tools (N = 243) were recovered along with pottery fragments and faunal remains. The microwear observed on these tools is associated with processing animal carcasses, hide cutting and contact with meat and bone. Middle Neolithic tools were used for a single purpose, whereas Early Bronze Age implements were used for different activities (Forgia et al., 2021).

The identification of faecal biomarkers in sediment samples from Vallone Inferno confirm the use of the rockshelter as a livestock pen during prehistoric and historic occupations (Vallejo *et al.*, submitted). The abundance of phytosterol (5β-stigmastanol and *Epi*-5β-stigmastanol) related to sterols (coprostanol and epicoprostanol) confirms the stabling of ruminants. The pronounced presence of deoxycholic acid related to lithocholic acid also corroborates this use. These biomarkers indicate that ovicaprines were the main ruminants inside the shelter (Bull et al., 2002; Vázquez et al., 2021). Along with husbandry, agricultural practices have also been documented in the area around Vallone Inferno through the presence of cereal pollen and seeds (*Triticum aestivum/durum*) and legumes (*Lens culinaris, Pisum sativum*) (Forgia et al., 2013). A flint sickle implement with traces indicating agricultural activities was also found in sublayer 3.4.a. However, agriculture would have been a secondary activity to the predominant activity of livestock rearing.

## 3. Material and methods

Layer 3.4 includes materials from the MN and EBA occupations that were partially mixed by periodic erosive processes caused by the Inferno stream (Forgia et al, 2021). We have treated the animal remains as a single assemblage for the purposes of this work, but without losing sight of the fact that these remains may form part of a palimpsest. This was taken into account when interpreting the data, in particular, the taxonomic frequencies and mortality profiles.

Faunal remains were collected by hand during fieldwork, individualised and referenced by their locations. Some remains were recovered in the screening process and added to the database with their respective approximate locations.

To reconstruct herd composition and management, and to evaluate the importance of hunting, specimens were identified taxonomically and anatomically and age at death was determined.

Sheep (*Ovis aries*) and goats (*Capra hircus*) were identified, when possible, using post-cranial (Halstead et al., 2002; Zeder and Pilaar, 2010) and dental (Payne, 1985; Helmer, 2000; Halstead et al., 2002) morphological criteria. Pigs (*Sus domesticus*) were identified using biometrical criteria (Albarella and Payne, 2005), and the remaining species were also identified using morphological criteria (Barone, 1969; Schmid, 1972). Sheep and goats were grouped as 'caprines' and pigs and wild boar (*Sus scrofa*) as 'suids' when species differentiation was not possible.

Whenever species identification or precise anatomical identification was not possible due to the fragmentation of the assemblage, the remains were classified by size categories. The morphological and size features of the fragments, in addition to species representation, were considered for this classification (large: cattle; medium-sized: red deer, adult suids; small: immature suids, adult caprines; very small: immature caprines, carnivores, and leporids).

Mortality profiles and estimated meat and offal weights of domestic animals (SI Table 6) provide information on culling strategies and herd management. Sheep and goat age at death was determined using dental eruption and wear criteria (Payne, 1973) of the lower teeth (dental series or isolated). The biometric method based on the crown height measurements of dP4 (Gourichon, 2004) was used to obtain a more precise age at death and allowed us to take advantage of the abundance of these dental elements in the assemblage. Bone criteria were also used (Zeder, 2006), especially for the identification of foetal individuals, for which bone criteria are more resolute than dental criteria (Martín and García-González, 2015).

To assess and compare taxonomic and anatomic frequencies, we made estimations based on the number of identified specimens (NISP), the minimum number of individuals (MNI) and the minimum number of animal units (%MAU) (Binford, 1981; Lyman, 2008; Gifford-Gonzalez, 2018). The %MAU of domestic caprines, cattle and suids was calculated, as they were the most numerous in the assemblage.

We performed a taphonomic analysis to assess the anthropogenic and non-anthropogenic impact on the faunal remains. The study of carcass butchering and consumption was based on the identification of cut marks (Binford, 1981; Nilssen, 2000); percussion marks (Blumenschine and Selvaggio, 1988; Blumenschine, 1994); tooth marks, focusing on human tooth marks (Binford, 1981; Fernández-Jalvo and Andrews, 2011; Saladié et al., 2012); and heat modifications caused by boiling (Bosch et al., 2011).

Other modifications were also analysed to assess the impact of inorganic and diagenetic processes on the faunal remains. We paid special attention to abrasion due to its relationship with the erosion processes caused by the Inferno stream. One of the main taphonomic agents leading to abrasion is water transport (Shipman and Rose, 1983; Fernández-Jalvo and Andrews, 2003; Fernández-Jalvo and Andrews, 2016). In our sample, we recorded abrasion as some degree of rounding and polishing, taking into consideration its distribution on bone and tooth surfaces.

## 4. Results

The remains of domestic animals predominate in the assemblage, with sheep and goats being the most abundant (Fig. 2; Table 1). Wild species are also represented, including herbivores, carnivores and insectivores (Table 1).

Caprines were the most frequent domestic animal in the whole assemblage. Bone breakage and the abundance of immature individuals in the sample made differentiating between sheep and goat remains difficult. We therefore grouped the two taxa into a single category, caprines, and noted the species whenever possible. Based on the MNI,

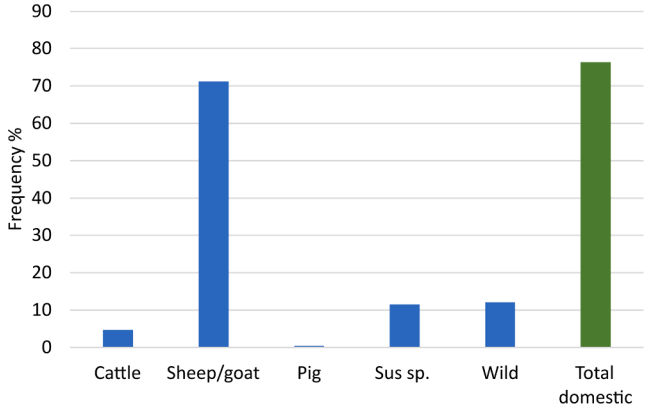


**Fig. 2.** Frequencies of domestic species (%NISP) compared to wild species.

**Table 1**
Quantification (NISP/NSP and MNI) of faunal remains from the Vallone Inferno layer 3.4, by taxon and weight-size category. The percentages (%NISP and % MNI) were compared to total NISP and MNI. The MNI of the remains identified by weight-size category was not calculated.

| | | NISP/NSP | | MNI | |
|---|---|---|---|---|---|
| **Taxonomy** | **Common Name** | **n** | **%** | **n** | **%** |
| *Bos taurus* | Cattle | 32 | 6.1 | 2 | 10.5 |
| *Ovis aries* | Sheep | 20 | 3.8 | 5 | 26.3 |
| *Capra hircus* | Goat | 11 | 2.1 | 2 | 10.5 |
| *Ovis aries/Capra hircus* | Sheep/goat | 452 | 87.2 | 8 | 42.1 |
| | Total domestic caprines | 483 | 93.2 | 15 | 78.9 |
| *Sus domesticus* | Pig | 3 | 0.6 | 2 | 10.5 |
| | **Total domestic** | **518** | **100** | **19** | **100** |
| *Sus* sp. | Wild boar/pig | 78 | 4.1 | 5 | 16.6 |
| *Cervus elaphus* | Red deer | 29 | 1.5 | 2 | 18.2 |
| Cervidae | Cervid | 23 | 1.2 | 2 | 18.2 |
| Leporidae | Hare | 3 | 0.2 | 1 | 9.1 |
| *Canis familiaris* | Dog | 2 | 0.1 | 1 | 9.1 |
| *Canis* sp. | Canid | 15 | 0.8 | 1 | 9.1 |
| *Felis silvestrys* | Wild cat | 3 | 0.2 | 1 | 9.1 |
| Mustelidae | Mustelid | 1 | 0.1 | 1 | 9.1 |
| Carnivora | Carnivores | 4 | 0.2 | 1 | 9.1 |
| Erinaceinae | Hedgehog | 2 | 0.1 | 1 | 9.1 |
| | **Total wild** | **82** | **4.1** | **11** | 9.1 |
| | **Total identified** | **678** | * | **35** | * |
| | Large size | 60 | 3.0 | * | * |
| | Medium size | 143 | 7.2 | * | * |
| | Small size | 885 | 44.3 | * | * |
| | Indeterminate | 230 | 11.5 | * | * |
| | **Total weight size** | **1318** | **66.0** | * | * |
| | **Total** | **1996** | * | **35** | * |

the ratio of sheep to goats is 5:2 (SI Table 3).

A minimum of 15 domestic caprine individuals were quantified according to dental eruption and wear criteria, and 11 individuals according to bone criteria (Table 1; SI Table 3 and 4). This difference in quantification is due to the greater precision of dental criteria. However, bone criteria must also be considered, which was most decisive in determining foetal and neonatal individuals. In total, 19 individuals were quantified, including four foetal individuals that were only identified by bone criteria. Excluding these foetal individuals, more than 50 % of the individuals were less than one year old at the time of death and 80 % were under two years old (Fig. 3). The foetal individuals identified were at different stages of gestation, from the end of the third month to the end of gestation (SI Table 4).

The distinction between pig and wild boar remains was based on the measurements of six lower suid teeth compared to the standard values of Neolithic pigs from Durrington Walls (Albarella and Payne, 2005) using the log-ratio technique (Meadow, 1999) (SI Fig. 1; SI Table 5). It was not possible to measure the postcranial skeleton due to its high degree of breakage. The lower teeth studied were from at least three individuals ranging in age from 0 to 12 months (SI Table 2). The values of at least two individuals from Vallone Inferno are below established standard values. The measurements of one of the dP3s are greater than the Durrington Walls standards, as are the widths of the *P*4 and M2. These data could indicate the presence of both wild and domesticated specimens in Vallone Inferno. Therefore, this article primarily refers to suids as a general category, considering that it can include both domestic and wild animals.

The small sample of suids and cattle precluded the creation of age-at-death profiles for these animals. At least one pig between 0 and 6 months of age and another between 6 and 12 months of age was identified (SI Table 2). In addition, three other suids (wild/domestic) were identified: an immature individual (0–6 months), a juvenile (1–2 years) and an adult (2–5 years). We only identified one cow, aged between 42 and 48 months.

Cattle, caprines, and pigs provided a very similar quantity of meat and offal weight (SI Table 6), even though cattle and pigs were represented by fewer individuals than caprines.

All anatomical regions of caprines were represented (Fig. 4a; SI Table 7); the appendicular elements, particularly the humeri, were the most abundant. Vertebrae and ribs were underrepresented due to the degree of breakage in the assemblage, and the difficulty of differentiating these elements taxonomically.

The representation of the anatomical regions of cattle and suids was not as complete (Fig. 4b and 4c; SI Tables 8, 9). Cattle mandibles and some forelimb and hindlimb elements were the most frequent. Suids were exclusively represented by the skull, especially isolated teeth, and phalanges.

Wild species represented 12 % of the total remains (excluding suids from quantification) (Fig. 2). Red deer remains were the most abundant (Table 1). Anthropogenic modifications caused by boiling, bone breakage and cut marks provided information on the hunting and processing of red deer and leporids for meat and skins (Table 2). We were unable to determine whether their presence at the site was due to anthropic or natural causes due to the absence of modifications and the scarcity of remains of other wild taxa (SI Table 1). Domestic taxa also presented anthropogenic modifications related to processing and

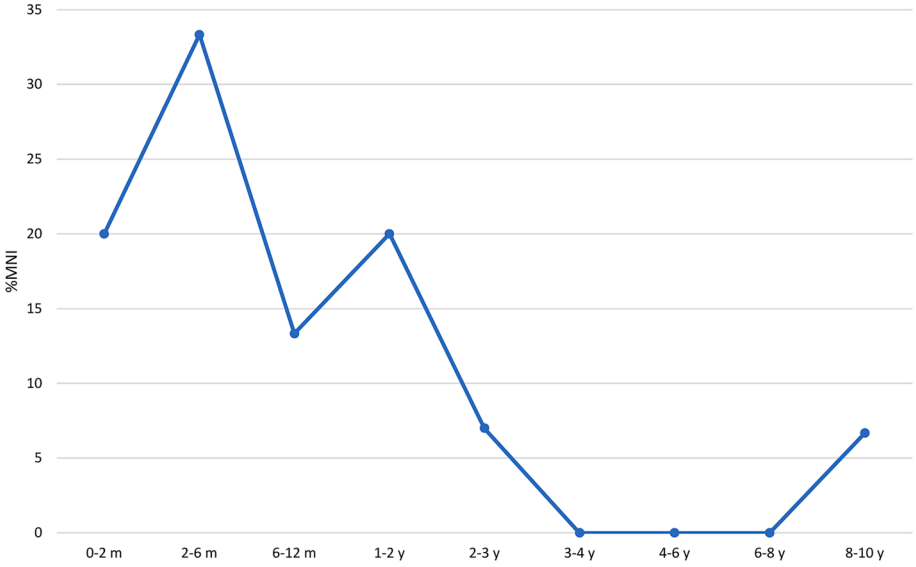


**Fig. 3.** Survivorship curves of Vallone Inferno caprines expressed in %MNI. Abbreviations: months (m), years (y).

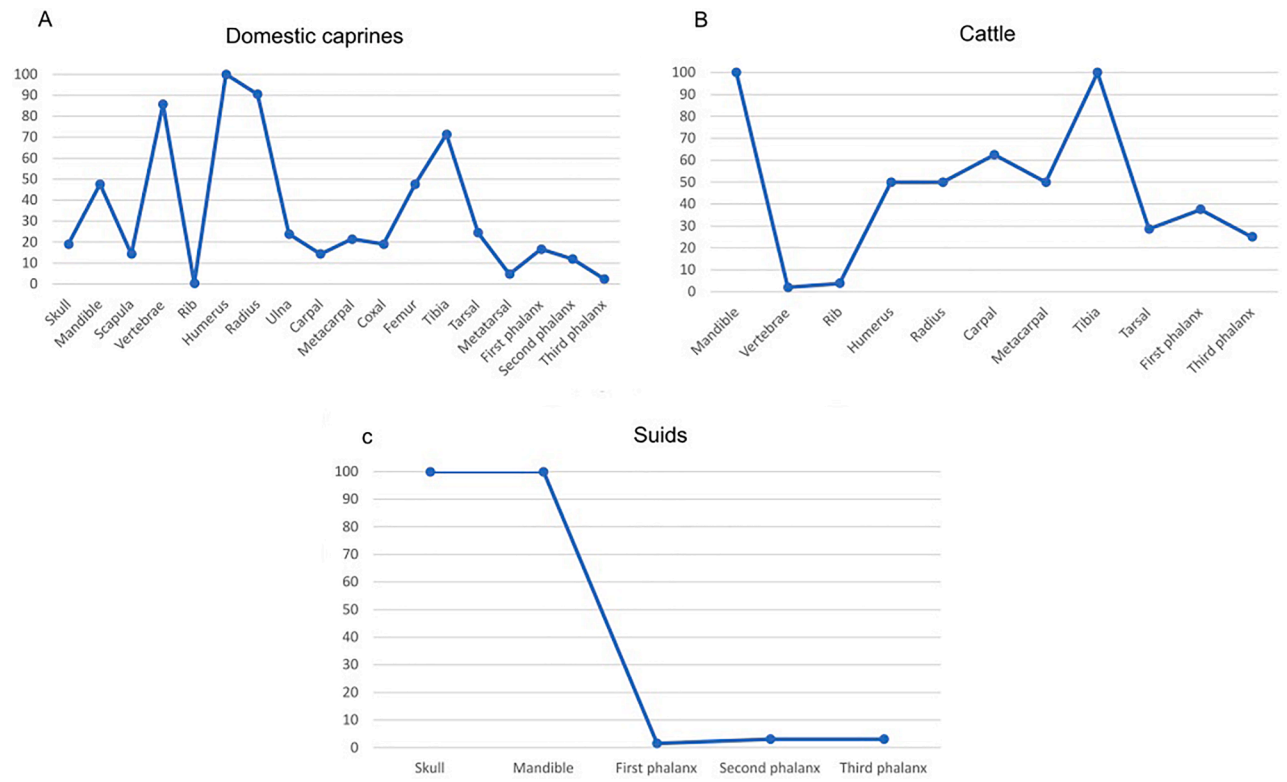


**Fig. 4.** Body part distribution curves in caprines (A), cattle (B) and suids (C) based on %MAU.

**Table 2**
Distribution of anthropic modifications by taxon, including the NISP and %NISP compared to total NISP of each taxon.

| | Cut marks | | Burning | | Boiling | | Breakage | |
|---|---|---|---|---|---|---|---|---|
| | NISP | % NISP | NISP | % NISP | NISP | % NISP | NISP | % NISP |
| Caprines | 25 | 5.2 | 24 | 5 | 44 | 9.1 | 62 | 12.8 |
| Cattle | 3 | 9.4 | 0 | 0 | 5 | 15.6 | 9 | 28.1 |
| Suids | 0 | 0 | 2 | 2.5 | 0 | 0 | 0 | 0 |
| Red deer | 2 | 6.9 | 0 | 0 | 7 | 24.1 | 6 | 20.7 |
| Cervidae | 2 | 8.7 | 0 | 0 | 0 | 0 | 4 | 17.4 |
| Leporids | 0 | 0 | 0 | 0 | 3 | 100 | 0 | 0 |

consumption (Table 2). Taphonomic alterations of the remains provided information on cooking processes (boiling), processing (cut marks and fracturing), and consumption (tooth marks) (NSP = 1193; %NSP = 39.2).

The incidence of modifications in the assemblage caused by inorganic processes was very low (Fig. 5). Black discoloration caused by manganese oxide was the most common alteration, followed by U shaped cross-section linear marks made by plants. Rounding was identified on 60 remains and polishing on 109. The degree of rounding was very low (R1) and microscopically affected the anatomical edges and fractures. The effect of polishing was also very low (*P*1 and *P*2) and was identified microscopically on fracture edges (*P*1) and bone surfaces (*P*2). These degrees of polishing and rounding are usually associated with low-energy water conditions (Shipman and Rose, 1983; Fernández-Jalvo and Andrews, 2003) or with other taphonomic processes, such as

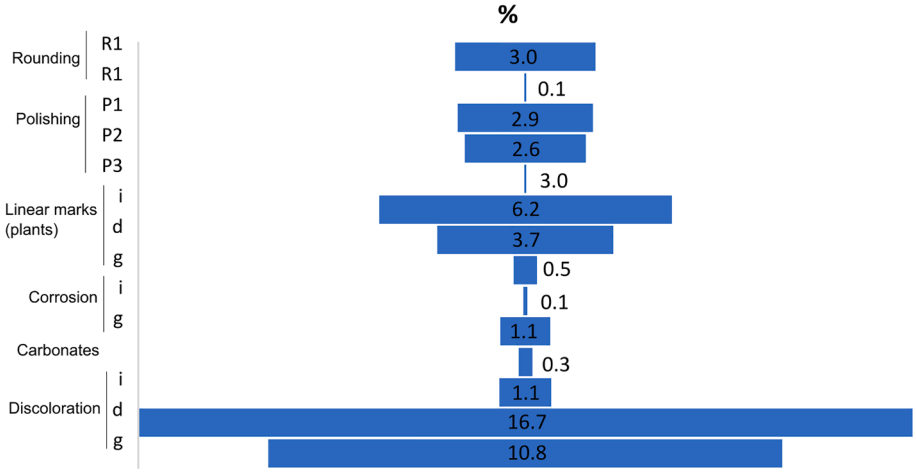


**Fig. 5.** Percentages of remains bearing taphonomic modifications related to inorganic processes. Abbreviations: isolated (i), dispersed (d), generalised (g).

boiling (White, 1992), which was also identified in the Vallone Inferno assemblage. Manganese, carbonates, and corrosion may also be related to hydrological processes (Fernández-Jalvo and Andrews, 2016). In any case, the low number of remains affected by these modifications seems to indicate a low incidence of erosive process caused by the Inferno stream on the preservation of the Vallone Inferno remains. Related to this, the anatomical frequencies of caprines, cattle and suids (Fig. 4; SI Tables 6, 7, 8) did not exhibit differential preservation of elements according to their density. Both high-survival (e.g., long bones and mandibles) and low-survival (e.g., phalanges) elements were documented (Marean and Cleghorn, 2003; Ioannidou, 2003).

## 5. Discussion

The mixed nature of the assemblage means that the conclusions that can be drawn from it are necessarily general and cannot be linked to either the Middle Neolithic or the Early Bronze Age occupations of Vallone Inferno. However, this is a pioneering work in terms of systematically approaching the first evidence of husbandry documented in the midlands of Sicily.

Husbandry was the main activity of the occupants of Vallone Inferno as evidenced by the high percentages of domestic species and low percentages of wild species uncovered at the site. This activity took full advantage of the diversity of flora of the Madonie massif and its orographic features (Massa, 2008).

Husbandry in Vallone Inferno was based on caprine rearing with a major focus on sheep breeding, a general trait of both MN and EBA Sicilian sites (Villari, 1995; Maniscalco et al., 2015a, 2015b). The abundance of immature individuals under two years of age, when they reach their optimum weight, would indicate that these animals were used to obtain meat. In addition, the abundance of individuals younger than six months of age may be related to milk exploitation (Payne, 1973). The fragments of *Tricromica figulina* pottery recovered in level 3.4 may be related to this use of dairy products. Isotopic analyses of individual fatty acids indicate that this type of vessel was used for unfermented ruminant dairy fats (McClure et al., 2018).

Pigs and cattle were also raised at Vallone Inferno for meat and probably milk, as well as to restock the herd in the specific case of cattle. In fact, although pigs and cattle were less numerous, they would have provided an amount of meat and offal very similar to that of caprines. Deer and leporid hunting was also a secondary source of meat and probably other resources, such as skins. Wild boar was also very probably hunted and consumed in Vallone Inferno. In this regard, the log-ratio analysis of the suids revealed some measurements exceeding the Durrington Walls standard values, which could correspond to wild boar remains (SI Fig. 1).

Similar values for domestic and wild animals were documented in the MN levels of Grotta dell'Uzzo (Tagliacozzo, 1993) and the EBA occupations of Case Bastione (Di Simone et al., 2019) (Fig. 6; SI Table 10). At these sites, breeding centred on domestic caprines, and hunting held greater importance than at other settlements near the coast less influenced by the mountains. Like Vallone Inferno, these two sites are located in high-relief areas. Case Bastione is located at 610 m.a.s.l. in the western Erei uplands (up to 1,192 m.a.s.l.) (Speciale et al., 2020), while Grotta dell'Uzzo is located at 100 m.a.s.l. at an intermediate point between the coast and the highest points of the Riserva Naturale dello Zingaro, which reach up to 900 m.a.s.l.

At other Sicilian open-air sites located in the lowlands near the coast with published faunal studies, MN as well as EBA, the percentages of domestic animals are significantly higher than those of hunted animals, and domestic caprines are the most abundant. At some of these sites, cattle also play an important role, in varying percentages. Hunting rates are important, even predominant, at Monte Belvedere and Catania Barriera and predominant in Rocchicella di Mineo. This variability in the

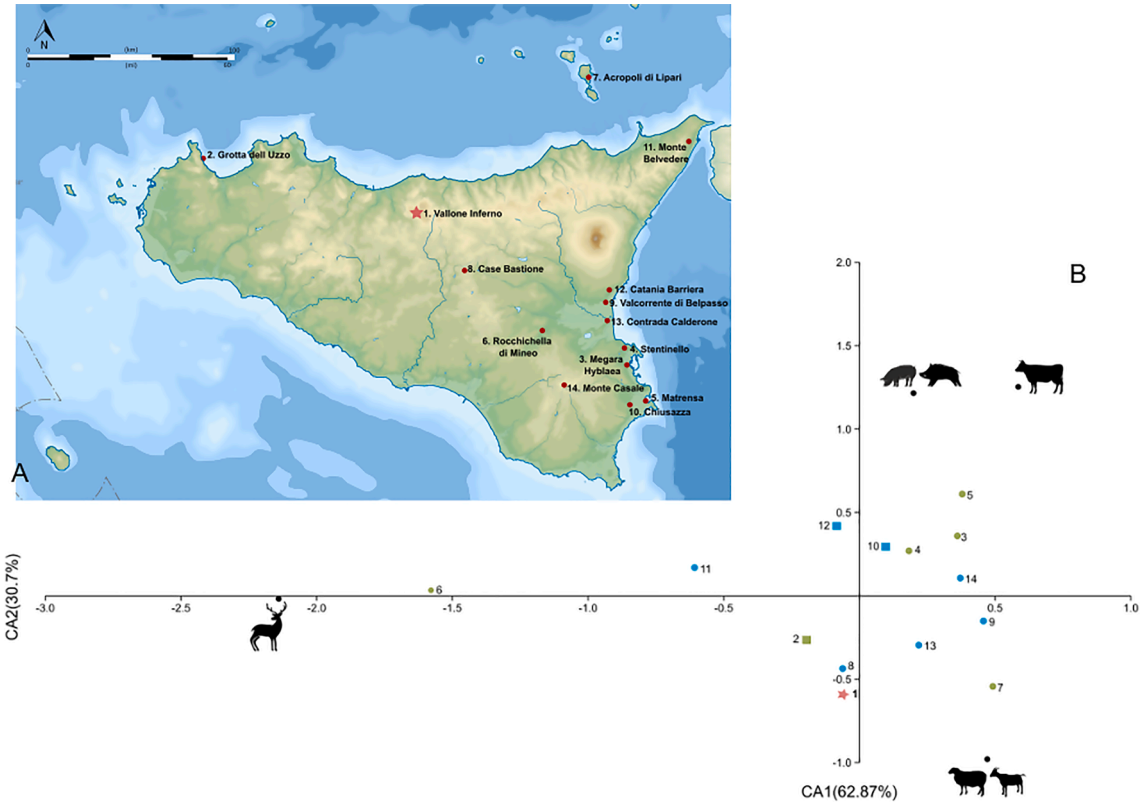


**Fig. 6.** A. Location of Middle Neolithic and Early Bronze Age sites with faunal data used for correspondence analysis. B. Correspondence analysis (CA) of husbanded and wild animals (red deer, fallow deer, leporids, dogs and/or equids) %NISP grouped by Middle Neolithic and Early Bronze Age Sicilian sites. The squares represent cave sites and the circles open-air sites. Green represents Middle Neolithic sites and blue Early Bronze Age sites. See raw data in SI Table 9.

patterns of exploitation of faunal resources at Sicilian sites indicates that animal husbandry was fully implemented from the Middle Neolithic onwards, with standardisation and intensification of domestic species breeding starting in the Early Bronze Age (Maniscalco et al., 2015a, 2015b). This process employed different adaptation strategies based on factors such as location and environmental conditions.

For Vallone Inferno, the economic system proposed, based on husbandry and complemented by hunting, allowed the groups to adapt well to the conditions and resources of the Madonie massif. Vallone Inferno is located on the mid-slopes of the Madonie massif at an elevation of 770 m.a.s.l., along a natural path between the Imera Valley and the summits. This location provides access to the natural resources of both the lowlands and the highlands. Mixed oak forests dating to the MN and the EBA have been documented in the surroundings (Forgia et al., 2013). The environment is well-suited to feeding domestic caprines and pigs, and good for hunting. On the other hand, both during the MN and the EBA, archaeobotanical analyses report a progressive opening of these midland and highland forests attributed to anthropogenic activities, mainly livestock farming, as cereal production was not widespread at these times (Tinner et al., 2016). In addition, cereal pollen values in Vallone Inferno are minimal (0.2 % in a single sample), while the indicators of pastoral pressure are very significant (around 50 % of the samples in the EBA phase).

According to the data provided by the palynological analysis, at level 3.4, and especially in the EBA occupation, some of the elements recovered are clearly linked to intensive anthropogenic land use. This implies the presence of grasses, plants associated with the practice of agricultural activities, weeds and ruderal herbs, which grow in environments rich in nitrogen, in addition to the negligible presence of cereals.

In fact, the results of the analysis of the seeds recovered in the MN and EBA phases point only to the presence of naked wheat, while evidence of crops, fruits and weeds is scarce. This would be consistent with the notion that agriculture spread from the fertile area in the south to the mountainous area in the centre and north of the island, consolidating in the area surrounded by Vallone later, already well into the Bronze Age (Leighton, 1999).

However, signs of livestock activity are much more clearly documented in the palynological record of Vallone Inferno, above all through the presence of plants that grow preferentially in contexts rich in nitrogen, such as Asteraceae, Poaceae and *Plantago* sp. These were especially relevant in the EBA context because, together with the presence of coprophilous fungi (*Polyporisporites*, *Neurospora* and *Chaetomium*), they clearly indicate the existence of pastoral pressure in the environment.

This opening up of the forests may have facilitated travel in the Madonie massif highlands for the practice of husbandry. In Mediterranean contexts, with summers marked by drought, vertical herd movements make it possible to optimise plant resource exploitation to feed herds. The herds spend the winter in the lowlands and the summer in the highlands to minimise the effects of drought (Halstead, 1987). Recent studies have suggested that the vertical movements of herds in Mediterranean contexts could date back to the 6th millennium cal BCE (Tejedor-Rodríguez et al., 2021). In fact, previous works have proposed seasonal (short) occupations of Vallone Inferno in relation to the practice of short- to medium-range seasonal movements of herds towards the uplands (Forgia, 2009; Forgia et al., 2021).

Several lines of evidence point to this. No knapping activities have been documented *in situ*. The number of ceramic fragments recovered is low and there is little typological variety, the sample consisting predominantly of storage vessels. In the Madonie massif and Imera Valley from Middle Neolithic times onwards, rivers served as a means to convey various cultural traditions, including pottery, with differences in vessels between the highlands and the river valley (Forgia et al., 2012). Vallone Inferno and Bommartino are the only sites in the Madonie from which *Castelluccio* facies have been recovered. The facies were mainly associated with settlements in the central and south-eastern parts of the island, and may be a proxy for the practice of vertical herd movements between lowland areas and the highest mountains on the island, Madonie and Nebrodi. Although there is no faunal data available from the Madonie highland areas because the nature of the sediment of these areas precludes bone preservation (Forgia et al., 2012), obsidian fragments have been documented, evidencing human occupations in the highlands (Forgia, 2009). Ethnographic examples also provide insight into these movements on the Madonie massif. Groups may have moved over short distances or travelled much greater distances. Either way, middle mountain pastures were occupied between March and May. The presence of flocks has also been documented in the village of Scillato in the winter and spring months, which were subsequently moved to high mountain pastures (1,400–1,500 m.a.s.l.) (Giacomarra, 2006).

The presence of perinatal remains in the faunal record suggests that part of the herd was bred on site and/or in the vicinity (Halstead, 1996), at least during the gestation period and the birthing season. Births in mid-latitude areas, such as Sicily, occur in the spring, between March and April (Balasse and Tresset, 2007). Assuming the shepherds did not modify this natural cycle, the data from layer 3.4 suggests that the cave was used at least during the winter and spring. The presence of shoots (possibly from the Rosaceae family) in the sequence, presumably harvested in spring, supports this interpretation (Forgia et al., 2013). Sequential isotope analysis of domestic caprine dental remains from Vallone Inferno would be needed to test the sheep and goat birth season and confirm the practice of vertical herd movement. The use of Vallone Inferno for seasonal and short occupations might explain the relatively low number of faunal remains recovered in each occupation, with partial anatomical representation of pigs and cattle. Traditionally, these two species are not part of the livestock movement system in Sicily (Giacomarra, 2006). These data could also be related to the occupation of the rockshelter for a large part of the year, but by small herds, as shown by the presence of some caprines aged between 6 and 12 months. These individuals, however, are young for the demands of highland movements and tend to stay in the sheepfold during their first year of life.

During these occupations, different domestic activities were carried out inside the Vallone Inferno rockshelter related to processing and consuming animals. This is attested to by anthropogenic processing modifications as well as the microwear analyses of obsidian tools (Di Simone et al., 2019; Forgia et al., 2021). In addition, considering the presence of foetal and neonatal individuals, the rockshelter was probably used as a breeding and birthing space for caprines. The use of caves as sheepfolds is a pattern observed during the Neolithic and Bronze Age (Rowley-Conwy, 1997; Miracle, 2006; Bréhard et al., 2010; Martín et al., 2016), for example, in Grotta dell'Uzzo (Brochier et al., 1992), which, like others on the Madonie massif, was used as a sheepfold even during the 20th century. Like Vallone Inferno, these caves were used as sheep and goat folds and as breeding and birthing places.

## 6. Conclusions

Little research has focused on the role of the island of Sicily in the spread of livestock farming in the Mediterranean. The earliest evidence of widespread adoption of livestock farming on the island dates back to the Middle Neolithic. This is one of the first studies dedicated to the analysis of early husbandry practices in Sicily, and the first to focus on a site located in the midlands of the north of the island, suggesting a seasonal shift of pastoral groups from the lowlands to the uplands.

Our results primarily revealed similarities between the organisation of the economic system at Vallone Inferno and other Sicilian sites with evidence of Middle Neolithic and Early Bronze Age occupations. These economic systems are all based on sheep and goat breeding, although there are some differences in the percentage representation of other domestic species and hunted animals. This is related to the groups' adaptation to the resources available in their environment. Thus, the herding groups of Vallone Inferno adapted to the environmental conditions of the Madonie massif and the midlands where the site is located.

The forest environment would have provided supplemental feed for livestock and served as a hunting area, and the site's proximity to the highlands would have provided the possibility of grazing. The shepherds carried out different domestic activities related to processing and using the animals inside the shelter. In addition, the abundance of perinatal sheep and goats may also be related to the use of the rockshelter as a sheepfold for these individuals.

## CRediT authorship contribution statement

**Patricia Martín:** Formal analysis, Investigation. **Chiara Messana:** Formal analysis. **Giovanni Di Simone:** Formal analysis. **Ethel Allué:** Writing – review & editing. **Isabel Expósito:** Writing – review & editing. **Andreu Ollé:** Funding acquisition, Writing – review & editing. **Josep Maria Vergès:** Writing – review & editing. **Vincenza Forgia:** Writing – review & editing, Project administration, Funding acquisition.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2022.103813.

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