

SIMONE FARINA (*)

LATE PLEISTOCENE MAMMALS FROM «GROTTA PARIGNANA» (MONTE PISANO, ITALY): BIOCHRONOLOGICAL IMPLICATIONS

Abstract - Late Pleistocene mammals from «Grotta Parignana» (Monte Pisano, Italy): biochronological implications. The classification of the fossil mammalian remains from «Grotta Parignana» is updated. Of the many taxa represented in the sample, some have never before been reported. These include *Felis silvestris* and *Cricetus* sp.

Basic information allowed to assess the minimum number of individuals and to make assumptions on the environmental conditions under which the fauna lived. The study permits to hypothesize the occurrence of two faunal assemblages (Parignana A and B). A comparison of the Parignana fauna with several other past mammal associations from central Italy indicates that it should be dated to an interval spanning the end of the MIS 5a or the beginning of MIS 4 (Parignana A) and the MIS 3 (Parignana B).

Key words - Mammals, Late Pleistocene, Monte Pisano, biochronology.

Riassunto - I mammiferi del Pleistocene Superiore della «Grotta di Parignana» (Monte Pisano, Italia): implicazioni biochronologiche. Vengono presentati i risultati dello studio paleontologico della collezione storica della Grotta di Parignana. Il lavoro ha consentito il recupero e la revisione sistematica dei resti fossili. Sono stati riconosciuti numerosi taxa, fra i quali alcuni mai citati in precedenza in questo sito, come *Felis silvestris* e *Cricetus* sp.

I dati raccolti hanno permesso di calcolare il numero di individui per una valutazione delle abbondanze relative dei taxa. Lo studio ha permesso di ipotizzare la presenza di 2 associazioni faunistiche (Parignana A e B) riferibili al Pleistocene Superiore vissute in condizioni climatico-ambientali diverse.

Inoltre, vengono tentate delle correlazioni biochronologiche tra queste associazioni e altre faune a mammiferi note, rinvenute in numerosi depositi del versante tirrenico dell'Italia centrale e riferite al Pleistocene Superiore.

Si ipotizza che l'associazione Parignana A sia riferibile alla fine dello stadio isotopico 5a o all'inizio dello stadio isotopico 4, mentre l'associazione Parignana B allo stadio isotopico 3.

Parole chiave - Mammiferi, Pleistocene Superiore, Monte Pisano, biochronologia.

INTRODUCTION

Tuscany has provided wealthy collections of fossil vertebrate remains of different ages. The most significant Late Pleistocene mammalian assemblages are those from Monte Tignoso (Livorno) (Caloi & Palombo, 1994; Del Campana, 1910; Malatesta, 1943), Maspino (Arezzo) (Azzaroli, 1979), «Grotta Gosto» (Siena) (Tozzi, 1974) and from several sites close to the Apuan Alps, such as «Buca del Tasso» (Fabiani, 1923), «Grotta del Capriolo» and «Buca della Iena» (Pitti &

Tozzi, 1971), «Grotta all'Onda» (Campetti *et. al.*, 2001), and especially the Equi Terme caves (De Stefani, 1916; Del Campana, 1947).

Monte Pisano is an isolated mountain that separates Pisa and Lucca plains. It is located between Arno and Serchio valleys (Fig. 1) (Rau & Tongiorgi, 1974). The South-Western side of Monte Pisano is rich in karst caves discovered in the second half of 1800 and rich in Late Pleistocene mammal fossils, such as those discovered at «Grotta di Cucigliana» (Acconci, 1880; Del Campana, 1914; Farina, 2011a), «Grotta del Leone» (Cardini, 1947; D'Eugenio, 1990) and «Buca dei Ladri» (Bianucci, 1980). Other fossil remains were collected from two quarries, «Cava la Croce» (Agnano) and «Cava le Conche» (Caprona) (Tavani, 1951). Grotta Parignana (also named «Buca delle Fate» or

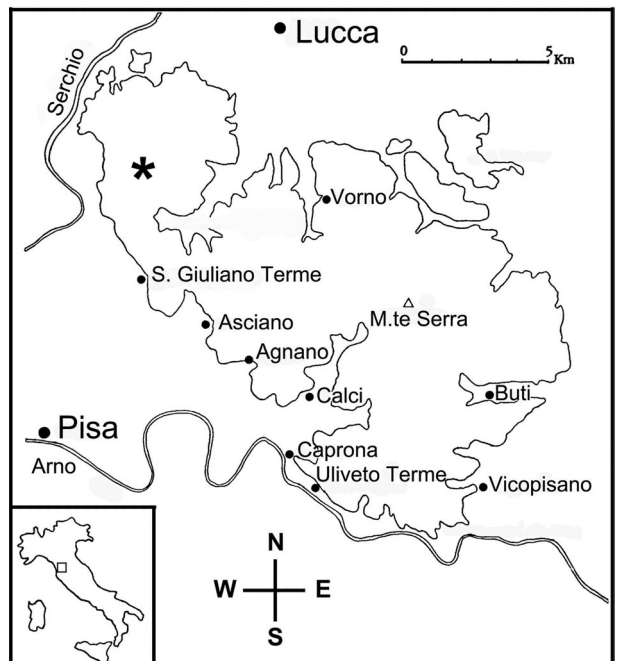


Fig. 1 - Map of the Monte Pisano area. The * represents the geographic position of «Grotta Parignana» (Ragaini, 1992, modified).

(*) Museo di Storia Naturale dell'Università di Pisa, via Roma 79, I-56011 Calci (Pisa) (Italy)
E-mail: simonefarina@inwind.it; simonefarina77@gmail.com

«Grotta delle Molina»; Caterini, 1921) (North Latitude 43°47'58.5" – East Longitude 10°26'04,5") is located at 230 m a.s.l., near San Giuliano Terme (Fig. 1). It is accessible by a narrow entry hole 9 m long. The cave consists in two rooms (A and B, Fig. 2) and the fossil material was collected from room B (Caterini, 1921).

Grotta Parignana was discovered by Carlo Regnoli in 1866 who collected abundant mammal remains. In later times, other specimens were recovered by Prof. M. Canavari, Forsyth Major, Prof. Stoppani and Mr De Bosniaski (Caterini, 1921).

The fauna was preliminarily examined by Regnoli and Forsyth Major. Subsequently, Caterini (1921) examined mammal remains and Del Campana (1925) worked on birds. Mammals include abundant *Marmota marmota*, *Ursus arctos*, and *Cervus elaphus* remains (Caterini, 1921), whereas birds have no paleontological interest (Del Campana, 1925).

According to Caterini (1921), the «Grotta Parignana» mammals are a Late Pleistocene fauna. Though abundant, the fossils were unfortunately collected with no concern for their stratigraphic position. This caused the loss of a great deal of valuable stratigraphical information.

The present work has two aims: the first is updating the classification of the paleontological collection of Grotta Parignana; the second is comparing the Parignana faunal assemblages with the most important and well dated Late Aurelian (Gliozzi *et al.*, 1997) mammal associations of Tuscany and Latium, to improve the biochronological framework of the Late Pleistocene in central Italy.

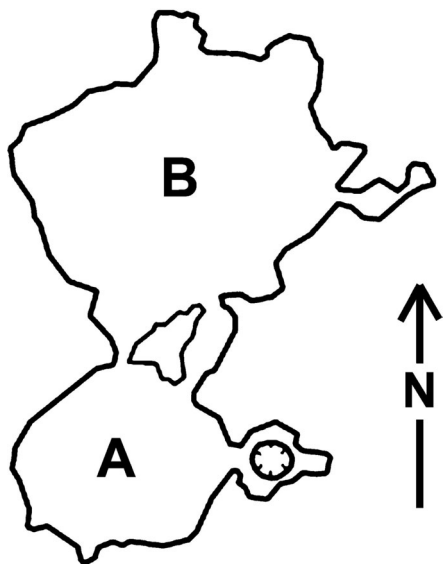


Fig. 2 - Plan of «Grotta Parignana». The scale is 1:100 (Caterini, 1921, modified).

MATERIALS AND METHODS

The paleontological collection of Grotta Parignana is now housed mainly at the «Museo di Storia Naturale dell'Università di Pisa», whereas a smaller part is stored at the «Dipartimento di Scienze Archeologiche dell'Università di Pisa». It consists of 1245 specimens. The material has been determined both anatomically and taxonomically, and the standard taphonomic parameters NISP (Number of Identified Specimens), MNE (Minimum Number of Elements) and MNI (Minimum Number of Individuals) (Grayson, 1984; Lyman, 2008; Chaplin, 1971) were calculated to evaluate the relative frequency of the taxa. MNE and MNI were assessed both on post-cranial and cranial specimens, taking into account age and size.

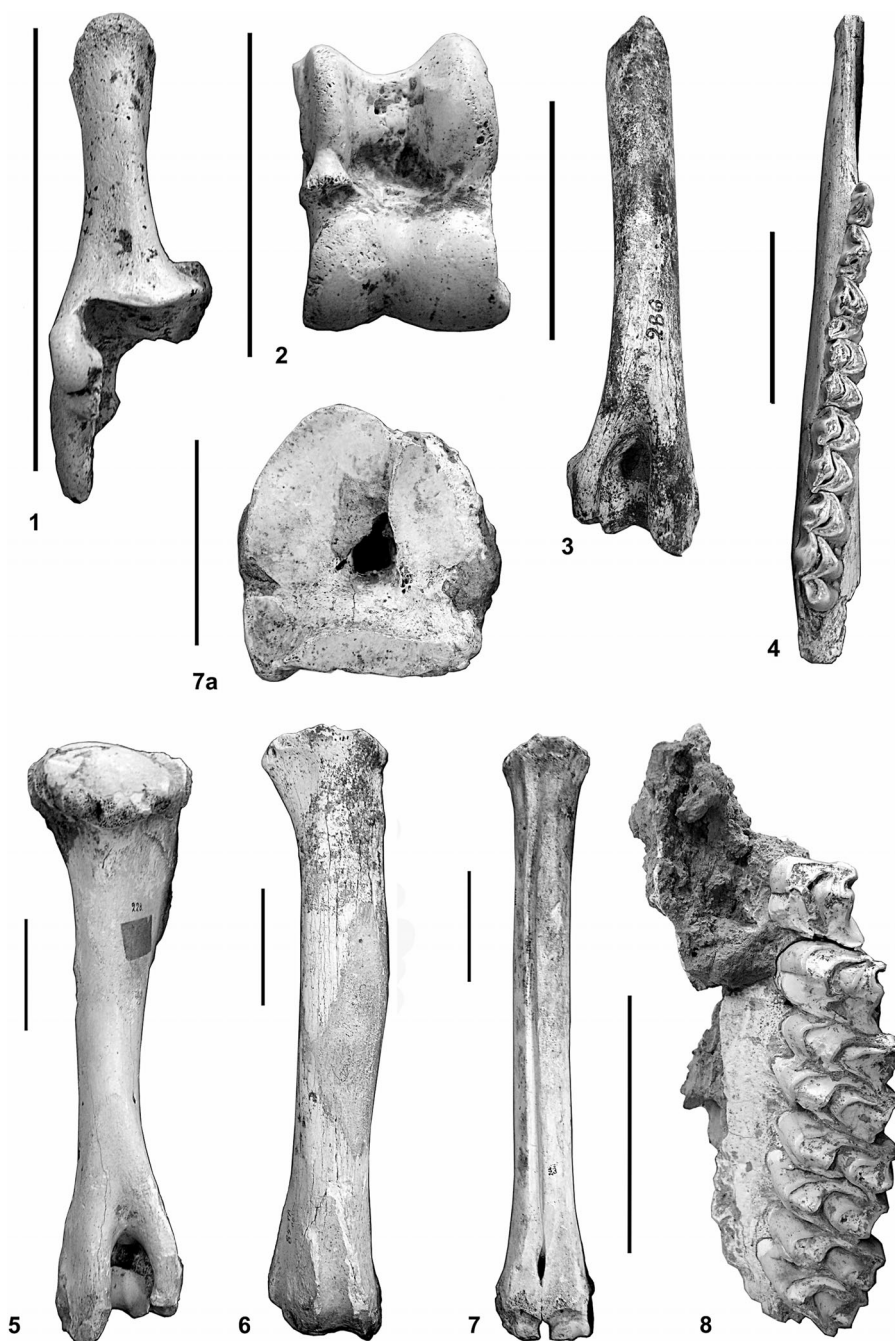
The analysis of these parameters, together with the ecological features of the determined species, allowed to make assumptions on the environmental conditions under which the fauna lived. The MNE/MNI ratio, which defines the intensity of fragmentation (Lyman, 2008), has not been calculated because the Parignana fossil material is a collection of selected specimens.

MAMMAL ASSEMBLAGE

The material is fairly well preserved. Alongside the mammalian species reported by Caterini (1921), which include *Capreolus capreolus* (Pl. 1, fig. 1, 2), *Cervus elaphus* (Pl. 1, fig. 4-8), *Rupicapra rupicapra* (Pl. 1, fig. 3), *Mustela putorius*, *Canis lupus* (Pl. 2, fig. 7, 8), *Vulpes vulpes* (Pl. 3, fig. 1), *Ursus arctos* (Pl. 2, fig. 1-6), *Stephanorhinus hemitoechus* (Pl. 3, fig. 3-5), *Erinaceus europaeus*, *Marmota marmota* (Pl. 3, fig. 9, 10), *Glis glis*, *Clethrionomys glareolus*, *Arvicola amphibius*, *Microtus* ex gr. *M. arvalis-agrestis*, *Chionomys nivalis*, *Apodemus* ex gr. *A. sylvaticus-flavicollis* and *Lepus timidus* (Pl. 3, fig. 6, 7), the presence of *Felis silvestris* (Pl. 3, fig. 2) and *Cricetus* sp. has been recognized in the present analysis. Caterini (1921) reported also *Talpa europaea*, *Spermophilus citellus?*, *Lepus europaeus*, *Martes martes?*, *Mustela nivalis*, and *Canis familiaris*. The specimens determined as *Lepus europaeus*, *Mustela nivalis*, and *Canis familiaris* are here reported as *Lepus* sp. (Pl. 3, fig. 8), *Mustela* sp., and *Canis* sp. because the remains of these taxa lack truly diagnostic elements, while the specimens determined as *Talpa europaea* and *Martes martes?* are here included in the only anatomically determined specimens.

RESULTS

The NISP, MNE, and MNI counts are reported in Tab. 1. Of the 1245 specimens examined here, 28 could be determined only anatomically, and 15 of



EXPLANATION OF PLATE 1

Capreolus capreolus (L.)

Fig. 1 - I15139A right calcaneus, anterior view. The scale is 5 cm

Fig. 2 - I15165C left astragalus, anterior view. The scale is 3 cm

Rupicapra rupicapra (L.)

Fig. 3 - I15151 left humerus, posterior view. The scale is 5 cm

Cervus elaphus L.Fig. 4 - I15076A right mandible (P₂, P₃, P₄, M₁, M₂, M₃), occlusal view. The scale is 5 cm

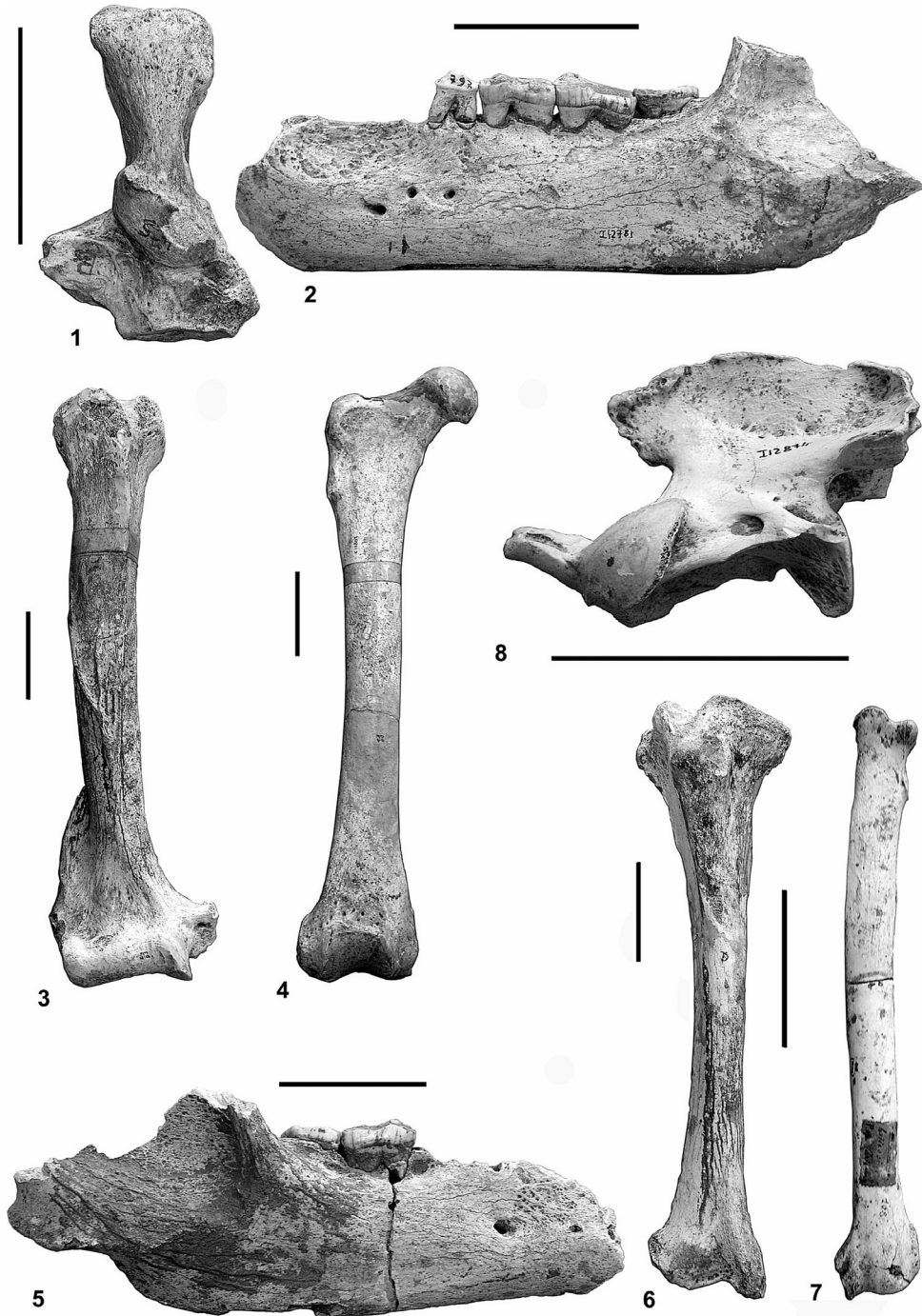
Fig. 5 - I15087 right humerus, posterior view. The scale is 5 cm

Fig. 6 - I15089 right radius, anterior view. The scale is 5 cm

Fig. 7 - I15117 right metatarsal, anterior view. The scale is 5 cm

Fig. 7a - I15117 right metatarsal, proximal epiphysis. The scale is 3 cm

Fig. 8 - I12756 left jaw (P³, P⁴, M¹, M², M³), occlusal view. The scale is 5 cm



EXPLANATION OF PLATE 2

Ursus arctos L.

Fig. 1 - I12819 left calcaneus, anterior view. The scale is 5 cm

Fig. 2 - I12781 left mandible (P₄, M₁, M₂, M₃), lateral view. The scale is 5 cm

Fig. 3 - I12795 right humerus, anterior view. The scale is 5 cm

Fig. 4 - I12807 right femur, anterior view. The scale is 5 cm

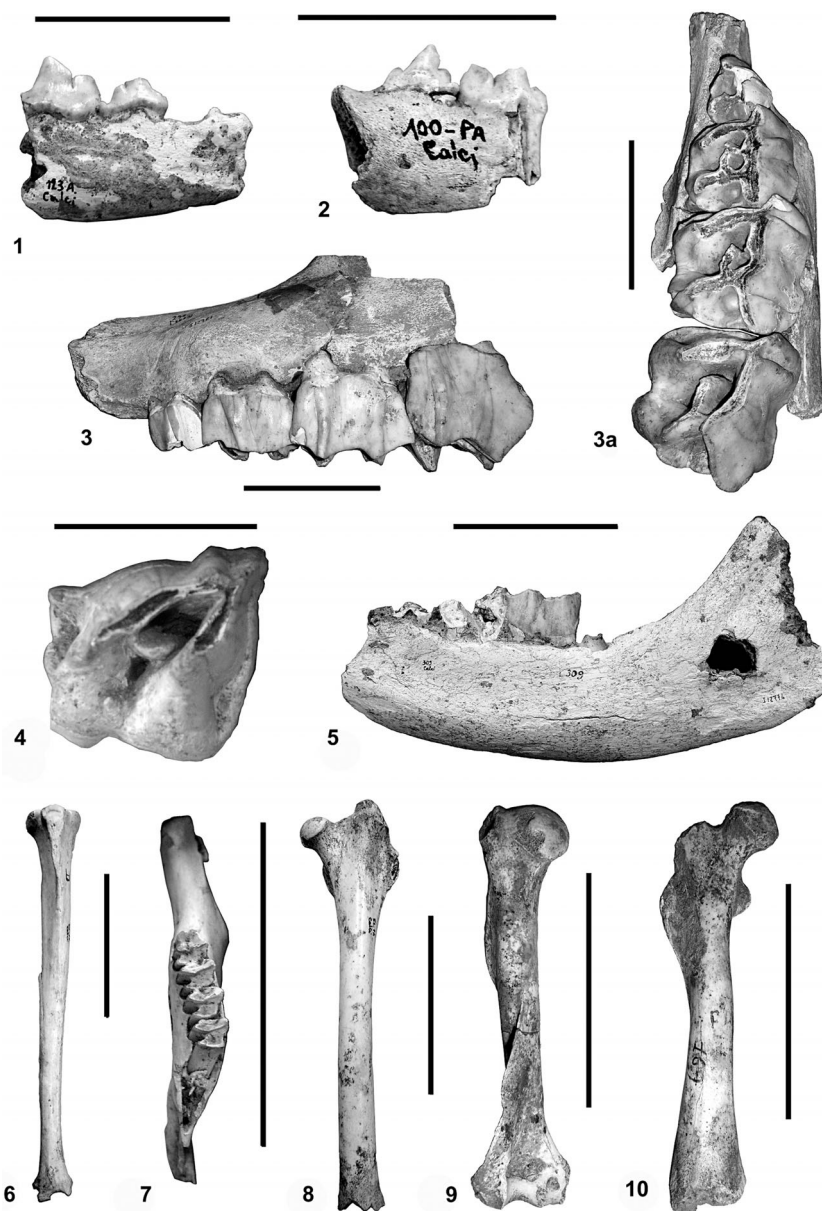
Fig. 5 - I12787 right mandible (M₂, M₃), lateral view. The scale is 5 cm

Fig. 6 - I12813 right tibia, anterior view. The scale is 5 cm

Canis lupus L.

Fig. 7 - I12886 left radius, anterior view. The scale is 5 cm

Fig. 8 - I12874 epistropheus, lateral view. The scale is 5 cm



EXPLANATION OF PLATE 3

Vulpes vulpes (L.)

Fig. 1 - I12913 right mandible (P₄, M₁), lateral view. The scale is 5 cm

Felis silvestris Schreber

Fig. 2 - I15179A left mandible (dP₃, dP₄), lateral view. The scale is 2 cm

Stephanorhinus hemitoechus (Falconer)

Fig. 3 - I12761 left jaw (P², P³, P⁴, M¹), lateral view. The scale is 5 cm

Fig. 3a - I12761 left jaw (P², P³, P⁴, M¹), occlusal view. The scale is 5 cm

Fig. 4 - I12270 right M³, occlusal view. The scale is 5 cm

Fig. 5 - I12774 left mandible, lateral view. The scale is 10 cm

Lepus timidus L.

Fig. 6 - I15188 right tibia, anterior view. The scale is 5 cm

Fig. 7 - I15226 left mandible (P₃, P₄, M₁, M₂), occlusal view. The scale is 3 cm

Lepus sp.

Fig. 8 - I15186 left femur, anterior view. The scale is 5 cm

Marmota marmota (L.)

Fig. 9 - left humerus, posterior view. The scale is 5 cm

Fig. 10 - right femur, anterior view. The scale is 5 cm

Tab. 1 - NISP, MNE and MNI values of the «Grotta Parignana» fauna.

ORDER	SPECIES	NISP	MNE	MNI
Insectivora	<i>Erinaceus europaeus</i>	1	1	1
	<i>Marmota marmota</i>	394	387	20
	<i>Glis glis</i>	6	6	2
Rodentia	<i>Cricetus cricetus</i>	2	2	1
	<i>Clethrionomys glareolus</i>	1	1	1
	<i>Arvicola amphibius</i>	47	45	7
	<i>Microtus ex gr. M. arvalis-agrestis</i>	3	3	1
	<i>Chionomys nivalis</i>	1	1	1
	<i>Apodemus ex gr. A. sylvaticus-flavicollis</i>	3	3	1
Lagomorpha	<i>Lepus timidus</i>	22	21	7
	<i>Lepus europaeus</i>	94	89	9
Carnivora	<i>Mustela putorius</i>	6	5	3
	<i>Mustela sp.</i>	3	3	2
	<i>Canis lupus</i>	61	54	3
	<i>Canis sp.</i>	47	1	1
	<i>Vulpes vulpes</i>	35	32	3
	<i>Ursus arctos</i>	118	109	6
	<i>Felis sylvestris</i>	3	3	2
	Perissodactyla	<i>Stephanorhinus hemitoechus</i>	22	18
Artiodactyla	<i>Capreolus capreolus</i>	18	18	3
	<i>Cervus elaphus</i>	197	185	14
	<i>Rupicapra rupicapra</i>	27	23	3
	total values	1111	1010	96
	anatomically determined specimens	28	28	-
	total determined specimens	1139	1038	96

them are metapodials. The indeterminate fragments are 105, and 78 of them are referred to rodents, whereas 27 are the completely undetermined fragments.

Mammals are dominated by *Marmota marmota* (NISP=394; MNI=20), followed by *Cervus elaphus* (NISP=197; MNI=14), *Ursus arctos* (NISP=118; MNI=6), and *Lepus sp.* (NISP=94; MNI=9), which are much less abundant. The other faunal components are rare.

Significant occurrences from this site are those of *Stephanorhinus hemitoechus*, *Rupicapra rupicapra*, and *Lepus timidus*.

The mammals recognized here for the first time, i.e., *Felis silvestris* and *Cricetus sp.*, are quite rare. *Felis silvestris* (NISP=3; MNI=2) is represented by a fragmental left lower jaw that retains dP₃ and dP₄, a complete right dP₄, and a complete left third metatarsal; whereas *Cricetus sp.* (NISP=2; MNI=1) is represented by an incomplete right lower jaw that retains M₂ and M₃, and by an incomplete left lower jaw that preserves M₁, M₂ and M₃.

DISCUSSION

The scanty stratigraphic information about these faunas reduces their potential paleoenvironmental and paleoclimatic significance. Despite that, the estimation of the relative frequencies of the taxa, and their paleoecologic

indications shed light on the environmental settings of the different assemblages. Moreover, the comparison of the Parignana mammal assemblages with the most important Late Pleistocene faunal associations from Tuscany and Latium, gives a clearer idea of Grotta Parignana's biochronology.

The faunal association of Grotta Parignana includes a mixture of both cold and temperate-warm species. Two faunal assemblages (Parignana A and Parignana B) have been identified on a paleoecological basis (Farina, 2010).

The first assemblage (Parignana A) is characterized by *Cervus elaphus* (MNI=14), *Capreolus capreolus* (MNI=3), *Ursus arctos* (MNI=6), *Canis lupus* (MNI=3), *Vulpes vulpes* (MNI=3), *Stephanorhinus hemitoechus* (MNI=5), and *Lepus sp.* (MNI=9). The assemblage indicates general temperate climatic conditions and a forested environment, with open areas included. In fact, alongside the species indicating forested environment (red deer, roe deer, and brown bear), the presence of steppe rhinoceros and *Lepus sp.* indicates open grassland areas.

On the South-Western side of Monte Pisano, the fossil mammals collected from «Grotta Cucigliana» and, particularly, the Cucigliana A faunal assemblage (Farina, 2011a), indicate climatic and environmental conditions similar to those suggested by Parignana A. In fact, the Cucigliana A assemblage is characterized by the occurrence of species typical of temperate and forested settings, such as *Cervus elaphus*, *Dama dama*, *Capreolus capreolus*, *Sus scrofa*, and *Ursus arctos*, associated to scanty remains of the pachyderms *Stephanorhinus hemitoechus* (NISP=11) and *Elephas antiquus* (NISP=2), which indicate open areas (Farina, 2011a).

In the biochronological framework of the Late Pleistocene mammal association of Tuscany (Fig. 3), the Parignana A assemblage is probably younger than the Monte Tignoso mammal association, which is referred to the MIS 5e or 5c (Caloi & Palombo, 1994), where abundant pachyderm remains were recognized, such as elephant, hippopotamus and steppe rhinoceros. These taxa indicate temperate-warm climatic conditions. The more recent age of Parignana A assemblage is suggested by the scanty remains (NISP=22; MNE=18; MNI=5) of steppe rhinoceros. Parignana A assemblage, however, is probably older than the Grotta Gosto association (Tozzi, 1974), which is referred to the beginning of MIS 3 (Caloi & Palombo, 1994), where no pachyderm remains were recognized probably due to the cooler climate as suggested by the presence of chamois.

Other mammal associations similar to Parignana A are those from Latium, which are referred to the end of the MIS 5a or to the beginning of MIS 4. In the stratigraphical succession of the «Canale Mussolini» or «Canale delle Acque Alte» (Blanc, 1935; Blanc *et al.*, 1957), and especially in those from layer C2 (Farina,

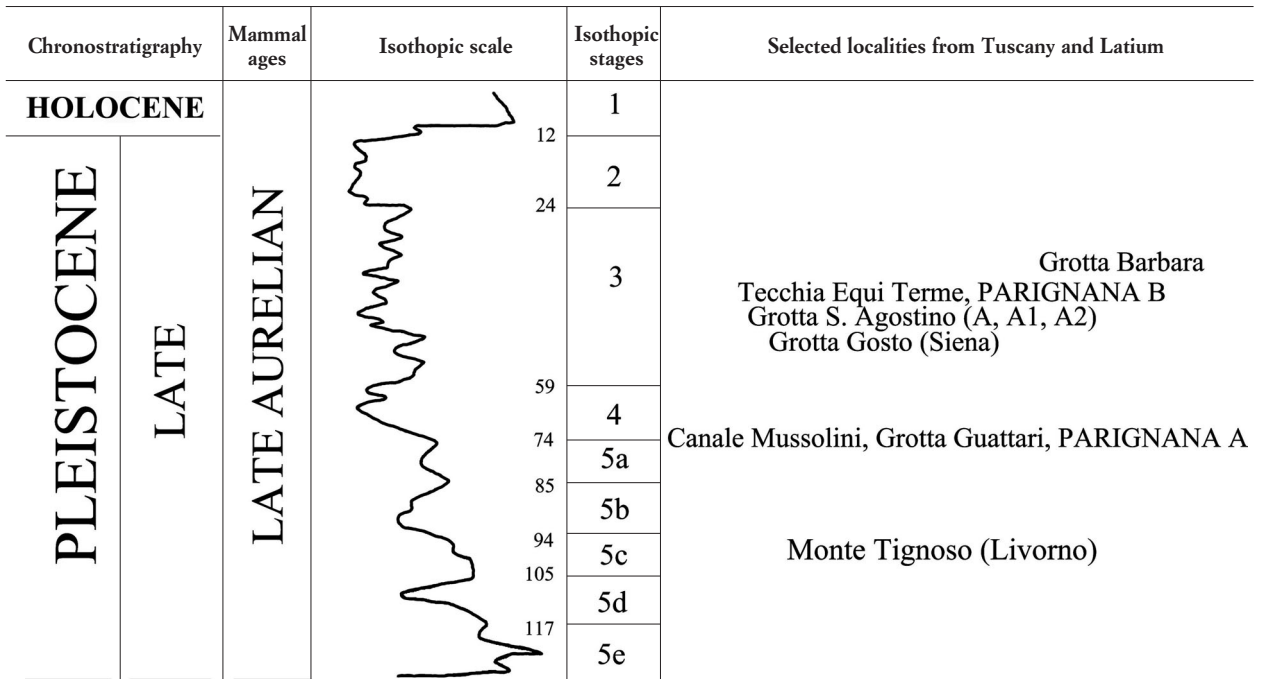


Fig. 3 - Chronological framework of Parignana faunal assemblages in comparison with some Late Pleistocene selected localities from Central Italy (Tuscany and Latium).

2011), scanty remains of pachyderms (*Elephas antiquus*, *Hippopotamus amphibius*, and *Stephanorhinus hemitoechus*) were recognized together with roe deer, red deer, and fallow deer, which indicate temperate climatic conditions and a forested environment, where the presence of horse (*Equus ferus*) and cattle (*Bos primigenius*), together with steppe rhinoceros, indicates the presence of open areas as well. Other mammal associations of Latium, which are characterized by the presence of steppe rhinoceros associated with a fauna of mixed environment, are those of «Grotta Guattari», «Grotta della Catena», and «Grotta del Fossellone» (Caloi & Palombo, 1994).

In conclusion, the Parignana A assemblage could be earlier than the MIS 4 climatic deterioration (Fig. 3), and could therefore be tentatively correlated bio-chronologically with the late MIS 5a or early MIS 4 mammal associations of the Latium coast.

The second assemblage (Parignana B) is characterized by *Rupicapra rupicapra* (MNI=3), *Felis silvestris* (MNI=2), *Lepus timidus* (MNI=7), *Marmota marmota* (MNI=20), *Cricetus cricetus* (MNI=1), *Clethrionomys glareolus* (MNI=1), and *Chionomys nivalis* (MNI=1). On the whole, the assemblage indicates cold mountain climate with the decrease of wood cover on the South-Western side of Monte Pisano. This is indicated by the presence of the varying hare, chamois, snow vole, hamster and, especially, by the marmot, which is the most abundant species (NISP=394; MNE=387). The

presence of chamois also suggests that the climate was not so dry, because of its preference for environments close to the forests, which were inhabited by *Felis silvestris* (NISP=3) and *Clethrionomys glareolus* (NISP=1). Therefore, the Parignana B fauna probably did not live during a phase of intense cooling.

Considering the other Late Pleistocene mammal associations of Tuscany, the Parignana B fauna could be correlated with the one from Equi Terme, whose assemblage is mainly dominated by carnivores (especially cave bear) and where the significant occurrence of the ibex, chamois, varying hare and marmot, associated to wood cover-indicating species such as *Felis silvestris* and *Cervus elaphus*, suggests climatic and environmental conditions similar to Parignana B.

The «Equi Terme» fauna has been correlated with the fauna of the layer 3 of «Grotta all'Onda» (Caloi & Palombo, 1994), which is referred to the central part of MIS 3 (Caloi & Palombo, 1994).

On the Latium coast, there are no mammal associations similar to Parignana B, and this is probably due to different geographic conditions. However, because of its abundance in «cold» indicators, Parignana B can be considered chronologically younger than the fauna coming from the upper layers (A-A1-A2) of «Grotta S. Agostino» (Fig. 3), where a «temperate» fauna is well represented (*Stephanorhinus hemitoechus*, *Cervus elaphus*, *Dama dama* and *Capreolus capreolus*), in contrast to the particularly rare «colder» taxa (*Marmota*

marmota and *Capra ibex*) (Tozzi, 1970). The «Grotta S. Agostino» faunal association is referred to the beginning of MIS 3 by radiocarbon dates which indicate an interval between 55.000 and 43.000 years ago (Kuhn, 1992 in Caloi & Palombo, 1994).

A mammal association referred to a MIS 3 cold oscillation is «Grotta Barbara» (Caloi & Palombo, 1994). Mammals are dominated by the red and fallow deer, but the occurrence of ibex is also significant (the third most abundant species; Caloi & Palombo, 1989). In contrast, roe deer, wild boar and carnivores (brown bear, fox and wolf) are rare (Caloi & Palombo, 1989). The occurrence of ibex probably indicates a demise of wood cover and a change towards cold climatic conditions, which were probably not so cold to permit the coexistence of ibex and fallow deer (Caloi & Palombo, 1989). The Parignana B fauna could probably be correlated with the mammal associations of «Equi Terme» and «Grotta Barbara» and could probably be referred to a cold oscillation of the central part of MIS 3 that reached higher peaks on the Apuan Alp than on the Latium coast (Fig. 3).

Finally, the paleontological collection of «Grotta Parignana» contains rare rodent remains (*Microtus* ex gr. *M. arvalis-agrestis*, MNI=1; *Apodemus* ex gr. *A. sylvaticus-flavicollis*, MNI=1; *Glis glis*, MNI=2; *Arvicola amphibious*, MNI=7) and of *Erinaceus europaeus* (MNI=1) and *Mustela putorius* (MNI=3) whose fresh state of preservation suggests that they likely result from modern infestations, as reported by Caterini (1921).

CONCLUSION

The analysis brought to a clearer definition of Grotta Parignana biochronology and allowed to stress some considerations about the environmental conditions under which the fauna lived. The ecological insights provided by species permit to identify two different faunal assemblages (Parignana A and Parignana B) referable to the Late Aurelian mammal age. The first assemblage (Parignana A) is characteristic of temperate forested environments (red deer, roe deer and brown bear), but it also includes steppe rhinoceros and hare which are typical open space dwellers. The Parignana A assemblage can be correlated with the mammal associations of «Canale Mussolini» and «Grotta Guattari» (which straddle the MIS 5a to MIS 4 transition) and can be included in the Melpignano Faunal Unit (Petronio *et al.*, 2007), which precedes the MIS 4 climatic deterioration.

The second assemblage (Parignana B) is characterized by the presence of «cold» mountain dwellers (varying hare, chamois, snow vole, hamster and especially marmot), but also by wild cat and bank vole, which also indicate a rare wood cover. The Parignana B assem-

blage can be correlated with the mammal associations of «Equi Terme» and «Grotta Barbara» (referred to the central part of MIS 3) and can be included in the Ingarano Faunal Unit (Petronio *et al.*, 2007).

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