

Late Pleistocene micromammal association from Praia a Mare (Calabria, Southern Italy): palaeoclimatological and biochronological implications

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ABSTRACT – A rich micromammal association was collected from terra rossa and breccia deposits laying against the calcareous dolomitic bedrock of Serra Vingiole (middle Trias-Lower Lias), near the railway line of Praia a Mare (Cosenza, Calabria). The following species were recognised: *Sorex araneus* Linnaeus, *Sorex minutus* Linnaeus, *Glis glis* (Linnaeus), *Eliomys quercinus* (Linnaeus), *Muscardinus avellanarius* (Linnaeus), *Clethrionomys glareolus* (Schreber), *Microtus (Microtus) arvalis* (Pallas), *Microtus (Microtus) agrestis* (Linnaeus), *Microtus (Terricola) savii* (De Selys Longchamps), *Arvicola terrestris* (Linnaeus) and *Apodemus (Sylvaeus) sylvaticus* (Linnaeus). *M. (M.) gr. arvalis-agrestis* are the more abundant species (70.9%). Their presence in the deposit of Praia a Mare leads to refer the fossil assemblage to a Late Pleistocene cold climatic phase. A comparison between the Praia micromammal association and other micromammal associations from several well dated central and southern Italy fossiliferous deposits suggested its chronological attribution to the Last Glacial and, in particular, to the end of the Isotopic Stage 3.

RIASSUNTO – [L'associazione pleistocenica superiore a micromammiferi di Praia a Mare (Calabria, Italia meridionale): implicazioni paleoclimatologiche e biocronologiche] – Viene presentato lo studio di una ricca associazione a micromammiferi rinvenuta in un deposito di breccia e terra rossa nella area di Praia a Mare (Cosenza, Calabria). Il deposito giace contro i calcari dolomitici triassico-liassici affioranti nell'area di Serra Vingiole. Sono state riconosciute le seguenti specie: *Sorex araneus* Linnaeus, *Sorex minutus* Linnaeus, *Glis glis* (Linnaeus), *Eliomys quercinus* (Linnaeus), *Muscardinus avellanarius* (Linnaeus), *Clethrionomys glareolus* (Schreber), *Microtus (Microtus) arvalis* (Pallas), *Microtus (Microtus) agrestis* (Linnaeus), *Microtus (Terricola) savii* (De Selys Longchamps), *Arvicola terrestris* (Linnaeus) and *Apodemus (Sylvaeus) sylvaticus* (Linnaeus). *M. (M.) gr. arvalis-agrestis* sono le forme più abbondanti (70.9%). La loro presenza nel deposito di Praia a Mare permette di riferire l'associazione ad una fase fredda del Pleistocene Superiore. Un confronto tra l'associazione a micromammiferi di Praia a Mare ed altre associazioni ben datate rinvenute in numerosi depositi dell'Italia centrale e meridionale ha permesso il riferimento cronologico all'ultimo glaciale, ed in particolare, alla fine dello Stadio Isotopico 3.

INTRODUCTION

In central and southern Italy, several late Middle and Late Pleistocene deposits yielded abundant micromammal remains, mainly localized in southern Campania (Tyrrhenian side) and southern Apulia (Ionian-Adriatic side) (Bartolomei, 1975; Bartolomei *et al.*, 1976, 1977; Sala, 1978, 1979; Cioni *et al.*, 1979; Masini & Abbazzi, 1997; Ronchitelli *et al.*, 1998; Bartolomei, 1980; De Giuli, 1980, 1983; Bon & Boscato, 1993, 1996; Rustioni *et al.*, 1994; Barbera *et al.*, 1995; Bertolini *et al.*, 1996). These deposits are often well dated by means of radiocarbon, U/Th, or on palaeontological basis and the composition of the micromammal associations seems to be strictly related to the age.

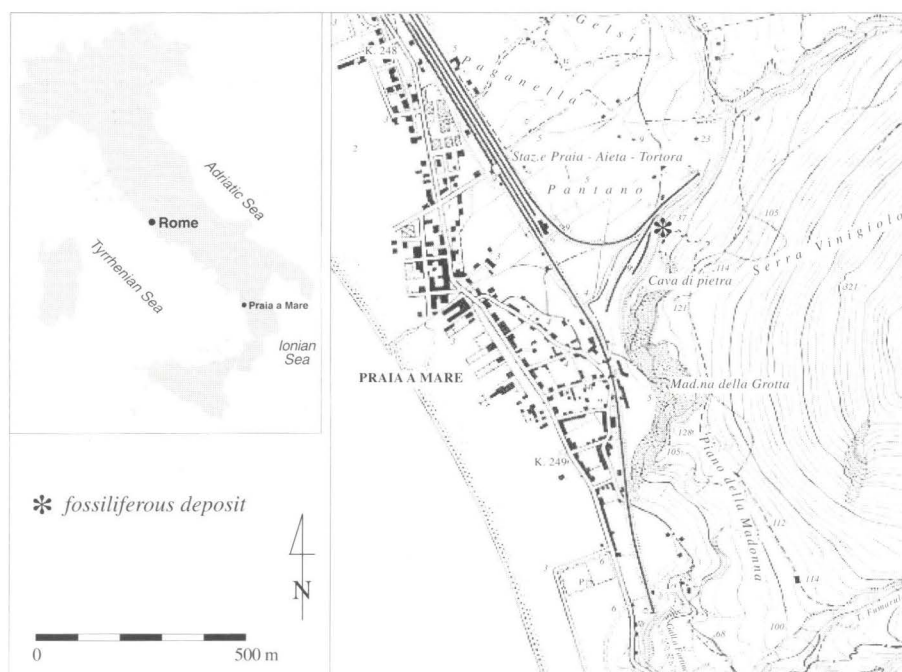
The fossiliferous deposit of Praia a Mare (northern Calabria) represents, up to present, the more southern gisement known along the Tyrrhenian side, that yielded a rich micromammal association, allowing palaeoecological and climatological interpretations.

Micromammal remains have been collected from terra rossa and reddish breccias few decimeter thick,

lying against or filling cavities inside the middle Trias-Lower Lias calcareous dolomitic bedrock; they crop out at the foothill of Serra Vingiole, along the railway near the Praia a Mare village (Text-fig. 1). The deposit is made of reddish silts and sands with dispersed angular calcareous clasts, without any stratification. Inside the red matrix abundant fossil bones, both cranial and post-cranial fragments, were scattered (Text-fig. 2a). Part of the ossiferous deposit lies against the calcareous bedrock pierced by *Lithophaga* holes at a height of 20-25 m a.s.l. (Text-fig. 2b). Taking into account the literature on the Quaternary marine shorelines in the northern Calabria area (Malatesta & Zarlenga, 1986; Carobene & Dai Pra, 1990, 1991; Carboni *et al.*, 1992; Barbera *et al.*, 1995) this *Lithophaga* band can be related to the Euthyrrenian (Isotopic stage 5e) sea-level high stand.

ANALYSIS OF THE MICROMAMMAL ASSEMBLAGE

About 20 kg of terra rossa and breccia sediments have been sieved with 10 mm and 0.250 mm sieve mesh and fossil bone remains have been hand picked



Text-fig. 1 - Location map of the fossiliferous deposit.

under stereomicroscope. More than 2000 fossil bones in a good state of preservation have been collected. They are represented by rare fragmentary portions of skulls and mandibles, by several post-cranial bones and by very abundant loose teeth (about eight hundred).

The following taxa have been recognized:

Reptilia indet.

Mammalia

Insectivora

Sorex araneus Linnaeus, 1758

Sorex minutus Linnaeus, 1766

Chiroptera indet.

Rodentia

Glis glis (Linnaeus, 1766)

Eliomys quercinus (Linnaeus, 1766)

Muscardinus avellanarius (Linnaeus, 1758)

Clethrionomys glareolus (Schreber, 1786)

Arvicola terrestris (Linnaeus, 1758)

Microtus (Microtus) arvalis (Pallas, 1779)

Microtus (Microtus) agrestis (Linnaeus, 1761)

Microtus (Terricola) savii (De Selys Longchamps, 1838)

Apodemus (Sylvaeus) sylvaticus (Linnaeus, 1758)

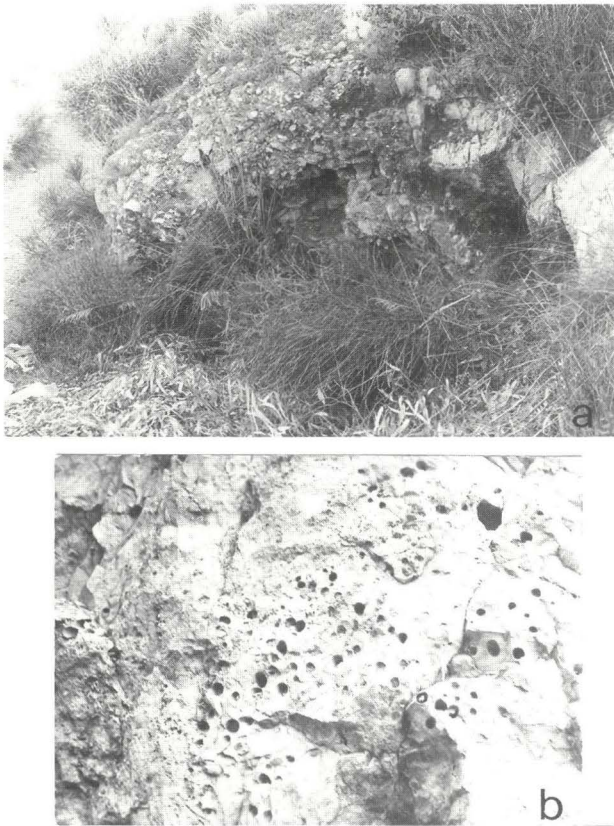
The abundant material collected in the Praia a Mare deposit allowed the calculation of the percentage frequencies of each recognized species. These frequencies have been calculated using the teeth, which are the most abundant anatomical part collected in the gisement. In the case of *M. (M.) arvalis* and *M. (M.)*

agrestis the separation of the teeth pertaining to each species has been based both on the morphological characters of the diagnostic teeth (M_1 , M^2 , M^3) and on their different size, taking into account that *M. (M.) arvalis* is slightly smaller than *M. (M.) agrestis* (Niethammer & Krapp, 1982a,b). Anyway, still a lot of the collected teeth (about 360 specimens out of 530) showed mixed characters so it was preferable to calculate the percentage of the whole *M. (M.) arvalis-agrestis* group.

The Praia a Mare assemblage is mainly represented by rodents (94.91%), while insectivores constitute only 4.82% of the whole fauna and bats are negligible (0.27%). Considering the dominance of rodents in the assemblage, it seemed more significant from a paleoecological perspective to calculate the percentage frequencies of each rodent species. *M. (M.) gr. arvalis-agrestis* represent the dominant forms with a percentage of 70.9%, while the other rodent species are far subordinated: *M. (T.) savii* 16.1%, *A. (S.) sylvaticus* 11.4%, Gliridae 0.9%, *C. glareolus* 0.4% and *A. terrestris* only 0.3%.

DISCUSSION

The fossiliferous deposit of Praia a Mare represents the first record of fossil micromammals in Calabria and, on the whole, it represents the more southern locality along the Tyrrhenian side that yielded a rich micromammal association. In fact it is located more or less at the same latitude of the southernmost fossiliferous caves of Apulia (both facing Ionian and Adriatic coasts) (Text-fig. 3) and this allows some

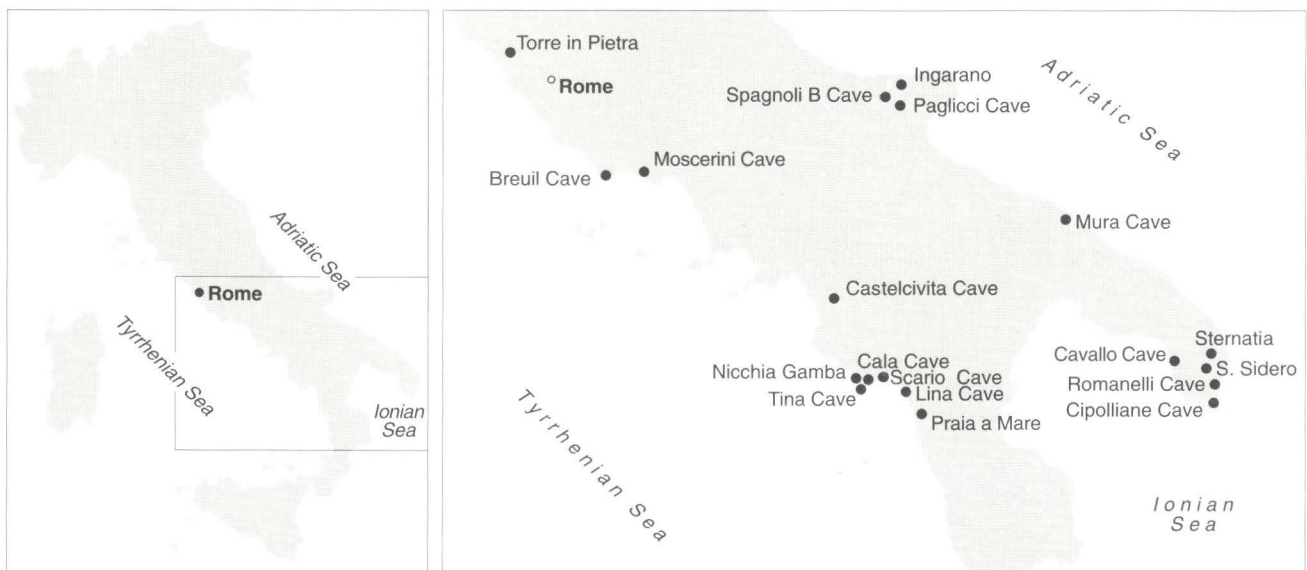


Text-fig. 2 - a) Terra rossa and reddish breccias bearing micro-mammal remains; b) *Lithophaga* holes referable to the Eutyrrhenian sea-level high stand piercing the Mesozoic basement. The fossiliferous deposit lies against them.

interesting palaeoecological and paleoclimatological considerations and comparisons.

The micromammal species collected at Praia a Mare can be grouped as follows, according to their ecological requirements: the glirids *G. glis*, *E. quercinus* and *M. avellanarius* together with the arvicolid *C. glareolus* are latifolia or coniferous wood and under-wood dwellers often typical of the Mediterranean environment; *M. (M.) arvalis* and *M. (M.) agrestis* inhabits humid and cold open grasslands; *A. (S.) sylvaticus*, *M. (T.) savii* and, partly, *S. minutus* live in Mediterranean open spaces (fields or at least edges of woods); *S. araneus* and *A. terrestris* are marshes and river bank dwellers (Toschi, 1959; Amori *et al.*, 1984). Almost all the recognized species are living at present in Italy with a wide geographical distribution. Only three species (*M. (M.) agrestis*, *M. (M.) arvalis* and *S. minutus*) show a more restricted dispersal area. As far as it is known, *M. agrestis* is distributed in northern Italy not south of the Po river, *M. arvalis* is distributed in northern Italy not south of the Padana Plain while the presence in southern Italy of *S. minutus* is only supposed but not confirmed (Toschi, 1959; Amori *et al.*, 1984; Bertazzini *et al.*, 1990).

Owing to the absence of stratification and to the low thickness of the fossiliferous deposit, the micromammal fauna of Praia a Mare has been considered on the whole. The great abundance of the bone remains probably minimize the selective effect of Strigiforms predators (Bertolini *et al.*, 1996). The faunal composition of Praia a Mare allows to reconstruct the palaeoenvironment of this portion of the Tyrrhenian coastal plain as an open and humid grassland bordered by woods. The dominance of *M. (M.) arvalis-agrestis* in an areal far southern in compar-



Text-fig. 3 - Location map of several central and southern Italian deposits which yielded abundant late Middle Pleistocene-Holocene micromammal assemblages.

<i>Fossiliferous localities</i>	<i>Chronology</i>	<i>Percentage frequencies of selected rodent species</i>		<i>References</i>
Nicchia Gamba Cave	11,630±230 yr Tardiglacial Final Epigravettian	<i>M. (Terricola) savii</i>	80%	Bartolomei <i>et al.</i> , 1977
Cala Cave (level M)	Isotopic Stage 2 Advanced Epigravettian	<i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i>	20-45% 40%	Bartolomei <i>et al.</i> , 1976
Cala Cave (level P)	Isotopic Stage 2 Advanced Epigravettian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Arvicola terrestris</i>	10-18% 40% < 5%	Bartolomei <i>et al.</i> , 1976 Bartolomei <i>et al.</i> , 1977
Castelcivita Cave (levels ars -gic)	Isotopic Stage 3 Denekamp temperate phase Advanced Protoaurignatian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	32.8-33.3% 0-9% 0-7.5% 28.4-66.7%	Cioni <i>et al.</i> , 1979 Masini & Abbazzi, 1997
Cala Cave (level Q)	about 28,000- 27,000 yr Isotopic Stage 3 Gravettian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	9-30% 30-40% 30-20% 10%	Bartolomei <i>et al.</i> , 1976
Castelcivita Cave [levels rsi (UI)-rsa]	33,220±780 / 32,930±720 yr Isotopic Stage 3 Uluzzian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	34.9-75% 0-20.9% 7.1-35.3% 0-21.4%	Cioni <i>et al.</i> , 1979 Masini & Abbazzi, 1997
Castelcivita Cave [levels gar- rsi (MA)]	Isotopic Stage 3 Hengelo temperate phase Musterian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	0-63.7% 0-33.3% 0-60% 0-32.2%	Masini & Abbazzi, 1997
Breuil Cave	about 37,000 Isotopic Stage 3	<i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	7% 58.2% 13.9%	Kotsakis, 1991
Cala Cave (level R)	?Late Isotopic Stage 5/4 or 3 (Hengelo temperate phase?) Musterian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	< 5% 29-31% 34-37% Rare	Bartolomei <i>et al.</i> , 1976
Moscerini Cave	Late Isotopic Stage 5/4	<i>M. (Microtus) gr. arvalis-agrestis</i>	Dominant	Kotsakis, com. pers.
Tina Cave (level B)	Late Isotopic Stage 5/4	<i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	Rare Dominant	Bartolomei, 1980
Scario Cave	Isotopic Stage 5 (post <i>S. bubonius</i> layers) early Middle Paleolithic	<i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	0-40% 0-62.5% 0-41.7%	Ronchitelli <i>et al.</i> , 1998
Lina Cave	Isotopic Stage 6	<i>M. (Microtus) gr. arvalis-agrestis</i>	Rare	Barbera <i>et al.</i> , 1995
Torrimpietra (upper levels)	Isotopic Stage 7/6 Advanced Acheulean	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	Rare Rare Dominant	Caloi & Palombo, 1978

Tab. 1 - Frequency percentages for selected rodent species from different fossiliferous localities cropping out along the Tyrrhenian side of central and southern Italy.

ison to their present distribution, implies air temperatures cooler than the present ones.

On the basis of these data and taking into account the geometry of the fossiliferous deposit which lies against the Eutyrrhenian coastline, the Praia a Mare micromammal association can be ascribed to a cold climatic phase of the Late Pleistocene.

COMPARISON WITH OTHER CENTRAL AND SOUTHERN ITALY MICROMAMMAL ASSOCIATIONS

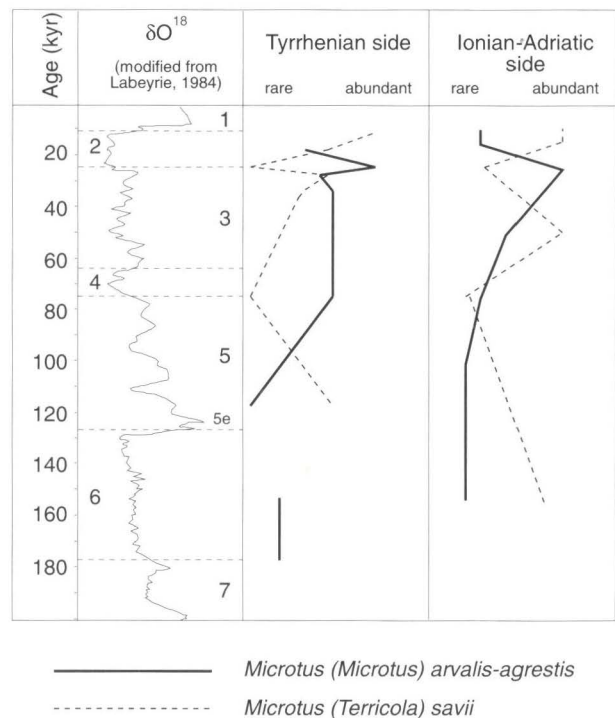
During Quaternary, several micromammal bio-events in Europe and Italy has been linked to global climate changes (Chaline, 1970, 1972; Kotsakis *et al.*, 1992; Sésé, 1994; Gliozzi *et al.*, 1997; Sardella *et al.*, 1998). Furthermore, also the variation of the percentage frequencies of some species or group of species inside an assemblage has been considered indicative of climatic changes (see for example Bartolomei, 1980; Bertolini *et al.*, 1996).

The abundant and diversified micromammal associations spanning from late Middle Pleistocene to Holocene, which came from several central and southern Italian localities represent a suitable material to test if the composition of the faunas could be useful to point out any palaeoecological and palaeoclimatical differences between the Tyrrhenian and Ionian-Adriatic sides of the Italian peninsula. Looking at the faunal compositions of these sites it is possible to point out the general alternate presence of *M. (M.) gr. arvalis-agrestis* and of *M. (T.) savii*. Since these species are indicative respectively of cold and humid or Mediterranean "dry" open spaces, their vicariance could be the response to climate changes. Moreover, a secondary purpose of this analysis is to see if the differences in the assemblage composition could represent a new tool to allow the chronological location of the Late Pleistocene micromammal assemblages.

A first analysis shows that the more ancient deposits recording the presence of *M. (M.) gr. arvalis-agrestis* outside their present distribution area are referable to the Isotopic Stage 7/6 transition (Torrimpietra, Latium, lower levels, Caloi & Palombo, 1978) in central Italy and to the Isotopic Stage 6 (Grotta Lina, Basilicata, Barbera *et al.*, 1995) in southern Italy. Data from literature allow to perform a comparative analysis between the micromammal assemblage of Praia a Mare and those from the coastal caves referable to the late Middle Pleistocene-Holocene: Grotta Breuil and Grotta dei Moscerini (Circeo, Latium) (Kotsakis, 1991; Caloi *et al.*, 1989), Grotta di Castelcivita (Campania) (Cioni *et al.*, 1979; Masini & Abbazzi, 1997), Grotta Cala, Nicchia Gamba, Grotta Tina, Grotta Grande di Scario and Grotta della Serratura (Marina di Camerota, Campania) (Bartolomei *et al.*, 1976, 1977; Bartolomei, 1980; Bertolini *et al.*, 1996; Ronchitelli *et al.*, 1998), Ingarano, Grotta Spagnoli B and Grotta

Paglicci (Gargano, Apulia) (Sala, 1978; Petronio *et al.*, 1995; Bartolomei, 1980; Galiberti, 1984), Grotta delle Mura (Salento, Apulia) (Bon & Boscato, 1993, 1996; Brunet-Lecomte *et al.*, 1994), Sternatia (Rustioni *et al.*, 1994), S. Sidero, Grotta Cipolliane and Grotta del Cavallo (Lecce, Apulia) (Bartolomei *et al.*, 1977; De Giuli, 1980, 1983; Bartolomei, 1980; Bon & Boscato, 1993, 1996) (Text-fig. 3).

In Tables 1 and 2 the frequency percentages of selected rodents are reported together with the age of the deposit for all the aforementioned sites. From these tables and from Text-fig. 4 it is possible to observe that *M. (M.) gr. arvalis-agrestis* is present during the cool phase corresponding to Isotopic Stage 4 both on the Tyrrhenian and the Ionian-Adriatic coasts. During these phases *M. (T.) savii* is rather absent or scarcely represented. During the Isotopic Stage 3 *M. (M.) gr. arvalis-agrestis* increases progressively its importance inside the assemblages but only along the Ionian-Adriatic coasts *M. (T.) savii* becomes dominant, suggesting a more arid climatic pattern on the eastern side of southern Italy. On the contrary, near the transition 3/2 the climatic differences between the two coasts seems to decrease: *M. (M.) gr. arvalis-agrestis* is the dominant if not the exclusive rodent in the assemblages while *M. (T.) savii* is rather rare. *M. (T.) savii* becomes again dominant in the



Text-fig. 4 - Comparison between the *M. (Microtus) gr. arvalis-agrestis* and *M. (Terricola) savii* frequency percentage curves from different fossiliferous sites facing the Tyrrhenian and the Ionian-Adriatic side, plotted against the Isotopic Curve.

<i>Fossiliferous localities</i>	<i>Chronology</i>	<i>Percentage frequencies of selected rodent species</i>		<i>References</i>
Mura Cave (level 3)	10,850±100 yr ?Preboreal Romanellian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	6.6% 87.8% 4.0% 0.6%	Bon & Boscato, 1993; 1996
Spagnoli B Cave	Holocene	<i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i>	Dominant Rare	Sala, 1978
Paglicci Cave (inner levels 7-2)	13,590±200 / 11,440±180 yr Tardiglacial Final Epigravettian	<i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	Dominant Rare Rare	Bartolomei <i>et al.</i> , 1977
Paglicci Cave (inner levels 9-8)	15,320±250 / 14,270±230 yr Tardiglacial Evolved Epigravettian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i>	5.0% 65-70%	Bartolomei <i>et al.</i> , 1977
Cavallo Cave	about 15,000 yr† Tardiglacial	<i>M. (Terricola) savii</i>	Dominant	Bartolomei <i>et al.</i> , 1977
Cipolliane Cave	about 15,000 yr Tardiglacial Evolved Epigravettian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	Scarce Dominant Rare Rare	Bartolomei <i>et al.</i> , 1977
Paglicci Cave (inner levels 21-18)	24,720±420 / 20,200±305 yr Isotopic Stage 3/2 Gravettian	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i> <i>Arvicola terrestris</i>	80-90% < 10% <10% < 5%	Bartolomei, 1975 Bartolomei <i>et al.</i> , 1977
Ingarano	? Isotopic Stage 3	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i>	Dominant Rare Frequent	Petronio, <i>et al.</i> , 1995
Sternatia	?Isotopic Stage 3	<i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i>	97.2% 1.7%	Rustioni <i>et al.</i> , 1994
S. Sidero 3	?Isotopic stage 3 ? Late Isotopic Stage 5/4	<i>M. (Microtus) agrestis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i>	Rare 95% Rare	De Giuli, 1980, 1983; Bartolomei, 1980
Paglicci Cave (outer levels 2-1)	Late Isotopic Stage 5/4 Musterian	<i>M. (Microtus) gr. arvalis</i> <i>M. (Terricola) savii</i> <i>Apodemus (Sylvaemus) spp.</i>	Frequent Rare Rare	Galiberti, 1984
Spagnoli B Cave	Late Isotopic Stage 5	<i>M. (Microtus) gr. arvalis-agrestis</i>	Rare	Sala, 1978
Paglicci Cave (outer levels 4-3)	Isotopic Stage 6 Advanced Acheulean	<i>M. (Microtus) gr. arvalis-agrestis</i> <i>M. (Terricola) savii</i> <i>Arvicola terrestris</i>	Rare Dominant Frequent	Galiberti, 1984

Tab. 2 - Frequency percentages for selected rodent species from different fossiliferous localities cropping out along the Ionian-Adriatic side of central and southern Italy.

micromammal assemblages during Last Pleniglacial and near the end of it, indicating that the dry conditions reached also the Tyrrhenian side. It is worth to point out that during the Last Pleniglacial *M. (M.) gr. arvalis-agrestis* was scarce in all the southern Italian peninsula and this could be due to a period of relatively cold temperatures coupled with dry conditions. A similar climatic pattern has been recognized also in Spain, where the drier phases correspond to those characterized by lower temperatures (Sésé, 1994). During Tardiglacial this aridity persisted, but on the Tyrrhenian side *M. (M.) gr. arvalis-agrestis* disappeared, while on the Ionian-Adriatic side it was still present, even if with low frequencies. The retreat towards north of its areal, anyway, should have been accomplished rather slowly during the Holocene or, at least, during the retreat relics populations remained scattered and isolated along the central Apennines, since abundant remains of *M. (M.) gr. arvalis-agrestis* have been collected from the Neolithic and Bronze Age deposits of Grotta Cocci (Umbria) (Salari, 1998).

The high percentage frequency of *M. (M.) gr. arvalis-agrestis* in the Praia a Mare deposits is comparable only with those calculated for Southern Italian localities referable to the Isotopic Stage 3/2 transition, then it is reliable to refer this deposit to the anaglacial phase of the Last Pleniglacial.

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