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Two late 1800s wolves, *Canis lupus* Linnaeus, 1758 (Mammalia Canidae), from the Hyblean Mountains, in eastern Sicily

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ABSTRACT The wolf, *Canis lupus* Linnaeus, 1758 (Mammalia Canidae), became extinct in Sicily in the past century, between 1930 and 1960. The present paper describes the unpublished remains of two wolves, killed in the late 1800s in the Hyblean Mountains and preserved within the vertebrate collection of the Museo Civico di Storia Naturale of Comiso, Ragusa, (Italy), that is an important asset for biodiversity research as well as for morphological and genetic studies. The two specimens constitute the only finds of the species that are known so far for eastern Sicily. Their measurements and the restoration carried out for museum display are presented. A morphological description of these two specimens is provided and the taxonomic problems of the Italian and Sicilian populations are discussed.

KEY WORDS *Canis lupus*; extinction; museum; Hyblaean Mountains; Comiso; Sicily.

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INTRODUCTION

The wolf, *Canis lupus* Linnaeus, 1758 (Mammalia Canidae), belongs to the order Carnivora and the family Canidae. According to Bocedi & Bracchi (2004), about 40 subspecies have been described worldwide, of which more than 20 are in North America alone. Subspecies were initially distinguished on the basis of morphological features and their distribution. Often, even populations that are apparently geographically isolated and different in some well-defined external character are later found to be in connection with other populations. *Canis lupus* is in fact a highly variable species in both colour and size, so it is difficult to separate it into subspecies on the basis of these variabilities alone. Only a few subspecies are currently considered valid: *C. lupus lupus* L., 1758, in central and northern Eurasia, *C. lupus arabs* Pocock, 1934, the light and small form of the Arabian deserts, *C. lupus pallipes* Sykes, 1831, of southern Asia and the Middle East, as well as a couple of subspecies for North America that are now often distinguished into tundra wolf and forest (or gray) wolf depending on where they live (Boitani, 1986; Lopez, 1999). Some authors also recognise the subspecies *C. lupus lanigerfor* Hodgson, 1847, the Chinese wolf (Lopez, 1999),

while the red wolf from Texas and Louisiana has been questioned because it is considered a hybrid between the wolf and the coyote, *Canis latrans* Say, 1823 (Ferrari, 1997).

As for the wolf present in Italy, it had previously been ascribed to the subspecies *C. lupus italicus* (Altobello, 1921) on the basis of sparse findings. Genetic investigations, however, would disprove the validity of this subspecies (Randi et al., 2000) while others would confirm it (Montana et al., 2017; Reale et al., 2019). However, it should be considered that the Italian wolf shows reduced genetic differentiation from the wolves of Central and Eastern Europe, due to the recent geographic and genetic isolation of the remaining Italian population, whereas until the 19th century it was in continuity with other European populations. Therefore, even today, some scholars consider the existence of the subspecies "*italicus*" to be valid (Nowak & Federoff, 2002; Montana et al., 2017), but its classification is still hotly debated.

Sicily and Malta are the only Mediterranean islands to have been characterized by a population of this carnivore, its first fossil evidence in eastern Sicily dating back to the Middle Pleistocene (Fabiani, 1929; Hunt & Schembri, 1999; Bonfiglio et al., 2002).

During the Holocene, this canid spread abundantly in the area of Palermo, the forests around the Etna Mountain, the Peloritani Mountains, Nebrodi, Madonie, Sicani and Ficuzza, where it probably remained isolated until its extermination around 1930–1960 (Toschi, 1959; Cagnolaro et al., 1974; Angelici et al., 2016). The species was also present further south, in the Erei and Iblei Mountains, where it was reported until 1928 (La Mantia & Cannella, 2008). Recent studies have proposed the inclusion of the Sicilian wolf in the new subspecies endemic to the island *C. lupus cristaldii* (Angelici & Rossi, 2018). The taxon was described based on the examination of a taxidermically prepared specimen (holotype) that also included a separate skull preserved at the Museum of Zoology "La Specola" of the University of Florence (Italy). The three paratypes are instead a mounted specimen preserved at the "Regional Interdisciplinary Museum of Terrasini", Terrasini (Palermo, Italy); another mounted specimen preserved at the Museum of Zoology "Pietro Doderlein", University of Palermo (Palermo, Italy); and yet another mounted specimen preserved at the "Museo Civico Baldassarre Romano" in Termini Imerese (Palermo, Italy) (Angelici & Rossi, 2018).

This paper is concerned with reporting the discovery of two more Sicilian wolf specimens from the Hyblean Mountains - hitherto unknown - and commenting on their possible placement within the newly established local subspecies.

MATERIAL AND METHODS

Currently hosted in the vertebrate collections of the Museo Civico di Storia Naturale of Comiso (MSNC), the two eastern Sicily specimens in this study (MSNC 4906 and MSNC 4907) come from the Natural History Cabinet of the Royal Technical Commercial Institute "Archimedes," founded in Modica in 1866 (Figs. 1–6). The latter still contains several zoological preparations of 19th-century origin. The educators with a keen interest in nature who definitely gave rise to the Modican institute's naturalistic collection were Clemente Grimaldi (agronomist and botanist), Carlo Stoppani (priest and geologist), Pietro Lancetta and Giacomo Albo (science professor). The original collection included specimens of local and foreign fauna.

Their capture in the territory of Ragusa is confirmed by the original labels in their bases, but the name of the taxidermist, probably a local professional, is unknown. Specimen MSNC 4906 is a complete skeleton of wolf adult female, well-preserved (Fig. 1), on which a thorough restoration of the skull (Fig. 2) and wooden base was carried out, as well as cleaning of the disassembled skeleton by bleaching and degreasing the bones through immersion in 130–volume hydrogen peroxide and diluted ammonia in an aqueous solution for 24 hours. The original label in the wooden base shows the name of the species, vernacular name, female sex, place and date of capture with holographic inscription: "Modica, 5 Gennaio 1875" (Fig. 3). The skull was fractured in several places, undoubtedly due to the lead bullets with which the animal was killed. In particular, the branch of the right hemimandibula was damaged. The broken bone portions were bonded with cyanoacrylate glue, and the fractures were filled with white Apoxie®Sculpt. After curing, the filled fractures

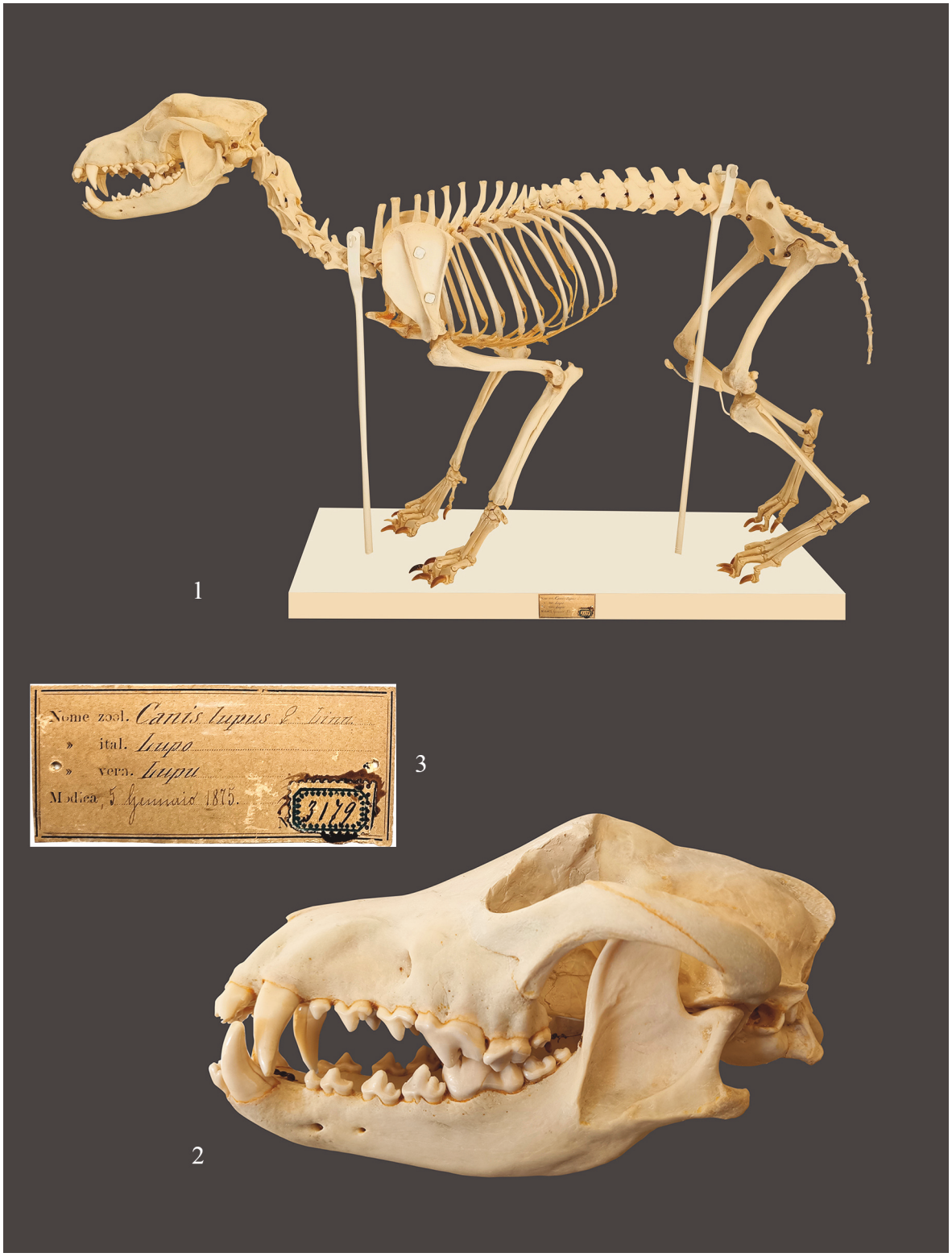

Figure 1. Female skeleton of *Canis lupus* (MSNC 4906). Figure 2. Female skull of *Canis lupus* (MSNC 4906). Figure 3. Original labels present on the bases of the two specimens of *Canis lupus* from the Hyblean mountains: female skeleton (MSNC 4906), "Modica 5 Gennaio 1875".

were stained with acrylic colors of the same shade as the bone.

Specimen MSNC 4907 belongs to a stuffed and fairly well preserved subadult male (Fig. 4). The original label in the wooden base shows the name of the species, vernacular name, male sex, place and date of capture with holographic inscription: "Modica, 24 Gennaio 1877

The taxidermist who prepared this specimen employed the classical method in use in the 20th century, consisting of stuffing of straw and twine, nails, iron rods for the four legs, and convex eyes of glass. The item had very dirty fur and the ventral suture was unstitched. For this reason, action had to be taken by carrying out a conservative restoration, gently washing the fur with neutral detergent and drying it delicately with a cold air blower. Subsequently it was partly sewn up ventrally with thread made of waxed polyester twine and other parts where it was not possible to sew it up due to the delicacy of the skin, it was consolidated with an impregnating agent based on Paraloid B79 diluted in acetone and polyvinyl acetate.

Also the wooden bases of both specimens were washed with neutral detergent, treated against woodworm, plastered with plaster and glue, and recoloured with acrylic basein matte white, the same original shade. The labels were dry-cleaned and reapplied in their original position on the bases and interspersed at the base with a layer of "Carton museum crescent" to make the preservation durable. This layer of cardboard consists of 100% pure cotton fiber and is also buffered with calcium carbonate, having a ph value of 8.5 to 9.5, which is able to

Figure 4. Stuffed male of *Canis lupus* (MSNC 4907).

reduce the oxidative effect of paper. Finally, both labels were fixed in their original position to the wooden base with brass pegs, removing the old iron pegs that were very rusty.

RESULTS

The two wolves (MSNC 4906 and MSNC 4907) were killed in the late 1800s in the Hyblean Mountains.

The coloration of the MSNC 4907 reflects the scientific description reported by Minà Palumbo (1868). In particular, it presents yellowish face with black ends of the dark hairs. Described as "*lionato*" (the colour of the lion) by Minà Palumbo (1868), this yellowish-isabella colour is more pronounced from the nostrils to the chin up to the nape of the neck. Black predominates because it is a young individual. Black moustache, from the back corner of the eye to the temples black predominates to the point of appearing like a wide band: fawn-brown ears externally, the entire back fawn-grey, streaked with black. The hairs form a fine ashen fluff with long coarse hairs. The colour is increasingly darker in the upper part, and almost black in the extremity. Generally speaking, the colour black predominates because it is a young individual. The legs are lighter in colour and the with whitish abdomen. Also forearms have, albeit slightly hinted, the typical line of the Apennine wolf (Figs. 5, 6).

Table I presents the measurements of the two specimens (MSNC 4906, 4907), while in Table II, skull measurements were obtained using the scheme proposed by Pitulko & Gasparov (2017).

DISCUSSION

The original occurrence of *C. lupus* in Sicily is undoubtedly based on the fossil record from the Middle Pleistocene onwards, as documented in particular for eastern Sicily, by the remains found in Contrada Tabuna di Ragusa (Fabiani, 1929; Patanè, 1936), Contrada Pianetti di Ragusa (Bonfiglio et al., 1997) and for western Sicily, by the caves in the Palermo area, Grotta dei Puntali, Grotta della Zà Minica, Grotta dei Carburangeli and Cava dell'Arena (Burgio et al., 2000, 2002). The analysis of the distinct faunal complexes that alternated in the

Figure 5. Detail of male *Canis lupus* forearm (MSNC 4907). Figure 6. Original labels present on the bases of the two specimens of *Canis lupus* from the Hyblean mountains: male stuffed (MSNC 4907), "Modica 24 gennaio 1877".

Pleistocene of Sicily shows that the wolf was present in different localities in both the Palaeolithic and Mesolithic "*Palaeoloxodon mnaidriensis*" fauna. The domesticated derivation of the wolf, namely the dog, also appears in the Neolithic. In the eastern territories of the island, no remains of the

carnivore are known in deposits from the Early Holocene, including associated Mesolithic faunas, while data from the Recent Holocene are very scarce (Mangano & Bonfiglio, 1998).

Angelici & Rossi (2018) proposed a new subspecies of Sicilian wolf, named *C. lupus cristaldii*, based on the examination of a few museum specimens from the 19th century from western Sicily. According to Angelici & Rossi (2018), the main phenotypic peculiarities of this Sicilian wolf could be summarised essentially in its smaller size compared to the continental population, due to the phenomenon of insular dwarfism, typical of species that have long since separated from the territories of their original population. Added to this would be some considerations on the colour of the coat, which would be characterised by "very pale tawny" shades somewhat reminiscent of the colouring of lions, the aforementioned "*lionato*" colour described by Minà Palumbo (1868). The forearms of the Sicilian wolf would also lack the dark brown band that characterises both the Apennine wolf and the rest of the world's population.

It should generally be considered that Angelici & Rossi (2018) may have missed the fact that the size of a naturalised specimen depends essentially on the taxidermist's ability to manipulate its skin and that, after so many years of naturalisation and the type of conservation, the depigmentation process can occur.

Angelici et al. (2018) also developed the genetic analysis of six specimens preserved in various Italian museums. The results of this study conducted on the mtDNA of the material just mentioned revealed that two specimens are characterised by the same haplotype, which differs by two subsubstitutions from the one currently most widespread in Italian wolves (W14) and by only one subsubstitution from the only other haplotype present in our country (W16). The third sample showed a "wolf-like" haplotype never described before, while the fourth is characterised by a haplotype commonly found in dogs. In this regard, it may perhaps be worth recalling that the effects of genetic drift on a population such as the Sicilian wolf, isolated even a short time ago (no more than 22–18,000 years ago) from the nearest continental population, can produce alleles, with the consequent phenotypes they represent, that are more common or rarer as successive generations pass, unequivocally characterising the new insular population.

Recent studies by Ciucani et al. (2023) sequenced four nuclear genomes and five mitogenomes from seven museum specimens in western Sicily to investigate the ancestry of the island's wolf, relationships with extant and extinct wolves and dogs, and diversity. The specimens considered turned out to be closely related to the *C. l. italicus*, although showing a clear lineage from European dogs of the Chalcolithic and Bronze Age, and confirming that the peculiar morphology and genetic origin of of wolves in Sicily remains debated. Overall, when it became extinct, the Sicilian wolf had high inbreeding and low genetic diversity, consistent with a population of an insular environment.

Measurements in cm	**MSNC 4906 femal skeleton**	**MSNC 4907 male stuffed**
Head-body length	86	104
Tail length	26	28.5
Height at withers	48	46
Height, including head	58.5	54
Ear length	-	8

Table I. Measurements of the two late 1800s specimens of *Canis lupus* from the Hyblaean mountains.

CONCLUSIONS

During the Pleistocene, the large mammalian faunas have been characterised by several changes corresponding to the faunal complexes that have varied from the typically insular Lower Pleistocene and Middle Pleistocene to the association of species with reduced or no endemism in the Castello F.C. (Upper Pleniglacial to Late Pleniglacial). The latter are derived from dispersive events and variations of large carnivore populations from southern Calabria.

It cannot therefore be ruled out that a Sicilian wolf with Pleistocene features became extinct even before this last faunal event and that it subsequently had a genetic turnover from *Canis lupus* cf. *italicus,*

N.	Femal skull MSNC 4906	Measurements (mm)
1	Total skull length	205
2	Condylobasal skull length	189
3	Basal skull length	178
4	Viscerocranium length	101
5	Length of the nasals	72
6	Breadth at the canine alveoli	41
7	Greatest palatal breadth at Pм4 position	66
8	Zigomatic breadth	117
9	Minimal interorbital breadth	35
10	Minimal breadth at the postorbital constriction	40
11	Greatest breadth of the braincase	61
12	Greatest occipital condylar breadth	41
13	Total alveolar length of tooth row	85
14	Alveolar length of cheektooth row Pm1-M2	71
15	Crown length of cheektooth row Pm1-M2	72
16	Crown length of tooth row Pm4-M2	56
17	Alveolar length of tooth row Pm4-M2	55
18	Pm4 crown length	19
19	Pm4 alveolar length	21
20	Pm4 greatest crown breadth	12
21	Pm4 greatest alveolar breadth	—
22	Palatal length	97
23	Snout height at Pm1–Pm2	36
24	Skull height at postorbital constriction	67
25	Total length from condyle process	153
26	Alveolar length of tooth row	96
27	Crown length of tooth row	—
28	Alveolar length of cheek tooth row Pm1-M3	78
29	Crown length of cheektooth row Pm1-M3	—
30	Alveolar length of molar row	38
31	Crown length of molar row	—
32	Alveolar length of M1 tooth	21
33	Crown length of M1 tooth	23
34	Alveolar breadth of M1 tooth	—
35	Crown breadth of M1 tooth	6
36	Mandible height behind the M1 tooth (measured atthe lingual side)	28
37	Mandible height behind the M3 tooth (measured at the lingual side)	32

Table 2. Skull measurements of specimen MSNC 4906, using the scheme proposed by Pitulko & Gasparov (2017).

from mainland peninsular Italy. Today, investigations into the genetic diversity of *C. lupus* show that the species can form structured populations, and this suggests a decline in population connectivity and gene flow, potentially due to human activity and disturbance of their habitat (Hindrikson et al., 2017; Goplùalakrishnan et al., 2019).

The specimen MSNC 4907, which we have just presented, shows the typical coloring described by Minà Palumbo (1868) for Sicilian wolves, but also presents the typical dark brown band of the Apennine wolf on the forearms, also present albeit weakly in paratype 2 described by Angelici & Rossi (2018).

Confirming that the peculiar morphology and genetic origin of the Sicilian wolf remain debated (Ciucani et al., 2023), the two specimens from the Museo Civico di Storia Naturale di Comiso represent the only evidence of the wolf in the Hyblean Montains, the only example of the population in eastern Sicily. For the reasons discussed above, and pending further confirmation, these specimens cannot be directly ascribed for the moment to the subspecies proposed by Angelici & Rossi (2018). The study group of the present work has already started further investigations to find out their genetic attribution, possible crossbreeding with dogs, but also the morphometric and a DNA comparison of fossil wolf remains found in the Hyblean region.

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