



# THE EUROPEAN BADGER *MELES MELES* FROM MIDDLE PLEISTOCENE TO EARLY HOLOCENE OF ITALIAN PENINSULA

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## KEYWORDS:

*Mediterranean;*  
*Carnivoran;*  
*size variability.*

## BULLET-POINTS ABSTRACT

- The first occurrence of *Meles meles* is from the late Early Pleistocene (1.3 Ma).
- European badger is widely widespread across Europe during the Early Pleistocene to Late Pleistocene.
- The size variability of *Meles meles* is not linked to evolutionary trend through the Middle Pleistocene to Early Holocene and/or considered as response to climatic changes.

## INTRODUCTION

True badgers (genus *Meles*) are widely spread across the Palearctic region, from the Iberian Peninsula to the Japanese archipelago (Macdonald, 2001; Proulx et al., 2016). The taxonomy and the relationships of the different species represent yet unresolved issues in the study of the Mustelidae family (Baryshnikov et al., 2003). Based on craniodental morphology, skull proportions, color patterns of the face marks and baculum structure, at least three distinct species can be identified: the European badger *Meles meles* Linnaeus, 1758 (spread in Europe and Southwest and Central Asia), the Asian badger *Meles leucurus* Hodgson, 1847 (continental Asia) and the Japanese badger *Meles anakuma* Temminck, 1844 (Japan). In addition, molecular phylogenetic studies (Del Cerro et al., 2010; Tashima et al., 2011) and morphometric investigations (Abramov and Puzachenko, 2006; 2013) led to the distinction of badgers from Caucasus and Middle-East from the Eurasian stock, known as *Meles canescens* (Caucasian badger).

In Eurasian fossil record, the genus *Meles* Blanford, 1875 probably evolved from *Melodon* during the Ruscinian (early Pliocene) in the temperate forests of Asia (Kurtén, 1968). The early representatives of the genus were widespread throughout the Europe (Neal & Cheeseman, 1996), reaching the Iberian Peninsula during the Plio-Pleistocene transition (Madurell-Malapeira et al., 2009). According to several authors (Madurell-Malapeira, 2010; Madurell-Malapeira et al., 2011a), the remains from early to middle Villafranchian sites (Pliocene to Early Pleistocene) of Europe can be referred to a single species, *Meles thoralis*. This species differs from its descendant *M. meles* in

several cranial and dental features (see Madurell-Malapeira et al., 2011a). Albeit several badger species/subspecies were established on fossil specimens from the late Villafranchian to early Aurelian faunal assemblages of Europe (*Meles thoralis spelaeus* Bonifay, 1971; *Meles dimitrius* Koufos, 1992; *Meles hollitzeri* Rabeder, 1976; *Meles atavus* Kormos, 1914), all the badger remains from the late Early to Late Pleistocene have recently been reconsidered as ecomorphotypes of the highly variable *M. meles* (Madurell-Malapeira et al., 2011b).

In the Italian fossil record, the presence of this carnivoran is reported by few localities from Early to Middle Pleistocene (Mecozzi et al., 2019). Its first occurrence is from the late Villafranchian site of Pirro Nord (Pirro 10) (Apulia, southern Italy), represented by a mandibular fragment (Petrucci et al., 2013). Although the European badger is a common element of the Middle to Late Pleistocene mammal assemblage (see Mecozzi et al., 2019), its materials are rarely studied and described, with the exception for a splanchnocranial portion from the Italian site of Ingarano (Iurino, 2014).

The morphometric comparisons of European badger from Early to Late Pleistocene sites of Italian Peninsula is here presented, in order to investigate the variability of fossil material.

## MATERIAL & METHODS

The sample of *Meles meles* is housed in several Italian Institutions and Museums were used as standard extant comparison (Tab. 1): fossil collections from the Middle Pleistocene sites of Casal Selce, G.R.A. Km2,

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Site	Abbreviation	Region	Age	MIS	Reference
Cava di Breccia	CBr	Italian Peninsula	Middle Pleistocene	16	This work
G.R.A. Km 2	G.R.A.	Italian Peninsula	Middle Pleistocene	12	This work
Melpignano	Mel	Italian Peninsula	Middle Pleistocene	9-8	This work
San Sidero	SSi	Italian Peninsula	Late Pleistocene	9-8	This work
Torre del Pagliaccetto	TPa	Italian Peninsula	Middle Pleistocene	7	Caloi & Palombo (1978)
Grotta Cucigliana	GCu	Italian Peninsula	Late Pleistocene	5	Del Campana (1914)
Grotta Laceduzza	GLa	Italian Peninsula	Late Pleistocene	4	This work
Grotta Uluzzo C - III	GUC-III	Italian Peninsula	Late Pleistocene	4	This work
Avetrana	Ave-8	Italian Peninsula	Late Pleistocene	3	This work
Buca della Iena	BdI	Italian Peninsula	Late Pleistocene	3	Pitti & Tozzi (1971)
Grotta Masseria del Monte	GMM	Italian Peninsula	Late Pleistocene	3	Anelli (1959)
Fondo Focone	FFo	Italian Peninsula	Late Pleistocene	2	This work
Grotta della Fornace	GdF	Italian Peninsula	Late Pleistocene	2	Fabiani (1919)
Santa Maria d'Agnano - Esterno	SMA-E	Italian Peninsula	Late Pleistocene	2	This work
Grotta Romanelli	GRo	Italian Peninsula	Early Holocene	1	This work
Extant <i>Meles meles</i>	Ext	Italian Peninsula			This work

**Tab. 1.** Extant and fossil remains from Middle Pleistocene to Early Holocene of *Meles meles* from Italian Peninsula.

Melpignano and San Sidero, and the Late Pleistocene sites of Avetrana and Early Holocene site of Grotta Romanelli are stored at the PaleoFactory Laboratory, Department of Earth Science, Sapienza, University of Rome; those from the Late Pleistocene sites of Grotta Laceduzza and SMA-esterno to at the Museo delle Civiltà preclassiche della Murgia Meridionale, Ostuni (Brindisi); those from the Late Pleistocene site of Fondo Focone at the Istituto Italiano di Paleontologia Umata (IIPU); those from the Late Pleistocene site of Grotta Uluzzo C at the Museo di Storia Naturale, Sezione di Geologia e Paleontologia, dell'Università di Firenze (Florence).

As comparison material extant badgers from Italian Peninsula has been used, belonging to the collections of the following Institutions: Museo di Storia Naturale G. Doria, Genova; Museo Friulano di Storia Naturale, Udine; Museo Civico di Storia Naturale, Milano; Museo di Zoologia dell'Istituto Superiore per la Protezione e la Ricerca Ambientale, Ozzano dell'Emilia (Bologna). According to [von den Driesch \(1974\)](#), 3 dental variables have been considered: the length of upper carnassial ( $P^4L$ ), length of the upper first molar ( $M^1L$ ) and length of the lower carnassial ( $M_1L$ ). The measurements were taken to the nearest 0.1 mm with a digital calliper. Literature data on fossil badgers from the Middle to Late Pleistocene sites of Italy used here are reported in Tab. 1. The variation in size of upper carnassial ( $P^4L$ ), upper first molar ( $M^1L$ ) and length of the lower carnassial ( $M_1L$ ) of the late Early to Early Holocene is tested throughout the time.

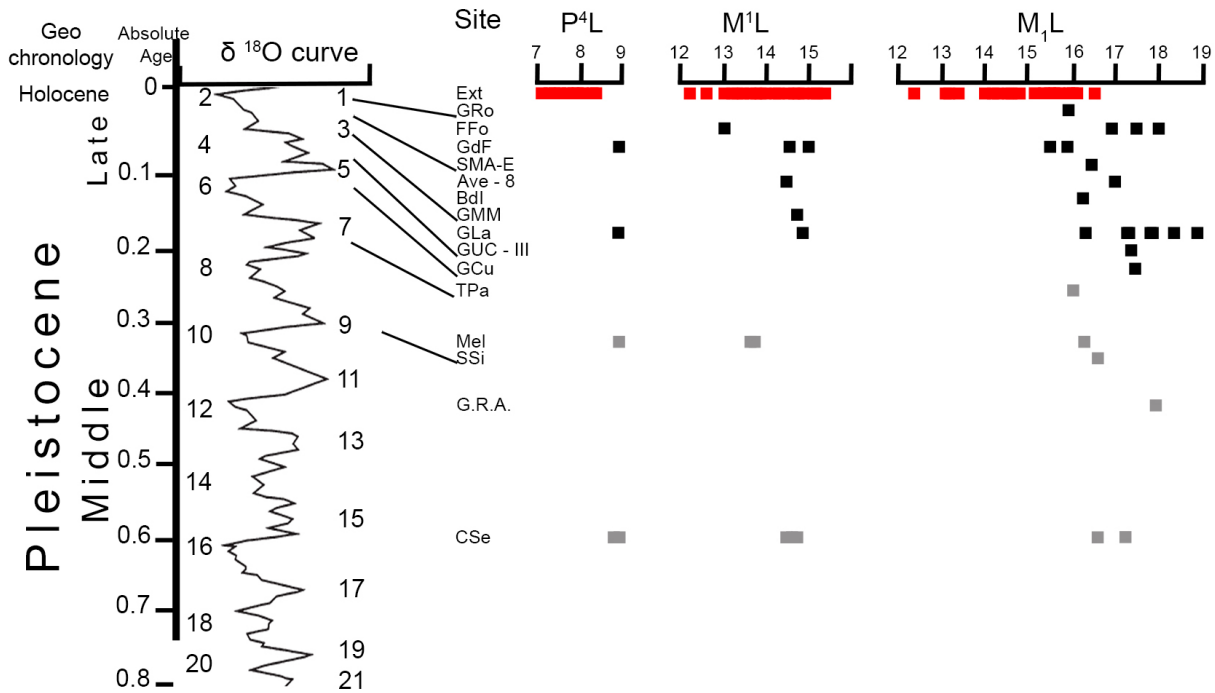
## DISCUSSION

The upper and lower teeth of *M. meles* from all

the considered Pleistocene sites show a moderate variability, excepted for lower carnassial (Fig. 1). The size upper carnassial is quite constant and no difference can be detected through the Middle Pleistocene to Early Holocene (Fig. 1). However, the  $P^4L$  in fossil *M. meles* is larger than in the extant Italian badger (Fig. 1). The dimension of the upper first molar of the fossil specimens falls in the large values of the variability of the extant *M. meles* (Fig. 1). The reduced values in the  $M^1$  were detected from the Middle Pleistocene site of Melpignano and Late Pleistocene site of Fondo Focone (Fig. 1).

Considering the lower carnassial, the fossil sample is larger on average than the extant Italian badger (Fig. 1). The size variability of the lower carnassial cannot be linked to evolutionary trend or geographical difference. The larger specimens are from the Middle Pleistocene samples site of G.R.A. Km2 and from the Late Pleistocene of Grotta Laceduzza and Fondo Focone; the range dimension of these specimens falls out the variability of the extant Italian badger.

The extant European badger possesses a high ecological tolerance, able to occupy a wide habitat range, with different climatic condition. Its wide distribution reflects the large phenotypic and genotypic variability, which led the identification of at least three distinct species. According to [Mecozi et al. \(2019\)](#), the fossil *M. meles* from the Pleistocene European sites shows a large craniodental variability, albeit the scarcity of fossils and their distribution over a large temporal and spatial scale, characterized by different climatic and ecological conditions. Due to this variability, the identification of a possible clinal variation and/or evolutionary trend is complicated.



**Fig. 1.** Size variation in *Meles meles*, as indicated by the length of the upper carnassial (P<sup>4</sup>L), upper first molar (M<sup>1</sup>L) and lower carnassial (M<sub>1</sub>L). Geochronology, age in millions of years and Oxygen isotope curves (after Shackleton, 1995) on the left, next the fossiliferous sites and their suggested ages indicated by line. Colors: red – extant specimens; black – Late Pleistocene to Early Holocene specimen; grey - Middle Pleistocene specimen.

The morphological and morphometric variability of fossil European badgers led the proliferation of several different evolutionary hypotheses and several species/subspecies, such as *Meles thoralis spelaeus* (late Middle Pleistocene, Lunel-Viel, France), *Meles dimitrius* (Early Pleistocene, Gerakarou and Apollonia, Greece), *Meles hollitzeri* (Early Pleistocene, Untermassfeld, Germany, and Deutsch-Alternburg 2, Austria), *Meles atavus* (Middle Pleistocene, Betfia-5, Hungary). An alternative scenario was recently proposed by [Madurell-Malapeira et al. \(2011b\)](#), which attributed the remains from the late Early Pleistocene to Late Pleistocene to a single species *M. meles*.

Considering the fossil sample from the Italian Peninsula, there is no morphometric differences among the specimens from early Middle Pleistocene, late Middle Pleistocene, Late Pleistocene and Early Holocene sites. Whilst the length of both upper carnassial and upper first molar is quite constant through the time; the length of lower first molar is huge variable. Despite this, its variability fails to reflect evolutionary trend through the time and/or size variation as response to climate. For instance, the specimens from the Last Glacial sites (MIS 2, Late Pleistocene) of Fondo Focone, Grotta della Fornace and SMA-esterno show a large morphometric variability, which completely fall in the dimensional

range of both fossil and extant materials.

## CONCLUSION

A large sample of European badger from Middle Pleistocene to Early Holocene of the Italian Peninsula was here analyzed. The morphometric comparison of the fossil and the extant specimens confirms the moderate size variability of this carnivoran. This size variation seems to be not linked to evolutionary trend through the Middle Pleistocene to Early Holocene and/or considered as response to climate. In this scenario, in accordance with [Madurell-Malapeira et al. \(2011b\)](#), the European fossil record should be referred to a highly polymorphic species *M. meles*.

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