Dogs, Past and Present

An Interdisciplinary Perspective

Edited by

Ivana Fiore and Francesca Lugli

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2.1 Size Variation of the Middle-Late Pleistocene Grey Wolf (*Canis lupus*) from the Italian Peninsula

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Abstract

Here we present a preliminary report on the biometric variability of the upper and lower carnassial of *Canis lupus* from several late Middle to Late Pleistocene sites of Apulia (southern Italy). Our results indicate a dimensional trend of wolves which allows two distinct chronological morphotypes to be identified, represented by medium-sized forms, reported until the MIS 4 followed by larger forms starting with the MIS 3.

Keywords: canids, carnivoran, Mediterranean, Apulia, biochronology.

1 Introduction

During the Late Pleistocene, the grey wolf (*Canis lupus*) was one of the most common species in the Eurasian carnivoran guild. In literature the earliest occurrence of *C. lupus* in Europe was reported in France from the late Middle Pleistocene site of Lunel Viel (MIS 11) (Brugal and Boudadi-Maligne, 2011). This attribution was widely accepted by specialists until the recent chronological revision of the levels 9–5 of this site, currently referred to MIS 9-7 (Uzunidis-Boutillier 2017, 2020) or MIS 9-8 (Brugal *et al.* 2019). According to this, the first occurrence of *C. lupus* in Europe would undergo a substantial change and the well-preserved skull from the Italian site La Polledrara di Cecanibbio (dated at 340–320 ka; MIS 9; Anzidei *et al.* 2012) could therefore represent one of the earliest and most reliable evidence of this taxon in Europe, but unfortunately a detailed description of this specimen is still lacking. Other remains referable to MIS 11 and ascribed to *C. lupus* consist of few isolated remains from Atapuerca TD10 (Spain, Cuenca-Bescos and Garcia 2007) and a lower M_1 from Castel di Guido (Italy, Sala and Barbi 1996; Petronio *et al.* 2019). The stratigraphy sequence of the Castel di Guido was dated between 327 ± 34 ka and 260 ± 37 with the US-ESR method (MIS 9, Michel *et al.* 2001, 2009), while other sequences of the area have been recently dated suggesting an older age for the deposit (412 ± 2 ka with $^{40}Ar/^{39}Ar$, MIS 11, Marra *et al.* 2018). During this time span (MIS 11-9) the disappearance of *Canis mosbachensis* and the earliest dispersal of *C. lupus* occurred in Europe. The strong morphological affinity, the large biometric overlap and the intraspecific variability of the teeth documented in both species (Jiangzuo *et al.* 2018; Mecozzi *et al.* 2020a), make the attribution of the canid remains from MIS 12-8 still a problematic issue. The isolated teeth recovered from Atapuerca TD10 and Castel di Guido could represent the earliest occurrence of the species in Europe, but the scarcity of the material requires caution in taxonomic attribution. According to this, at present we prefer to consider the complete cranium from La Polledrara (Anzidei *et al.* 2012) the most reliable specimen to represent the first record of *C. lupus* in Europe.

Starting from the late Middle Pleistocene (early Aurelian), the grey wolf became a common element of the carnivoran guild in Europe (Sardella *et al.* 2014; Bertè and Pandolfi 2014; Mecozzi and Bartolini Lucenti 2018, Mecozzi *et al.* 2020a).

The taxonomic status of the late Middle to Late Pleistocene canids from the Italian Peninsula has long been debated, as the case of the well preserved material from the Level G of Grotta Romanelli site (Castro, Lecce), which was initially attributed to *Canis aureus* by Blanc (1920; 1928), successively referred to the small-sized *Canis mosbachensis* (Masini *et al.* 1991; Sala *et al.* 1992) and finally classified as *C. lupus* through morphological, biometric and CT-scan analysis (Sardella *et al.* 2014). The sample from Grotta

Figure 1. Fossil remains of *Canis lupus* from the Apulian Peninsula. (a) P3592, left hemimandible from Grotta Romanelli G; (b) P3590, left hemimandible from Grotta Romanelli G; (c) A8-25, right hemimandible from Avetrana 8; (d) AND17, right hemimandible from Avetrana 8; (e) CC394, right hemimandible from Cardamone; (f) CC10, right maxillary from Cardamone; (g) IN634, left hemimandible from Ingarano; (h) IN635, left hemimandible from Ingarano; (i) IN504, cranium from Ingarano; (j) MPND860, left hemimandible from Melpignano (Cava Bianco); (k) MPND859, right hemimandible from Melpignano (Cava Bianco); (l) MPND842, left maxillary from Melpignano (Cava Bianco); (m) M7449, cranium from Grotta della Jena; (n) M7450, mandible from Grotta della Jena; (o) ZINZ.B6 3-1-59, left hemimandible from Grotta Zinzulusa; (p) SSND201, left maxillary from San Sidero (SS3); (q) PU100373, left hemimandible from San Sidero 1. Scale bar: 3 cm.

Romanelli (Level G) is characterised by reduced size and slender cranial morphologies especially if compared with the Late Pleistocene wolves from Italy (Sardella *et al.* 2014).

Some authors suggest that an increasing of size during the last 300 ka can be recognised, (Bonifay 1971; Sansalone *et al.* 2015; Mecozzi and Bartolini Lucenti 2018), and some chronosubspecies were instituted on the basis of biometric analysis: *C. lupus lunellensis* (late Middle Pleistocene), *C. lupus santenaisiensis* (early Late Pleistocene) and *C. lupus maximus* (late Late Pleistocene) (Brugal and Boudadi-Maligne 2011; Boudadi-Maligne 2012).

In recent years, several biometric studies on fossil wolves from the Italian Peninsula have been performed, attesting the presence of two distinct chronological morphotypes: slender forms spanning from the late Middle to early Late Pleistocene, and robust ones from the second part of the Late Pleistocene (after MIS 3) (Sardella *et al.* 2014; Bertè and Pandolfi 2014; Sansalone *et al.* 2015; Mecozzi and Bartolini Lucenti 2018; Mecozzi *et al.* 2020a). Despite this, further studies are needed to clarify the time and mode of the dispersal of the robust *C. lupus* in the Italian Peninsula. The peculiar geographical position of the Italian Peninsula and the richness of the canid fossil record represents a great blend to depict the evolutionary history of this iconic predator in the framework of Mediterranean Europe.

Here, we present a large sample of *C. lupus* from late Middle to Late Pleistocene sites of Apulia (southern Italy) (Figure 1). Biometric comparison of the upper and lower carnassial provides preliminary remarks on the biochronology and body size variation of Italian wolves.

Table 1. Fossil material of *Canis lupus* from the late Middle to Late Pleistocene sites of the Italian Peninsula.

Sites+A1:G33	Abbreviations	Region	Age	MIS	References	Repository
La Polledrara di Cecanibbio	LPo	Latium	Middle Pleistocene	9	Anzidei *et al.* (1989)	
Melpignano - Cava Bianco	CBa	Apulia		9-8?	This work	PL
Melpignano - Cava Nuzzo	CNu	Apulia		9-8?	This work	PL
Melpignano - Mirigliano	Mir	Apulia		9-8?	This work	MPUN
San Sidero - SS3	SS3	Apulia		9-8?	This work	PL
Grotta del Poggio	GPo	Campania		6	Sala (1979)	
Grotta dei Ladroni	GLa	Apulia	Late Pleistocene	5	This work	IsIPU
Monte Tignoso	MTi	Tuscany		5	Del Campana (1909)	
Grotta Laceduzza	GLc	Apulia		4	This work	MPCCSM
Grotta Romanelli - Level G	GRo	Apulia		4-3	Sardella *et al.* (2014); this work	MUCIV
Grotta di Sant'Agostino	GSA	Campania		4-3	Tozzi (1970)	
Grotta Tina	GTi	Campania		4-3	Martini *et al.* (1974)	
Riparo Mochi	RMo	Ligury		3	Arellano (2009)	
Buca della Iena	BdI	Tuscany		3	Pitti and Tozzi (1971)	
Cava Spagnulo	CSp	Apulia		3	Mecozzi *et al.* (2017)	
Caverna Pocala	CPo	Friuli-Venezia Giulia		3	Bertè (2013)	
Grotta del Broion	GBr	Veneto		3	Bertè (2013)	
Grotta del Principe	GPr	Ligury		3	Arellano (2009)	
Grotta Mora Cavorso	GMC	Latium		3	Salari *et al.* (2017)	
Ingarano	Ing	Apulia		3	This work	PL
Grotta della Masseria del Monte	GMM	Apulia		3	Anelli (1959)	
San Sidero 1	SS1	Apulia		3	This work	MGP
San Sidero 2	SS2	Apulia		3	This work	MGP
Sternatia	Ste	Apulia		3	Rustioni *et al.* (1994)	
Avetrana 8	Ave	Apulia		3	Mecozzi and Bartolini Lucenti (2018); this work	MUST
Riparo Fumane	RFu	Veneto		3	Cassoli and Tagliacozzo (1994)	
Grotta della Jena	GJe	Apulia		3-2	This work	MPUN
Buco del Frate	BFr	Lombardy		2	Bertè (2013)	
Cardamone	Car	Apulia		2	This work	ITCGC
Covoli di Velo	CVe	Veneto		2	Bertè (2013)	
Grotta Paglicci	GPa	Apulia		2	Bertè (2013); Boscato (1994)	
Grotta Zinzulusa	GZi	Apulia		2	This work	IsIPU

2 Material and methods

The studied material was collected from localities in Apulia (Figure 1) and is housed in different Italian Institutions and Museums (Table 1): PaleoFactory Laboratory, Department of Earth Science, Sapienza, University of Rome (PL); Paleontological Museum of the University of Naples Federico II (MPUN); Italian Institute of Human Paleontology (IsIPU); Commercial Technical Institute 'Galilei-Costa' (ITCGC); Museum of Geology and Paleontology of Turin (MGP); Museum of Pre-Classical Civilisations of Southern Murgia (MPCCSM), Museum of Civilisation (former National Museum of Prehistory and Ethnography 'Luigi Pigorini') (MUCIV), University Museum of Earth Sciences, Sapienza University of Rome (former Museum of Paleontology, MPUR) (MUST).

Set up our comparison dataset by considering the available studies on *C. lupus* specimens from the late Middle to Late Pleistocene of the Italian Peninsula (Table 1).

The length of the upper (P^4) and lower (M_1) carnassial were taken to the nearest 0.1 mm with a digital caliper following Driesch (1976).

The average values of the teeth of the Apulian specimens were compared with literature data on late Middle to Late Pleistocene specimens from Italy standard univariate plot.

3 *Canis lupus* from several late Middle to Late Pleistocene sites of Apulia

3.1 The Apulian region

Apulia, which extends for more than 350 km from the north-west to the south-east, and with a minimum extension of 30 km along the south-west-north-east axis, occupies the southern part of the Italian Peninsula and, due to its conformity, can be considered as a peninsula within a peninsula. In this region many fossiliferous sites have been discovered since the end of the 1800s. Many of these, also include evidence of human occupation in this area with fossils attributed to *Homo neanderthalensis* and *Homo sapiens* (e.g., Fondo Cattiè, Corridi, 1989, Grotta Romanelli, Sardella *et al.* 2019), and a rich amount of artefacts attributable to the Middle and Upper Palaeolithic.

From a paleontological perspective, mammal faunas recovered from Apulian deposits are a reference point for the Italian large mammal biochronological scale, especially for the late Middle to Late Pleistocene (Grotta Romanelli, Ingarano, Melpignano, San Sidero; Petronio *et al.* 2007). Difficulties in reconstructing the evolution of mammal faunas in Apulia persist since most of the sites lacks clear chronological constrains. A new project to study the Pleistocene mammal faunas of Apulia started in 2016, with the aim to revise the fossil samples from several localities and their chronological context. For instance, many deposits have long been chronologically referred to the early Late Pleistocene (MIS 5, e.g., Melpignano, San Sidero, Grotta Romanelli; Sala *et al.* 1992; Bologna *et al.* 1994; Petronio *et al.* 2007), but the ongoing revision would suggest an older age (Meccozzi *et al.* 2021a).

3.2 Apulian sites

Here we discuss the age of *C. lupus*-bearing sites from the late Middle to the Late Pleistocene of Apulia.

The older remains were found in the karst fissures of Melpignano and San Sidero (fossiliferous area of Maglie, Lecce). The age of the deposits was generally attested at the early Late Pleistocene (MIS 5). A recent revision of the large mammal remains from these localities expanded their chronological attribution, with some faunal assemblages attributed to the late Middle Pleistocene (MIS 9-8, Mirigliano Collection, Cava Nuzzo, Cava Bianco of Mepignano and SS3 of San Sidero), whereas others were referred to the Late Pleistocene (MIS 3, Fissure 1 and Fissure 2 of San Sidero) (Mecozzi *et al.* 2021a; Table 1).

A preliminary faunal list from the lower deposit of Grotta Laceduzza was reported by Mecozzi *et al.* (2019). The study of mammal remains is still in progress (Table 1).

The canid sample from the level G of Grotta Romanelli was described by Sardella *et al.* (2014), including a nearly complete cranium. This cave is long considered a key site for the study of the past Mediterranean ecosystems thanks to its archaeological and palaeontological content, and the relative stratigraphical, geomorphological and radiometric data (Sardella *et al.* 2014, 2018, 2019). The ongoing revision of the stratigraphical succession and chronological framework of the deposit does not exclude a possible late Middle Pleistocene age for the lower complex (including the level G). Despite this, the canid sample from the level G is referred to MIS 4-3, following the historical framework.

Mammal remains from Ingarano have been studied in a number of works (Capasso Barbato *et al.* 1992; Petronio *et al.* 1996; Petronio and Sardella 1998; Bedetti and Pavia 2007; Iurino 2014; Iurino *et al.* 2015; Mecozzi *et al.* 2020b, 2021b). The level B was dated with the $^{329}Th/^{234}U$ method providing an age of 40 ± 2 ka. According to Bedetti and Pavia (2007), the vertebrate fossil remains and lithic artefacts were accumulated during the MIS 3.

The canid sample from Avetrana analysed here, was collected from bed 8. The revision of the mammal fauna from this level suggests a chronological attribution to MIS 3 (Mecozzi and Bartolini Lucenti 2018; Salari *et al.* 2019).

Remains of *C. lupus* from Grotta della Jena were figured by Giuscardi (1875) (Figure 2). Fieldwork activities on this deposit were conducted by F. Anelli during the 1950s, who also reported a preliminary faunal list (Anelli 1956, 1959), but the material was not formally described and figured. The faunal composition suggests an attribution to the latest Pleistocene (end of MIS 3-2). Here, we present the material of Giuscardi's collection.

Grotta Zinzulusa is one of the most renowned caves of Apulia, annually visited by approximately 70,000 people (Sardella *et al.* 2019). The cave includes several infilling successions which yielded rich vertebrate fossil and lithic samples (Iannucci *et al.* 2020). The studied material come from the upper levels B5-3 of the Antro B succession, chronologically referred to MIS 2.

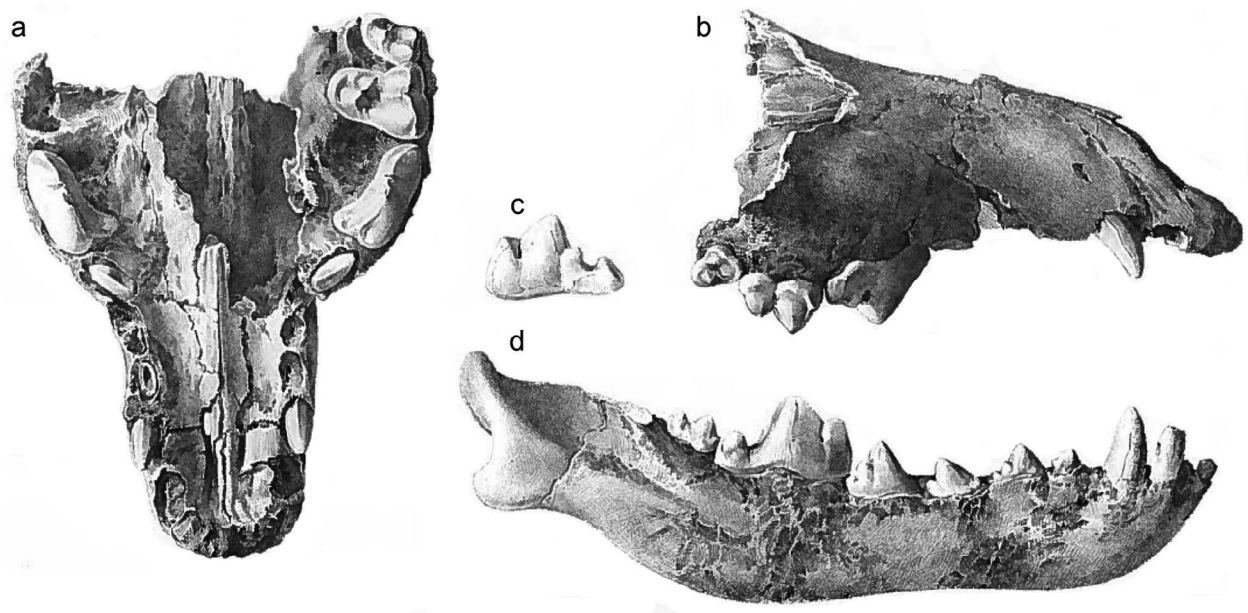

Figure 2. Historical representation of *Canis lupus* from Grotta della Jena. (a) rostrum in occlusal view; (b) rostrum in right lateral view; (c) M_1 in lingual view; (d) right hemimandible in right lateral view. After Giuscardi (1873).

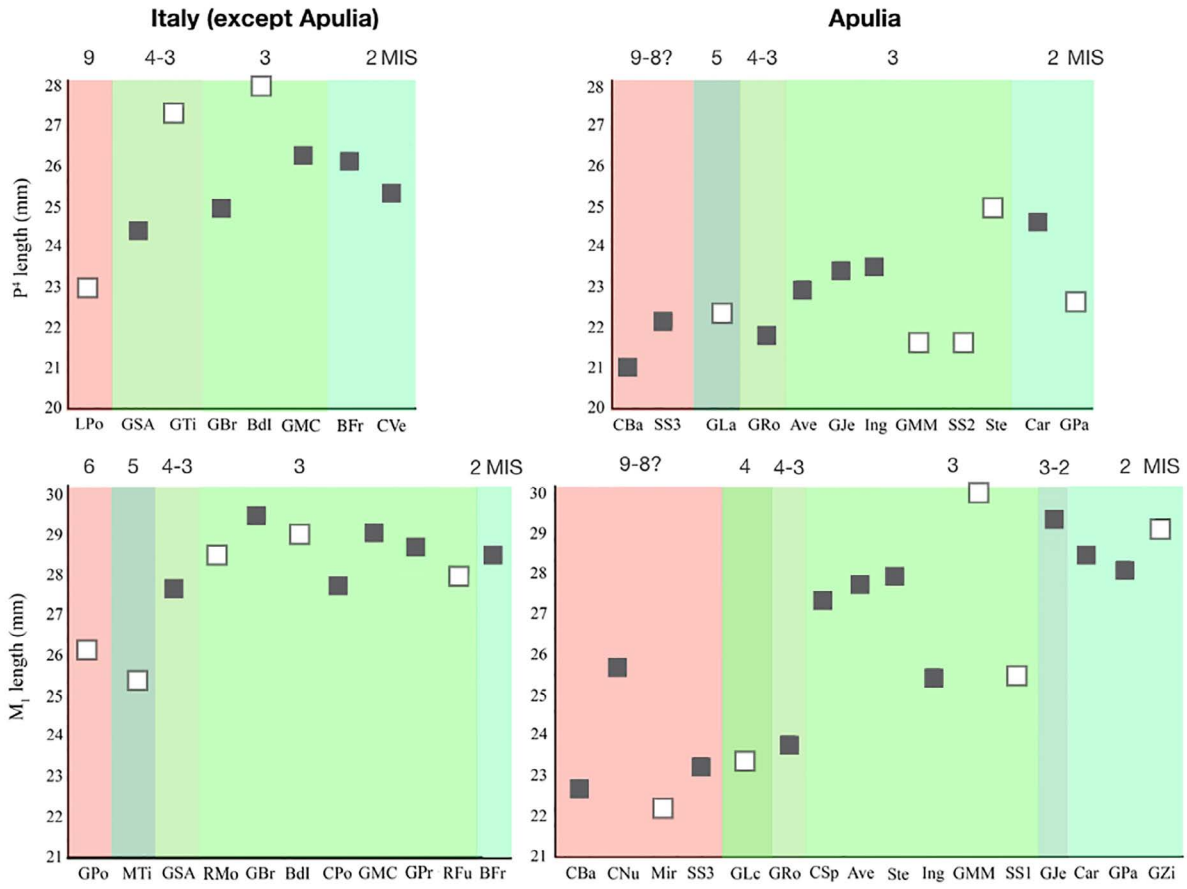

Figure 3. Variation in average length of the P^4 and M_1 of the Italian fossils of *Canis lupus* from the late Middle to Late Pleistocene sites. White squares indicate the presence of only one specimen per site, while grey squares indicate the presence of several specimens per site. For abbreviations see Tab. 1.

The faunal assemblage recovered from the karst infilling deposit of Cardamone was recently revised by Rustioni *et al.* (2003). The mammal fauna includes the woolly rhino (*Coelodonta antiquitatis*) and the woolly mammoth (*Mammuthus primigenius*), typical elements of the '*Mammuthus-Coelodonta* Faunal Complex'. Following this, the faunal assemblage was chronologically attributed to the climax of the Last Glacial Maximum (22–18 kyr).

4 Discussion and conclusions

According to our results, the relative increasing body size of the studied sample fits the general trend reported in literature (Bertè and Pandolfi, 2014; Sardella *et al.* 2014; Sansalone *et al.* 2015; Mecozzi and Bartolini Lucenti 2018), but with a different resolution between the upper and lower carnassial. The size variation of the P^4 during the time is less informative if compared to the M_1 in both the Italian and Apulian wolves (Figure 3). Focusing on the Italian specimens, those referred to MIS 9-5 would seem to be smaller compared to those from MIS 4-2, although the former are represented only by 1 P^4 and 2 M_1 respectively. More data for MIS 9-5 are required to better evaluate the time related variation of the size in Italian wolves.

Conversely, for the Apulian record the dimensional trend seems to be clearer, especially if the lower carnassial is compared to the sample from MIS (9-4), smaller than that from MIS 3-2 (Figure 2). Moreover, the specimens from Avetrana 8, Cava Spagnulo, Grotta della Jena and Grotta della Masseria del Monte show a larger size than those from Ingarano and San Sidero 1 (single M_1) indicating a considerable variation of the M_1 size during the MIS 3.

Excluding the sites of Ingarano and San Sidero 1, the length of the lower carnassial of the Apulian sample referable to MIS 3-2 overlaps with the Late Pleistocene (MIS 4-2) sample from Italian deposits (Figure 2).

However, among the other Italian sites, three are located in southern Italy, Grotta del Poggio (Sala 1979), Grotta di Sant'Agostino (Tozzi, 1970) and Grotta Tina (Martini *et al.* 1974). The first is referred to the late Middle Pleistocene (MIS 6), whereas the age of the other two is still unclear (probably MIS 4-3). The P^4 from Grotta Tina shows the largest size when compared to the whole Apulian record, whereas the dimension of the specimens from Grotta di Sant'Agostino are closer to those of Sternatia and Cardamone (Figure 2). For the M_1, the size of the specimen from Grotta del Poggio is smaller than those of MIS 4-2 from the Italian and Apulian sites. A few M_1s recognised from Grotta di Sant'Agostino are similar to those from Avetrana 8, Cava Spagnulo, Sternatia and Grotta Paglicci (Figure 2).

The biometric variation, especially of the M_1, can be interpreted as a consequence of a possible dispersal event from North to South of larger wolves which occurred during MIS 3 (Bertè and Pandolfi 2014; Sansalone *et al.* 2015; Mecozzi and Bartolini Lucenti 2018). Starting from MIS 2, the dimensions of the M_1 are very similar throughout the Italian Peninsula.

Unfortunately, Avetrana 8, Cava Spagnulo, Grotta della Jena and Grotta della Masseria del Monte have only been dated on a biochronological basis, preventing a detailed chronological attribution of this dispersal event.

In conclusion, the difference in the carnassial size, and in particular of the M_1, observed from the late Middle Pleistocene to early Late Pleistocene of the Italian record, can be interpreted as a dimensional trend of wolves, with medium-sized forms reported until the MIS 4 followed by larger ones starting with MIS 3. Compared to European fossil wolves, the size of the specimens from MIS 3-2 of the Italian Peninsula is closer to the large forms recognised in the second part of the Late Pleistocene (generally named *C. lupus maximus*, *sensu* Boudadi-Maligne 2012). The analysis of a wider sample and more craniodental characters is required to confirm such a trend.

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