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The Grotta Grande of Scario (Salerno, Italy): Archaeology and environment during the last interglacial (MIS 5) of the Mediterranean region

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A R T I C L E I N F O

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A B S T R A C T

Archeological and paleo-environmental researches carried on the Grotta Grande site illustrate the importance of a multidisciplinary approach among archeologists, palynologists and paleontologists. The archaeology, fauna, pollen and micro-charcoal recovered in two short sedimentary successions (trenches A, F) located close to the entrance of the cave are discussed. The cave opens directly on the Tyrrhenian Sea, 2 km from Scario (Salerno, Campania, Southern Italy). The morphology of the cave and sedimentary processes were controlled by eustatic fluctuations during the late Middle Pleistocene and the early Late Pleistocene. The sea repeatedly occupied the cave. The cave was frequented by humans of Middle Palaeolithic culture. Archaeological and faunal record of the two trenches can be positioned within the climatic fluctuation posterior to the warm interglacial MIS 5e peak. Pollen have been retrieved in the older series (b–c) of trench A, referable to MIS 7–6.

The most important archaeological finds are the occurrence of structures that indicate the living space (trench F) together with hearths and lithic industry. The latter is characterised by the presence of the Levallois system and by the prevalence of sidescrapers among tools. The systematic use of limestone is observed only in trench F.

Large and small mammal remains recovered within the two trenches show that in the neighbourhood of the site, a diversified assemblage occurred, including eleven large mammals, among which the hippo, the straight tusked elephant and the narrow-nosed rhino are noteworthy, and fourteen small mammal taxa, mainly rodents, with a significant amount of glirids. The fauna is indicative of a temperate, forested Mediterranean environment. Variation of faunal composition suggests that environments underwent some minor fluctuations towards cooler and/or drier landscapes.

Pollen indicates vegetation organized in different belts, mainly Mediterranean evergreen forest/maquis and mixed forest with conifers and deciduous broadleaved trees. Fresh water plant communities are mainly represented in trench A. Some records of "Tertiary taxa" suggest stands of survival of these plants in the surroundings of the cave. Over the time span, the landscape become more open, due to some episodes of steppe vegetation spread caused by variation in temperature and humidity.

Deposit of this age are rather uncommon even in the Italian peninsula, and therefore the integration of sedimentological, archaeological, faunal and palynological data provides an important piece of information to the puzzling reconstruction of the Late Pleistocene Mediterranean environments before the onset of the glaciation.

1. Introduction

The Grotta Grande of Scario is a coastal cave located in the centre of the Mediterranean region on the Tyrrhenian side of the Italian Peninsula. It opens directly on the sea, on the Cilento coast between Palinuro and Sapri, about 2 km southwest of the village of Scario at La Masseta (S. Giovanni a Piro, Campania, Southern Italy;

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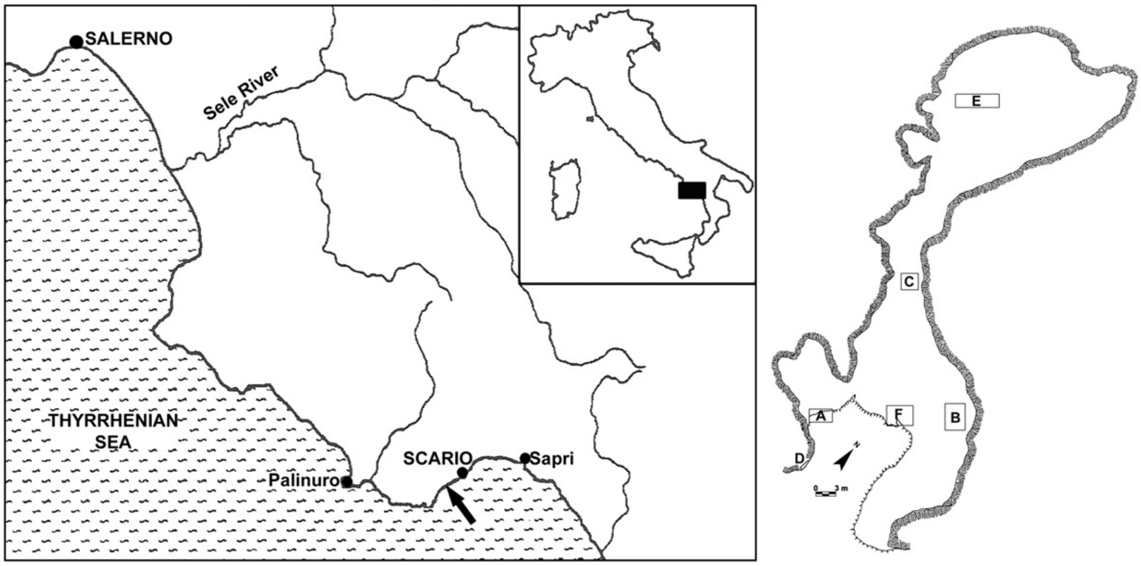


Fig. 1. Site location (on the left); plan of the cave (on the right).

Fig. 1). The morphology of the cave and the sedimentary processes of its infilling were controlled by eustatic fluctuations during the late Middle Pleistocene and the early Late Pleistocene. Humans of the Middle Palaeolithic frequented the cave, which extends 85 m along a fault running normal to the coastline. Two large chambers are joined by a short corridor: an external one, set on two levels, and an internal one, with a vaulted roof.

After a first, limited study by Milan University at the beginning of the 1960s (Fusco, 1961), systematic excavations were carried on from 1979 to 2002 by the University of Siena in collaboration with "Soprintendenza per i Beni Archeologici" of Salerno. The original deposit has been quite completely dismantled by marine erosion, leaving only some cemented relics within the sheltered areas of the cave.

Six test pits have been excavated in several areas of the cave (Fig. 1): in the lower level of the entrance chamber (pits A–D–F), along the corridor (pits B–C) and inside the inner chamber (pit E). The most significant pits are trenches A and F, with several anthropic levels, which are the subject of the present paper. The study of a third important pit (trench C) is in progress. In the internal area (pit E), without prehistoric finds, a Roman Age burial (4th century AD) was found in the upper levels.

2. Stratigraphy

2.1. Trench A

Two different series have been recognised in trench A (Ronchitelli et al., 1998). The older one, about 2.4 m thick, is represented by a marine conglomerate at the bottom (**a** in Fig. 2), followed by continental red sandy – silty deposits (**b** in Fig. 2) sealed by a stalagmite (**c** in Fig. 2). An erosional surface cuts these deposits, followed by a red cemented breccia with alternating concreted archaeological and earth levels that represent the younger series (**d** in Fig. 2) which is about 1 m thick, and is divided in three horizons: lower (cuts 22–18), middle (cuts 17–13) and higher (cuts 12–10 in Fig. 2).

The evolution of the deposit is deeply influenced by oscillations of sea-level (Gambassini and Ronchitelli, 1998). After a first marine transgression (unit **a**), which invaded the cave (lithodomous boreholes at 13 m asl), a continental deposit (units **b**–**c**) followed, which probably filled a large part of the external chamber. The occurrence of *Cladocora coespitosa* and *Spondylus* sp. within the basal conglomerate and a 135 ± 11 ka date ($^{230}Th/^{234}U$ method; H.P. Schwarcz, unpublished) of the stalagmite suggests that the lower series of this trench may have formed during the interglacial–glacial cycle correlated to MIS 7 – MIS 6. A second marine transgression eroded these levels, leaving a deposit of beach rock, plated onto the older marine conglomerate (cut 22 in Fig. 2), still visible in other areas of the cavity. The retrieval of *Strombus bubonius* within this level indicates that the deposition of this series possibly started during a high-stand phase nearly contemporaneous or slightly after the Eutyrrhenian (MIS 5e). The following

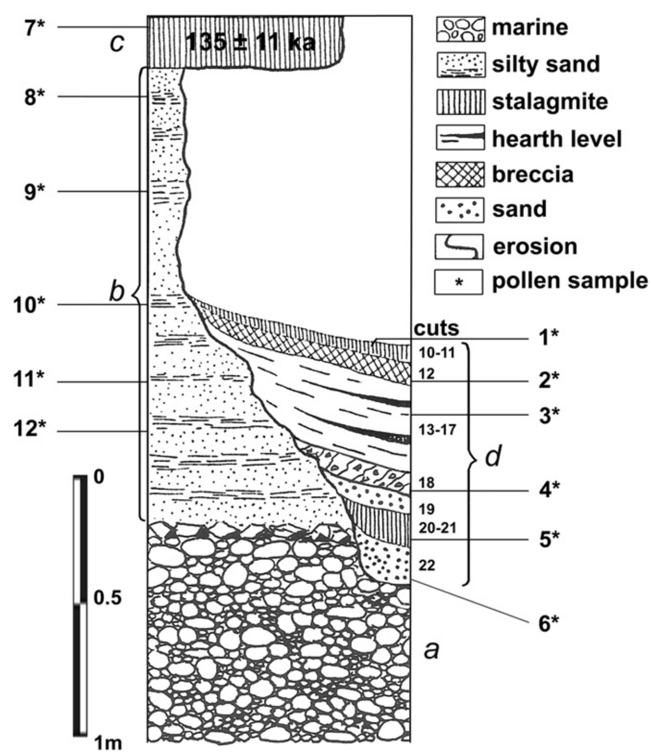


Fig. 2. Trench A: stratigraphic scheme.

regression allowed humans to enter the cave (unit **d**). Probably during the "Versilian" transgression (Holocene, "Atlantic"), the sea entered again and removed the greater part of the archaeological deposit.

2.2. Trench F

Trench F is characterised by a low tunnel (3 × 3 m), a sort of small "cave within a cave", eroded by a transgression before the arrival of humans (probably MIS 7) and sealed to the ceiling by the following deposit (layers 1–10 in Fig. 3). The sequence (about 1 m thick) is articulated (Ronchitelli, 1998; Boscato and Ronchitelli, 2004) and a brief report is given here. The base is a breccia with *S. bubonius* and *Patella ferruginea* (layer 10) followed by a marine conglomerate (layer 9), probably the same as the one at the base of the younger series of trench A. The following continental deposits (layers 8–2) are mainly archaeological and are sealed by tephra (layer 1). The occurrence of the warm mollusc assemblage (*S. bubonius* and *P. ferruginea*) in the basal level suggests that the deposition of this series also started after the Euthyrrhenian high-stand phase (MIS 5e).

3. Archaeology

3.1. Trench F

Trench F is particularly interesting for the presence of structures which illustrate the living space, both horizontally as well as vertically, in between them, unfortunately also partly dismantled by marine erosion (Ronchitelli, 1998; Boscato and Ronchitelli, 2004; Peretto et al., 2004). These structures, rather rare in Middle Palaeolithic, indicate a settlement organization, with clean areas separated from spaces with waste product accumulation. A small wall made up of a large stalagmite intentionally rested on a pile of stones, bones and ground (layer 7 in Fig. 3), with base stones immersed in layer 8, characterises the human presence in this particular part of the cave. This wall was constructed in a point where the ceiling of the niche is lower. It divides the atrium (1.5 m high) from a sort of tunnel where the maximum height is reduced to 80 cm. The same structure also delimits a change in the mode of deposition (layer 8 in Fig. 3). The atrium is characterised by an accumulation of ashes and charcoal, mixed together with very few lithic and faunal remains, uniformly distributed. Inside the tunnel there is an accumulation of stones, pebbles and fragments of concretions, lithic instruments and bones along the two lateral walls. The central band is almost totally free of materials and completely free of charcoal (Fig. 4). In the internal space are numerous remains, above all cranial ones, almost completely absent on the outside. The lithic industry (Fig. 5 and Table 1) is characterised by the prevalence of calcareous knapped pebbles over debitage products, only half being flint materials.

These calcareous elements are not standardised (Boscato and Ronchitelli, 2004). Whereas they are not infrequent in the Middle Palaeolithic culture, here they are particularly important. Their use is at the moment unknown, so functional and experimental studies are on progress to clarify if they were related with faunal remains and could indicate the use of the area for a particular activity. In the outside zone the finds consist, on the other hand, of small bone fragments, often burned. Only in this zone do retouched implements appear, mostly lateral convex and transversal rectilinear sidescrapers (Fig. 5: 11–15), together with flakes and more numerous cores, often calcareous. The Levallois system is present, but does not seem to be the only production modality of this industry. The raw material used by prehistoric humans was mainly flint pebbles, but also jasper or quartzite were utilised. A small part of the lithic industry is made out of poor quality flint, stratified in the limestone exposed near the cave. Thirteen fragments of stalagmites and stalactites, equally distributed between internal and external areas, were collected by humans in other parts of the cave and introduced to this sector.

The finding of a coprolite and of an ibex scapula with chewing evidence in the atrium, probably due to hyena, and the tight space in the tunnel, may indicate transport of part of these bones by carnivores. Moreover, the almost total absence of materials in the central part of the tunnel may be due to the frequenting of this area by these animals in a time when humans were absent. On the other hand, at the present state of the investigation, the occurrence of the vertical structure (layer 7, Fig. 3), a wall most certainly built by humans, and the scarcity of traces of chewing on the bones (partially cemented and corroded), suggests that the action of the carnivores was limited.

The vertical structure was still functional during the successive level (layer 6, Fig. 3), corresponding to another palaeosurface with evidence of organized living space (Fig. 4, top). This structure consists of stones and stalagmite concretions forming a semicircle separating an area free of materials from an area with accumulated bones and lithic finds. Industry (Fig. 5 and Table 1) and fauna are analogous to those of the tunnel except for the occurrence of elephant, indicated by a fragmented molar. This structure is situated in the atrium area, as the tunnel became impracticable owing to sediment accumulation. The only important specimen collected here is a fragment of cranium of *Bison priscus*, overturned alongside the large stalagmite forming the top of the vertical structure (Fig. 4). Coupled stalagmite-bison remains have been found also inside a niche within the "Riparo del Molare", a fossil site 60 m from Grotta Grande cave. These are associated with a stone circle in an area with few remains, suggesting a symbolic rather than a practical significance (Ronchitelli, 1993; Peretto et al., 2004).

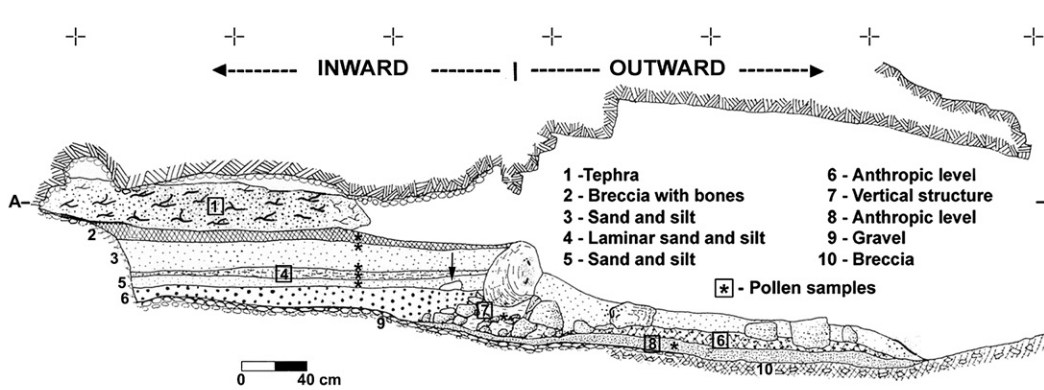
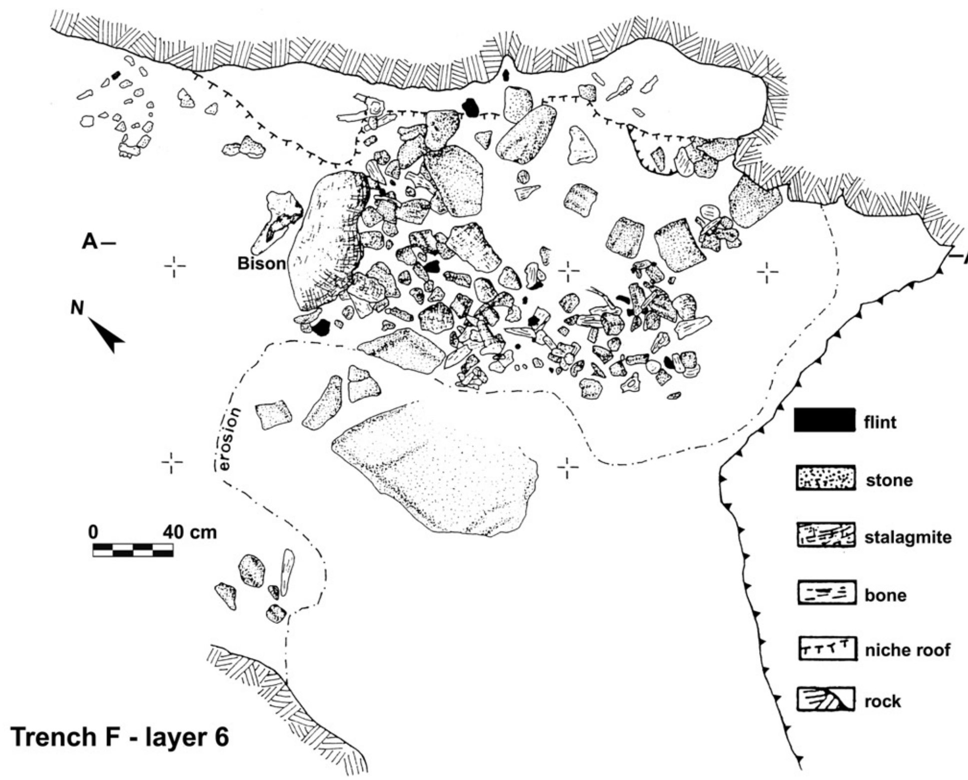


Fig. 3. Trench F: stratigraphy (the arrow points to the cranium of bison).



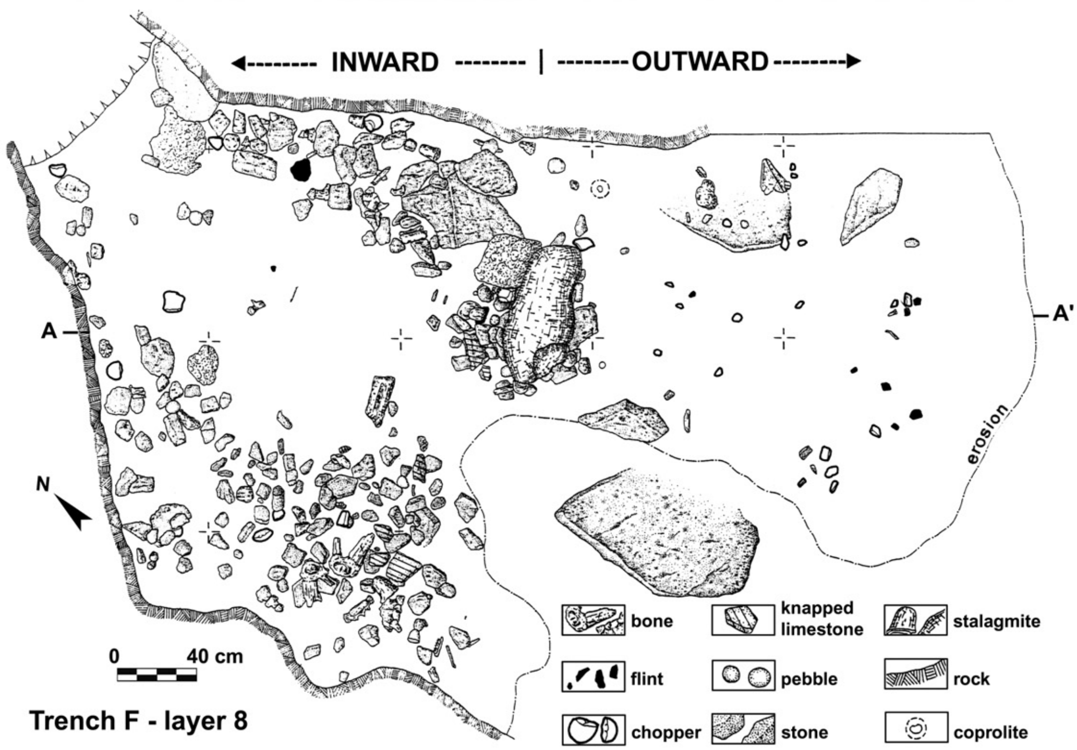


Fig. 4. Trench F: maps of layer 6 (top) and layer 8 (below) (plans by P. Boscato).

3.2. Trench A

Studies on artefacts of trench A are still in progress. The raw material and procurement were the same than that of trench F, except for the very limited use of limestone.

The lithic industry is constituted by sidescrapers (more than 70%), above all laterals (Fig. 5: 3–5), some made on blades (Fig. 5: 3), followed by transversal (Fig. 5: 6) and lateral-transversal sidescrapers. The shape of the retouched margin is mostly convex, in the second place straight. The other implements are points (Fig. 5: 1–2) and, to a lesser degree, denticulates. Carinated types are present, with "demi-Quina" retouch.

A main difference appears between the upper levels (cuts 10–12), and the middle ones (cuts 13–17), as long scrapers and

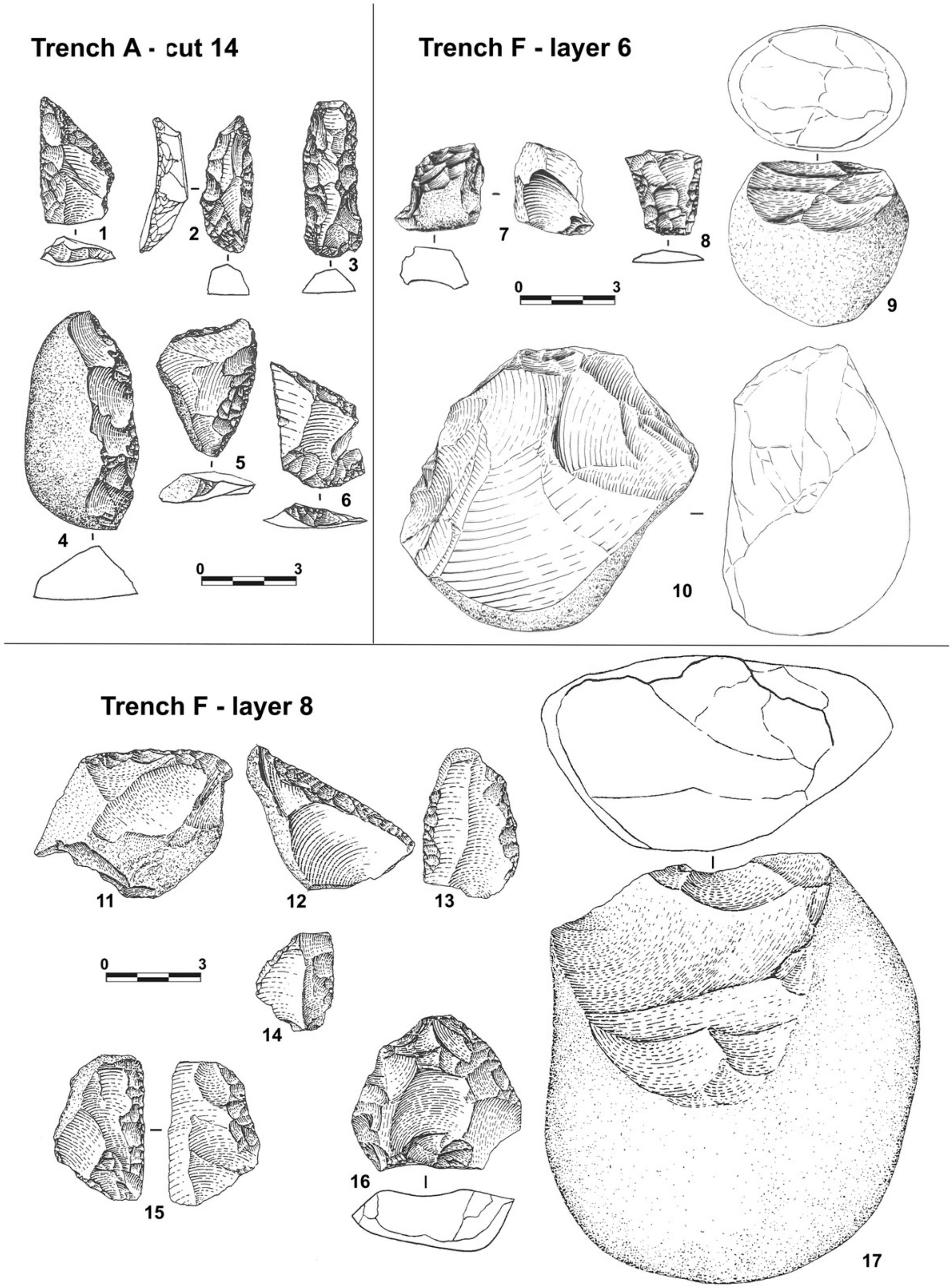


Fig. 5. Lithic industry – Trench A: 1) point; 2) "limace"; 3–6) sidescrapers. Trench F, layer 6: 7–8) sidescrapers; 9) chopper; 10) nucleus. Trench F, layer 8: 11–15) sidescrapers; 16) nucleus (all outward); 17) chopper (inward) (drawings by G. Fabbri, A. Moroni and S. Ricci).

denticulates increase towards the top. The lower horizon (cuts 18–22) is very poor in archaeological finds.

From a technological point of view, the faceted platforms index is medium but the Levallois system is not exclusive. The differences between the flint complexes of trenches A and F are not relevant.

4. Vertebrates

Mammals, birds, reptiles and amphibians remains have been found in both trenches, but only mammals have been studied in detail.

Table 1
Trench F: Lithic industry composition.

Layers in Trench F	6	7	8		10	Total per tool
			Inward	Outward		
Nucleus		1	1	5		**7**
Pre-nucleus	4	2	3	4		**13**
Blanks	20		4	42	9	**75**
Tools	5	1		13	3	**22**
Choppers	2	1	8	2		**13**
"Percutés"	4	1	1	5		**11**
Hammers	1		1	3	1	**6**
Total per layer	**36**	**6**	**18**	**74**	**13**	**147**

Table 2
Faunal list of small and large mammals from trench A and F.

Taxa	Trench A	Trench F
Elephas cf. antiquus		X
Hippopotamus amphibius		X
Stephanorhinus hoemitecus	X	
Sus scrofa	X	X
Bison priscus	X	X
Capra ibex	X	X
Rupicapra pyrenaica	X	
Cervus elaphus	X	X
Dama dama	X	X
Capreolus capreolus	X	
Ursus arctos	X	X
Apodemus sylvaticus	X	X
Microtus (Terricola) cf. savii	X	X
Myodes glareolus		X
Arvicola amphibius	X	X
Glis glis	X	X
Muscardinus avellanarius		X
Eliomys quercinus	X	
Erinaceus europaeus		X
Crocidura suaveolens	X	X
Crocidura leucodon		X
Talpa caeca		X
Talpa europaea	X	X
Talpa romana		X
Lepus europaeus	X	X
Chiroptera indet.	X	X

4.1. Large mammals

Continental deposits of trenches A and F yielded a fairly diversified large mammal assemblage (Tables 2–4) (Ronchitelli, 1998; Ronchitelli et al., 1998; Boscato and Ronchitelli, 2004). Ruminants are common in both trenches and include ibex, fallow deer, red deer and bison, while roe deer and chamois are present in trench A only (Figs. 6 and 7). The occurrence of wild boar is sporadic. Scarce remains document the occurrence of the straight tusked elephant and of a hippo in trench F (Fig. 7), while a single specimen documents the narrow-nosed rhino in trench A (Fig. 6). The absence of horses is also a distinctive feature of both assemblages. Carnivores are rare: only the brown bear is represented by skeletal remains, and the probable occurrence of a hyena is documented by one coprolite found on the human occupational surface in trench F.

The territory close to the cave, frequented by Neanderthal hunters, is characterised by steep slope hills favourable to the diffusion of ibex. From the data obtained from the stratigraphic series of Riparo del Molare (Arobba et al., 2004) dated to MIS 5, the morphology of this area particularly favoured the occurrence of this caprine which was abundant even during the interstadial phases. A coastal plain, presently covered by the sea, completed the hunting areal and probably gave hospitality to bison, auroch, hippo, elephant, and partially to cervids.

4.1.1. Trench A

The large mammal assemblages from trench A have been described in Ronchitelli et al. (1998). Large mammals are well represented in unit **d,** in layers related to the human frequenting of the cave. The remains are concentrated in the middle – upper portion of the unit (cuts 16 to 10–11). Some 280 remains have been taxonomically determined (Table 3). The assemblage is characterised by the occurrence of abundant ibex which dominates the assemblage with percentages around 50% in most of the cuts, while the deer assemblage (red, fallow and roe deer) roughly represents the remaining 50% of the total abundance (Fig. 6). Rare elements are the brown bear (*Ursus arctos*), the chamois (*Rupicapra pyrenaica*), the boar (*Sus scrofa*) and the bison (*B. priscus*). The occurrence of a single specimen of the narrow-nosed rhino (*Stephanorhinus hemitoechus*) is noteworthy. This taxon is considered as an indicator of open ("steppe") landscapes; it is widespread in the Middle Pleistocene and was still present during part of the Late Pleistocene. According to Stewart (2007), the narrow-nosed rhino likely survived in the European regions until the Late Glacial Maximum, or possibly even later. The deer assemblage is very characteristic, as the fallow deer, followed by roe deer, are dominant over the red deer. This dominance is unusual for the Late Pleistocene assemblages, where the red deer is the most common element. The dominant fallow deer suggests that a Mediterranean environment persisted in the area. On the other hand, the occurrence, even sporadic, of the narrow-nosed rhino indicates prairies or steppe-like patches, while the presence of the chamois at such a low altitude is indicative of a climate cooler than expected for the climatic optimum of the Eemian interglacial.

4.1.2. Trench F

In trench F, remains of macrofauna are directly related to the anthropic palaeosurfaces. Most remains have been found within layers 6 and 8. Most bones belong to ungulates, while carnivores are rare: two skeletal remains within layer 6 and only one from layers 7 and 8. Only the brown bear has been recognised (Table 4; Ronchitelli, 1998; Boscato and Ronchitelli, 2004). The setting of bones on the surface of layer 8 and the particular concentration of cranial fragments within the same layer in the "low tunnel" suggest selection and positioning of the skeletal elements due to the scarcity of space (Fig. 4). The cranial fragments belong to the red deer, fallow deer, ibex and brown bear. A palatine and four fragments of frontal bones, all with peduncle and portion of antlers, are referred to the red deer. The fallow deer is represented by a maxilla and a premaxilla fragment, a peduncle and two cranial vault fragments both with attached small portions of antler. The particular abrasion of one of the cranial vaults may resemble analogous remains chewed by carnivores. Two further antler fragments have been attributed to Cervidae indet. The ibex is represented by two cranial portions referable to adult males. Noteworthy is the recovery of five skeletal remains attributed to hippo (two vertebras, a sacrum, a femur fragment and a part of a lower canine) and of a premaxilla with attached maxilla fragment attributed to the brown bear. Some other smaller remains including isolated teeth and limb bones, pelvis, homoplate, and mandible fragments complete the amount of skeletal remains found in layer 8. A few of these bones show evidence of intentional crushing by humans, probably due to bone marrow recovery.

The large mammal remains recovered from layer 8 attributed to a taxonomic level are represented by a total amount of 45 elements (Table 4). The most representative species are the ibex and the fallow deer (both with 13 remains), followed by red deer, hippo, a large-sized bovid (an auroch or a bison) and brown bear (Fig. 7).

Table 3
Absolute and percentage abundance of large mammals in trench A.

Levels Trench A	*Stephanorhinus hemitoechus*		*Sus scrofa*		*Bison priscus*		*Capra ibex*		*Rupicapra pyrenaica*		*Cervus elaphus*		*Dama dama*		*Capreolus capreolus*		*Ursus arctos*		**MNS per strata**
	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	
10–11							9	32.1	1	3.6	2	7.1	13	46.4	2	7.1	1	3.6	**28**
12	1	1.3					39	50.0			5	6.4	25	32.1	8	10.3			**78**
13			1	1.5	1	1.5	33	48.5			5	7.4	18	26.5	10	14.7			**68**
14							27	42.9	1	1.6	6	9.5	8	12.7	20	31.7	1	1.6	**63**
15			1	9.1			6	54.5					4	36.4					**11**
16							15	55.6			2	7.4	8	29.6	2	7.4			**27**
17							2	66.7							1	33.3			**3**
18																			
19							2	50.0					1	25.0			1	25.0	**4**
20–21							1	100.0											**1**
22																			
Total	**1**		**2**		**1**		**134**		**2**		**20**		**77**		**43**		**3**		**283**

The same species associated with remains referred to the straight tusked elephant has been found in the following layer 6 (Table 4), another paleosurface with evidence of spatial human organization. In this layer, ibex is more abundant at 39% (Table 4 and Fig. 7). The comparison of the percentages of the different taxa between the two layers indicates a decrease of deer from layer 8 (55.4%) to layer 6 (37.2%): the largest decrease is observed for the fallow deer (from 28.8% to 17.6%), together with a lesser number of hippo present with an unique remain in layer 6. The increase of ibex is accompanied by the increase of bison.

The ungulate assemblage recorded in layer 8 suggests forested areas and a temperate climate, as indicated by the abundance of the fallow deer and occurrence of the hippo. In layer 6, the environment became more open due to a more arid climatic phase.

4.2. Small mammals

Small mammals are represented by less numerous remains than large mammals in trench A while they are more abundant and evenly distributed in trench F (Abbazzi and Masini, 1998). The remains document a well diversified assemblage, in which rodents insectivores, bats and lagomorphs are present (Tables 5 and 6, Figs. 8–10; Ronchitelli, 1998; Ronchitelli et al., 1998; Boscato and Ronchitelli, 2004; Surdi, 2007). Rodents represent the majority of small mammal finds.

Apodemus sylvaticus (Linnaeus, 1758) is nowadays found throughout Europe, in central and southwestern Asia and northwestern Africa. The long tailed field mouse is a very common and widespread species due to its commensality with humans. Wood mice prefer woodlands and forests, grasslands, and cultivated fields, although they will live anywhere they can find adequate shelter. The wood mouse is the dominant taxon and is by far the most common rodent occurring quite in all levels of both trenches, with 18 specimens in level two of trench F and 15 in level 13 of trench A (Tables 5 and 6). As it is rather opportunistic and cannot be considered as a clear environmental indicator, its abundance does not supply any precise palaeoecological indication. It should be noted, however, that these mice are never abundant in open landscape environments, and their abundance in the Grotta Grande reinforces the forested valence of other taxa such as the dormice.

Microtus (Terricola) ex gr. *savii* (de Sélys Longchamps, 1838) is a characteristic fossil species occurring in the whole peninsula and in Sicily, while nowadays it is endemic in Europe and found throughout northern Italy (with the exception of the extreme northeast), especially in Central – Southern Italy and in Sicily. It is found in the majority of terrestrial habitat types, with the exception of high mountains, dense woodlands, and some very sandy, rocky or wet areas. It occurs in many anthropogenic habitats including pastures, arable lands, gardens, and urban areas (Contoli, 1999).

The Savi vole is present in both trenches but it is more abundant in trench A (Tables 5 and 6). The taxon reaches up to 40% abundance in trench A, while within trench F it is rather rare in the lower levels and gradually increases towards the top, where it reaches some 20% abundance (Figs. 8 and 9). Some morphological – morphometrical observations made on the occlusal surface of the first lower molar show that the vole of trench A has a more elongated and constricted anterior part (Locatelli et al., in press) than that of the vole of trench F (Table 7). The observed characters show that the vole of trench A is closer to the "subterraneus type" than that from trench F. These observations suggest that the Savi vole from trenches A and F are somewhat distinct morphologically, and therefore that they represent local populations that are not coeval.

Table 4
Absolute and percentage abundance of large mammals in trench F.

Levels Trench F	*Elephas* cf. *E. antiquus*		*Hippopotamus amphibius*		*Bos* vel *Bison*		*Bison priscus*		*Capra ibex*		*Cervus elaphus*		*Dama dama*		*Sus scrofa*		Cervidae indet.		*Ursus arctos*		Carnivora indet.		**MNS per strata**
	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	
2									5	62.5	1	12.5	2	25.0									**8**
3																							
4																							
5																							
6	1	1.9	1	1.9			8	15.7	20	39.2	10	19.6	9	17.6					1	1.9	1	1.9	**51**
7							1	25.0			1	25.0	1	25.0					1	25.0			**4**
8			5	11.1	1	2.2			13	28.8	10	22.2	13	28.8			2	4.4	1	2.2			**45**
10													4	80.0	1	20.0							**5**
11																							
Total	**1**		**6**		**1**		**9**		**38**		**22**		**29**		**1**		**2**		**3**		**1**		**113**

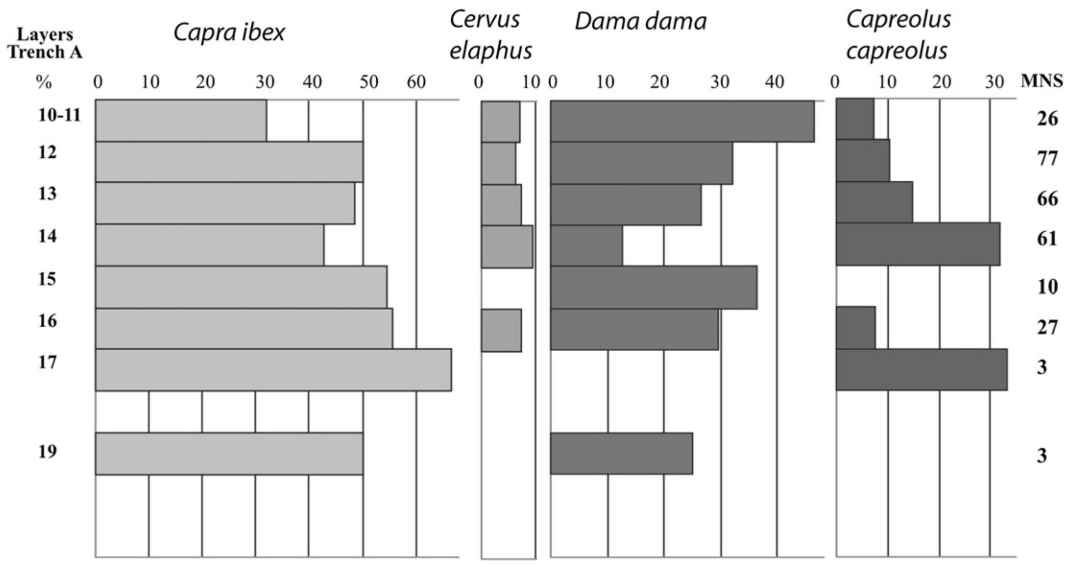


Fig. 6. Percent abundance of large mammals from trench A. The sporadic remains of ibex, brown bear, chamois, rhino, wild boar and bison are reported in Table 3.

Arvicola amphibius (=*Arvicola terrestris*) (Linnaeus, 1758) has a wide range extending from France and the United Kingdom in the west, through much of continental Europe and Russia. This large vole is fully adaptable and lives in a wide range of habitats but all near humid areas as around rivers, streams and marshes in the lowlands and the mountains (Harrison and Bates, 1991). It is ubiquitous but its survival depends on the presence of waters. The water vole is indifferent to climatic variations and is never dominant in the stratigraphic successions of the two trenches where it is discontinuously present with a maximum percentage of 11% within the level 10 of trench F and 35% in level 15 of trench A (Figs. 8 and 9, Tables 5 and 6).

A sub-sample of lower first molars of the water vole from trench A has been analysed by Maul et al. (1998) and later by Masini et al. (2003, 2007). These authors considered two parameters, the total length, and the quotient of enamel differentiation (SDQ, Heinrich, 1978). The water vole from the Grotta Grande of Scario is fairly distinct from coeval populations from western and central European locations, as well as from a recent sample from northern Italy, thus suggesting it belongs to a separate evolutionary lineage (Fig. 11; Maul et al., 1998; Masini et al., 2007). According to Maul et al. (1998) and Masini et al. (2003, 2007), it is likely that the *Arvicola* from Scario is a representative of a "Mediterranean" Italian Peninsular water vole that can be considered as a subspecies (or a species) distinct from the Central and Western European populations grouped within *A. amphibius*. Such possibility is also supported by the results of molecular phylogenetic studies on extant *Arvicola* carried on by Wust Saucy (1998).

Myodes (=*Clethrionomys*) *glareolus* (Schreber, 1780), bank vole, has a wide range in the Palaearctic regions, from the British Isles through continental Europe and Russia. In the north, its range extends beyond the Arctic Circle, and in the south it reaches northern Turkey and northern Kazakhstan (Shenbrot and Krasnov, 2005). It is widespread in Europe, although it is absent in very dry regions such as southern Iberia, and in the Mediterranean islands. In Italy its extant distribution extends from the Alpine arch southwards along the Apennines mountain range. *Myodes glareolus* is known in the Italian peninsula since the Middle Pleistocene and, although it is usually represented by a low number of remains, it is a fairly constant occurrence during the last glacial cycle and in the Holocene. The bank vole is an indicator of forested environments and inhabits all kinds of woodland, preferring densely-vegetated clearings, woodland edge, and river and stream banks in forests. It is also found in scrub, parkland, and hedges (Viro and Niethammer, 1982). The bank vole is recorded in trench F only, where it is a subordinate taxon in respect to the other rodents. It reaches some 10% in layers 10–11, and has a scattered occurrence at the top of the sequence with some 3–4% (Tables 5 and 6 and Figs. 8 and 9).

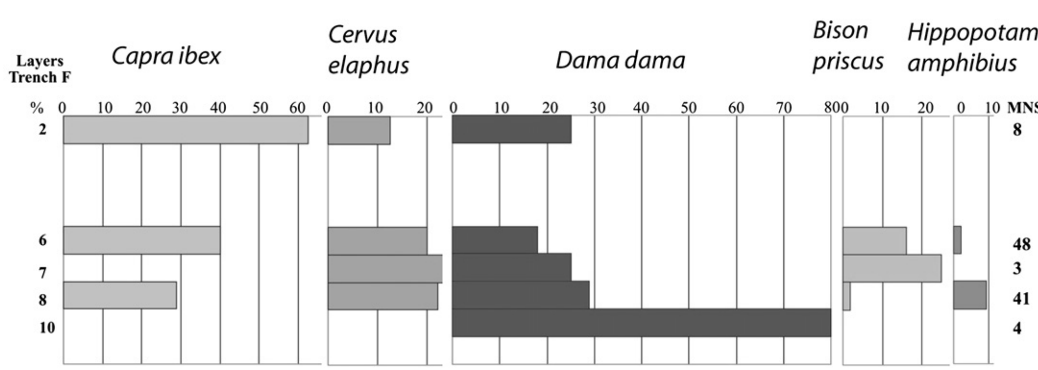


Fig. 7. Percent abundance of large mammals from trench F. The sporadic remains of elephant, brown bear, wild boar and Cervidae indet are reported in Table 4.

Glis glis (Linnaeus, 1766) has a global distribution that extends across Europe to the Caucasus. It is found also in some Mediterranean islands such as Sicily, Sardinia, Elba and Salina. The fat dormouse is not very common in the Würmian sites of the Italian Peninsula. It is typically found in mature deciduous and mixed woodland although it also occurs in maquis and shrub land on rocky areas along the Mediterranean coast. Nowadays it lives also in human-made habitats such as gardens and orchards (Macdonald and Barrett, 1993).

The fat dormouse is present in both trenches and is most abundant in the lower levels of trench F (layers 11 to 6) where it reaches an abundance of about 30% in layers 10–11. In trench A, the taxon is scarcely represented and discontinuously distributed within the stratigraphic succession, while records an acme of abundance (50%) in level 22 (Figs. 8 and 9, Tables 5 and 6). This dormouse is a good indicator of the occurrence of wood in the surrounding of the cave. The fat dormouse can rest in caves or rock shelters and its occurrence and abundance within the sediments can be related to this habit, or, possibly, also due to commensalism with humans.

Muscardinus avellanarius (Linnaeus, 1758), common dormouse, occurs in Europe and northern Asia Minor. In continental Europe it is absent from Iberia, southwest France, northern parts of Russia, eastern Ukraine and southern Russia. It is rather uncommon in the archaeological Würmian sites of the Italian Peninsula (Kotsakis et al., 2003). The dormouse inhabits forest edges, secondary growth, coppices, and other wooded areas with a dense shrubby understorey. The taxon lives in coniferous forests with abundant shrubs, preferring the most opened areas and the clearings. Preferring deciduous woodland, favouring hilly landscapes with abundant coppice, its presence indicates temperate climate and more humid forested environments. Even rarer than the fat dormouse, the common dormouse has been found only in the lower layers of trench F (levels 8–11; Fig. 9 and Table 6). Abundance in these levels is only subordinate to that of *G. glis*. The taxon is a good indicator of clearing within wooded areas.

Eliomys quercinus (Linnaeus, 1766) is endemic to Europe. It is now largely confined to western Europe, including numerous Mediterranean islands. Its main habitat is woodland (coniferous, deciduous, and mixed), although it is sometimes found in orchards and gardens. It is less arboreal than the other dormice, and is often found on the ground in rocky areas, cracks in stone walls, and even in houses (Le Louarn and Spitz, 1974; Vaterlaus, 1998; Bertolino and Cordero di Montezemolo, 2007). The garden dormouse is limited to two remains recovered in trench A (Fig. 8 and Table 5). It is part of the Italian fossil fauna from the Middle Pleistocene, and nowadays spread in all the European forested ecosystems, mainly on the well exposed sides with rocky areas for hiding purposes.

Insectivores, Chiropterans and Leporids are less frequent within the micromammal assemblages of both trenches. Their occurrence is more constant through the succession of trench F while in trench A they are rather scarce (Tables 5 and 6).

Among insectivores of trench F, the better represented shrew is *Crocidura suaveolens* (Pallas, 1811). The lesser white-toothed shrew has a wide global distribution. In western and southern Europe it is found in a wide range of habitats including vineyards, olive groves, terraced farmland on hillsides, dry Mediterranean shrub land, sand dunes, rocky areas in the mountains, and damp densely-vegetated patches near to the water. It tends to avoid dense forests (Vlasák and Niethammer, 1990; Libois et al., 1999). This shrew is homogeneously distributed through the succession of trench F where it is associated (level 3) with the bicoloured shrew, *Crocidura leucodon* (Hermann, 1780), recognised from a unique mandible (Table 6). The lesser white-toothed shrew also occurs in trench A (level 17) with a sole remain (Table 5).

The genus *Talpa* occurs in trench F with three species. The smallest *Talpa caeca* (Savi, 1822) was found at the top and in the lowermost levels of the stratigraphic succession (Table 6). The taxon is endemic of Europe and is distributed in the Italian Peninsula (with the exceptions of easternmost and southernmost sectors) and in the Balkan area. It occurs in deciduous woodland, meadows and pastures in hilly or mountainous areas. It requires deep soil that is not too dry. The larger *Talpa* remains, which were recovered in the uppermost part of the succession (Table 6), are referable to *Talpa romana* (Thomas, 1902), a species endemic to Italy. It is now confined to the mainland, having last been recorded on Sicily in 1885 (Loy, 1999). Its ecology is similar to that of the European mole *Talpa europaea*. It is found in a variety of habitats including arable fields, pastures, and woods, and it feeds predominantly on earthworms (Niethammer, 1990; Loy, 1999). The third species is *Talpa europaea* (Linnaeus, 1758) occurring in levels 2, 5 and 11 of trench F and also recorded in level 16 of trench A (Tables 5 and 6). The European mole occurs from Britain and Spain eastwards through much of continental Europe (Corbet, 1978; Kryštufek, 1999; Wilson Don and Reeder Dee Ann, 2005). In the Mediterranean, it is generally widespread, although it is absent from southern Iberia, southern Italy, the southern Balkans (where it is replaced by other species of mole). It occurs in most habitats where there is sufficiently deep soil to permit digging of its extensive burrows. It prefers meadows, pastures, arable land, gardens and parks, and is rarely found in coniferous forests, or habitats with sandy, stony or permanently waterlogged soils (Kryštufek, 1999). The hedgehog, *Erinaceus europaeus* (Linnaeus, 1758), has been identified by a single specimen in layer 3 of trench F. Hedgehogs are always rare as fossils, possibly because of the different taphonomy

Table 5
Absolute and percentage abundance of small mammals in trench A.

Levels Trench A	*Apodemus sylvaticus*		*Microtus (Terricola)*		*Arvicola amphibius*		*Eliomys quercinus*		*Glis glis*		*Crocidura suaveolens*		*Talpa europaea*		*Lepus europaeus*		Chiroptera indet.		**MNS per strata**
	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	
10–11																			
12	1	16.7	1	16.7	2	33.3			2	33.3									**6**
13	15	68.2	5	22.7	1	4.5			1	4.5									**22**
14	9	47.4	8	42.1	2	10.5													**19**
15	4	28.6	3	21.4	5	35.7									1	7.1	1	7.1	**14**
16	7	35.0	8	40.0	2	10.0			2	10.0			1	5.0					**20**
17	12	48.0	5	20.0	3	12.0	1	4.0	3	12.0	1	4.0							**25**
18																			
19							1	100.0											**1**
20–21																			
22	1	50.0							1	50.0									**2**
Total	**49**		**30**		**15**		**2**		**9**		**1**		**1**		**1**		**1**		**109**

Table 6
Absolute and percentage abundance of small mammals in trench F.

Levels Trench F	*Apodemus sylvaticus*		*Microtus (Terricola)*		*Arvicola amphibius*		*Myodes glareolus*		*Glis glis*		*Muscardinus avellanarius*		*Erinaceus europaeus*		*Crocidura suaveolens*		*Crocidura leucodon*		*Talpa caeca*		*Talpa europaea*		*Talpa romana*		*Lepus ex gr. europaeus - corsicanus*		Chiroptera indet.		**MNS per strata**
	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	MNS	%	
2	18	40.9	11	25.0	4	9.1	2	4.5	1	2.3									1	2.3	4	9.1			3	6.8			**44**
3	17	48.6	8	22.9	1	2.9	1	2.9	1	2.9			1	2.9			1	2.9					2	5.7	3	8.6			**35**
4	2	50.0	1	25.0											1	25.0													**4**
5	17	68.0	2	8.0	1	4.0			1	4.0					1	4.0					1	4.0	1	4.0	1	4.0			**25**
6	12	42.9	5	17.9	1	3.6			4	14.3					2	7.1											4	14.3	**28**
7	2	33.3							1	16.7																	3	50.0	**6**
8	7	46.7	1	6.7					2	13.3	3	20.0			1	6.7									1	6.7			**15**
10	10	37.0			3	11.1	2	7.4	7	25.9	1	3.7			1	3.7			1	3.7					1	3.7	1	3.7	**27**
11	9	31.0	1	3.5			4	13.8	11	37.9	1	3.5							1	3.5	1	3.5					1	3.5	**29**
Total	**94**		**29**		**10**		**9**		**28**		**5**		**1**		**6**		**1**		**3**		**6**		**3**		**9**		**9**		**213**

respect to other small mammals, such as voles, which are intensively preyed and accumulated by owls.

Some remains of bats were recovered from the low-central part of trench F and were attributed to two different genera (Table 6), while in trench A a unique remain not yet determined has been recovered from level 15 (Table 5). The larger sized bat was attributed to *Rhinolophus*, perhaps *Rhinolophus ferrum-equinum*. The smaller bat, referred to the genus *Myotis*, occurs in level 6. The sole leporid found among the small mammals assemblage is a hare referred to *Lepus* ex gr. *europaeus* – *corsicanus*, as the distinction between these two species is impossible on the base of the available remains. The taxon is discontinuously distributed through the succession of trench F and occurs with a sole remain from level 15 within trench A (Tables 5 and 6). Both species are highly adaptable and can persist in many habitat types so that the occurrence of this hare does not allow any relevant palaeoenvironmental indication.

4.3. Reconstruction of the environment based on mammals

The percent abundance of small mammal taxa indicates a forested environment in the lower part of the continental deposits of trench F, as documented by the abundance of dormice (*Glis* and *Muscardinus*) and the occurrence of the bank vole (Fig. 9). The decrease in abundance of the glirids, coupled with an increase of the Savi vole in the upper portion of this sequence (units 5–2), suggests that the landscape evolved towards more open conditions (perhaps related to more arid climate). The occurrence of the hippo and the abundance of fallow deer remains confirm the temperate–warm climate in the lower deposits (units 8–6; Fig. 7).

The lower series of trench A lacks vertebrate remains, whereas vertebrates occur in the upper part of the younger sequence (unit **d**). The large mammal assemblage is dominated by the ibex followed by the fallow deer and the roe deer. The sporadic occurrence of the chamois and of the narrow-nosed rhino is noteworthy (Fig. 6). Among small mammals, the Savi ground vole is abundant, while the dormice are poorly represented (Fig. 8). This assemblage seems to indicate a landscape that was locally less forested and had cooler climatic conditions, likely posterior to the warmer forested environment in which the F trench series was deposited.

5. Pollen and micro-charcoal

Thirty samples were taken from trenches A, C, D, F, with 18 modern surface control samples collected near the trenches and in one transect along the cave. Pollen was extracted from sediments and examined with current standard methods. Pollen terminology is according to Berglund and Ralska-Jasiewiczowa (1986) and plant names follow Pignatti (1982). The names of pollen types are according to the relevant keys. The text omits the terms “cf., type, group”, which are reported in Table 8. Micro-charcoal was studied according to the method described by Torri et al. (2009), which divides the particles in five classes: <10 μm; $>10–50$ μm; $>50–125$ μm; $>125–250$ μm; >250 μm. Pollen and micro-charcoal have been studied in the sequences of trench A (Ronchitelli et al., 1998) and trench F to date. The relevant data are synthetically presented here. The analyses of the other trenches are in progress.

5.1. Trench A

A provisional percentage pollen diagram from trench A has been described in Ronchitelli et al. (1998). Subsequently, further pollen and micro-charcoal analyses were carried out. The main features obtained from 10 samples containing pollen out of 12 samples

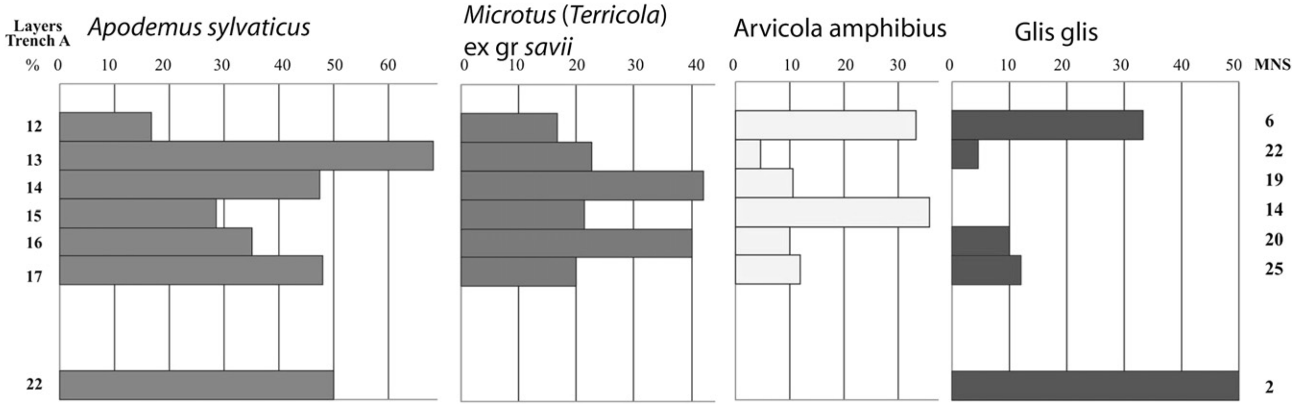


Fig. 8. Percent abundance of rodents from trench A. The unique remain of *Eliomys quercinus* together with the abundances of insectivores, lagomorphs and chiropterans are reported in Table 5.

examined, plus a recent control sample (moss sample) (Fig. 12) are discussed here.

About 100–260 *p*/sample were identified (p = pollen and fern spores). All classes of micro-charcoal (=m) were counted. Pollen concentration was very low (10^1–10^2 *p*/g). The state of preservation was sufficiently good. Pollen flora was quite rich (ca 100 taxa, half of which were trees/shrubs and half herbs (Table 8). The most frequent or abundant taxa were *Alnus*, *Celtis*, *Carpinus orientalis/Ostrya*, *Corylus*, *Erica*, *Juniperus*, deciduous *Quercus*, *Olea europaea*, *Quercus ilex*, *Pinus, Platanus orientalis*, *Taxus*, Cichorioideae, Gramineae, and Chenopodiaceae. Flora includes a number of food plants: bramble – *Rubus*, hazel – *Corylus avellana*, chichory – *Cichorium*, fennel – *Foeniculum*, fig – *Ficus carica*, mint – *Mentha*, oak – *Quercus*, olive – *Olea europaea*, stone pine – *Pinus pinea*, sweet chestnut – *Castanea sativa*, and walnut – *Juglans regia*. Micro-charcoals were found in all samples, in good amounts (10^4–10^5 m/g), but the particles of the two highest classes were not always present.

Four pollen zones were identified. The bottom zone, GGSA1 (=Grotta Grande of Scario, units **b** and **c**, pollen samples 10–7) which precedes the settling of humans in the cave, shows a forested landscape (trees/shrubs = 62–85%), with different vegetation belts shaped by conifers (*Abies*, *Pinus*, *Juniperus*, *Taxus*), which in time yield to deciduous broadleaves (*C. avellana*, *Carpinus betulus*, *Ostrya/Carpinus orientalis*, *Fagus*, *Fraxinus excelsior*, *Fraxinun ornus*, deciduous *Quercus*, *Tilia*, *Ulmus*). There also were oscillating Mediterranean evergreens (especially *Q. ilex* and *Olea*, with some *Phillyrea*, *Pistacia*). Some "Tertiary" plants, no longer growing wild in Italy, were found (*Cedrus*, *Planera, Taxodium*). At the top of the zone, in unit **c**, there is an increase in trees/shrubs of fresh water communities (mainly *Alnus*, *Populus*, *Salix*). Among micro-charcoals (total concentration = 10^4–10^5 m/g), the greatest particles (>125 and >250 μm) are absent.

The subsequent zone GGSA2 (unit **d**-lower, pollen samples 6–3, archaeological layers) shows the beginning of forest clearance (trees/shrubs = 55–72%, with the lowest value in pollen sample 4). Conifers mainly shape the landscape, first together with deciduous broadleaves (mainly *Castanea*, *Carpinus orientalis/Ostrya Corylus*, *Quercus*) and subsequently, at the top of the zone, with Mediterranean woods. Some "Tertiary" taxa were found (*Cedrus, Liquidambar*). Hygro-hydrophytes are well represented. Plants useful for food were frequent. Among micro-charcoals (10^4–10^5 m/g), some large-sized particles (>125 μm), were found.

In the following zone, GGSA3 (unit **d**-upper, pollen samples 2 and 1, archaeological layers) the opening of the landscape continued (trees/shrubs = 40–67%). Woods are characterised by deciduous broadleaves, while conifers and Mediterranean evergreens show a strong decrease. Conifers fall to 6–9% versus 15–50% in the previous zones and Mediterranean taxa fall to 0–2% versus 4–20%. Hygrophytes strongly increase first, than decrease. Tertiary taxa are absent. Plants useful for food are similar as in the previous zone. Micro-charcoals are abundant (10^4–10^6 m/g^4) and the particles of the greatest class (>μm 250) appear.

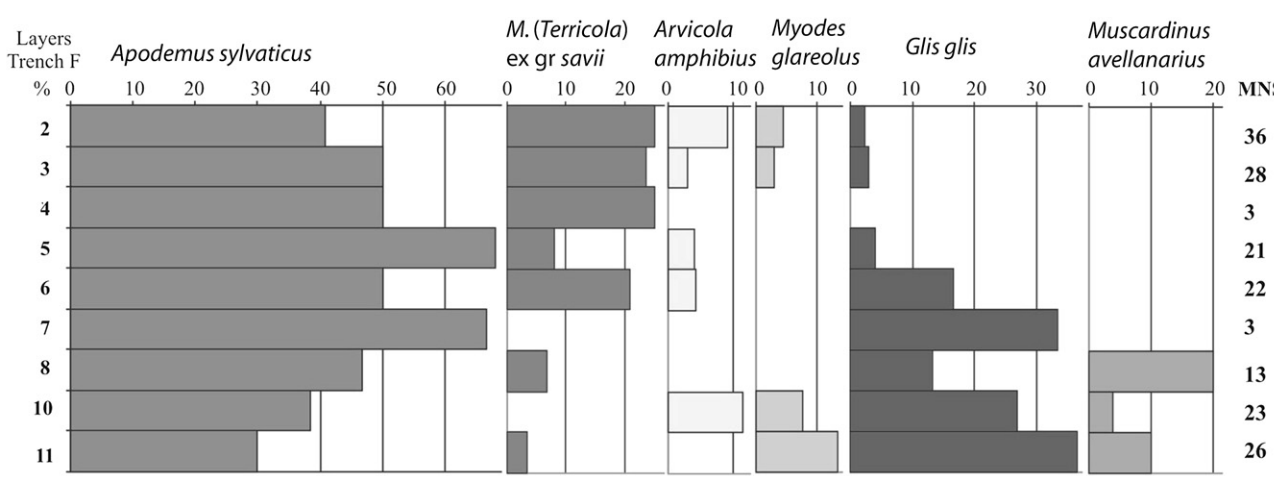


Fig. 9. Percent abundance of rodents from trench F. The insectivores, lagomorphs and chiropterans abundances are reported in Table 6.

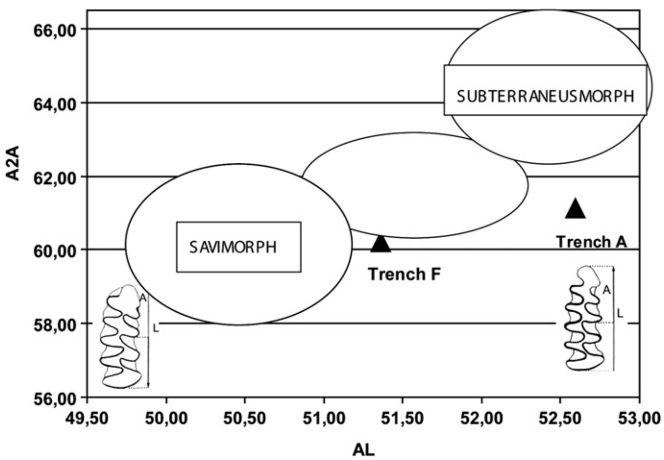


Fig. 10. Bivariate diagram of the morphological indexes AL versus A2A of the first lower molar of *Microtus (Terricola) savii* from the two trenches.

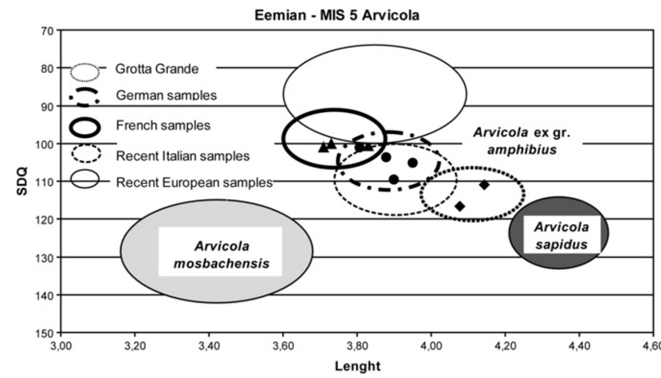


Fig. 11. Bivariate diagram of length versus SDQ of the first lower molar of *Arvicola amphibius*, showing the position of the water vole from Grotta Grande di Scario (trench A and C). The range of recent *A. amphibius* from the Italian peninsula and from various European locations is plotted. *Arvicola mosbachensis* (fossil, Middle Pleistocene localities from European and Italian Peninsula sites) and the extant *Arvicola sapidus* (Spain) are also plotted for comparisons. Data from Maul et al., (1998), Masini et al., (2003, 2007) and data partially unpublished by the authors of the previous papers.

Altogether, the pollen diagram of trench A suggests that when humans settled the cave, the landscape was forested and shaped by communities of different vegetation belts: Mediterranean evergreen forest, mixed forest with broadleaves and conifers. There were relicts of "Tertiary" trees such as *Taxodium* and *Planera*. Conifers and Mediterranean trees/shrubs had first a more important role in the landscape, likely under a temperate climate with oscillations in temperature and humidity. Later, they ceded space to deciduous broadleaves and hygrophilous trees, probably due to a colder and wetter oscillation. In the time span when humans took shelter in the cave, the forest began to be cleared, especially in the Mediterranean vegetation belt and the landscape began to open. A steppe-like vegetation, characterised by plants of the grass and daisy family began to spread, likely following a cold climatic oscillation, first wet, as indicated the increase in fresh water plants in sample 2 (ca 20%), and then, in the top pollen spectrum of the cave (sample 1), dry, as shown by the falling in fresh water plant communities and the general fall in woody plants. Possibly, both climate and humans were involved in the opening of the landscape, as micro-charcoals suggest, as the greatest charcoal particles, which suggest local fires, appear in the archaeological unit **d**.

The top zone GGS4 is the control sample, obtained from the moss sample. It more or less matches the current semi-natural/cultural vegetation landscape. It shows that both the Mediterranean vegetation of the surrounding area and the deciduous broadleaf vegetation belt of Mount Bulgheria, raising to 1225 m a.s.l., ca 8 km inland (Moggi, 1960) are largely modified by humans, growing *Olea*, cereals, *Castanea*. The modern age of the moss pollen spectrum is indicated by records of *Zea mays* and exotic Cupressaceae (*Chamaecyparis*).

5.2. Trench F

Limited data were obtained from this trench. Nevertheless, they are presented due to the importance of the site and the low availability of pollen data concerning caves of this time and area. Seven samples, out of eight examined, contained pollen, in very low concentrations (10^1p/g) and variable states of preservation, from bad to good. Pollen flora is poorer than in trench A (40 taxa, half of which are trees/shrubs and half herbs), in part certainly due to the lower number of pollen grains recorded (12–80 *p*/sample). "Tertiary" taxa are represented by *Cedrus*. Pollen assemblages are quite similar in flora and vegetation. A-pollen diagram was tentatively prepared, excluding samples 4 and 7 where less than 20 pollen grains were found (Fig. 12). Due to the scarcity of data, no pollen zones were drawn. The main features of pollen assemblages are reported below.

Layer 8 (anthropic level): forested landscape (trees/shrubs = 83%): conifers (*Pinus*, *Juniperus*) prevail accompanied by deciduous broadleaves (*Quercus*) and Mediterranean trees (*Q. ilex*). Among herbs, wild Gramineae and Compositae (Cichorioideae and *Aster* type) prevail. Plants of fresh water communities are absent.

Table 7
Measures and morphological indexes of first lower molar of *Microtus (Terricola) savii* from the two trenches.

	L	A	W	Wt	AL	A2A	BW	CW	DW	EW	DE	L4L5
Trench F												
n	24	24	20	24	24	24	20	19	20	20	22	23
Mean	2.71	1.39	0.92	0.95	51.36	60.22	4.87	21.55	34.46	86.85	39.49	77.84
SD	0.13	0.09	0.07	0.05	1.98	3.05	2.07	3.97	7.99	4.61	8.81	2.46
Min	2.47	1.25	0.75	0.84	48.13	54.76		13.16	25.00	81.08	26.15	74.16
Max	2.92	1.59	1.05	1.04	54.95	67.00	8.53	30.00	51.67	96.67	55.17	84.44
i.c. 95%	0.05	0.04	0.03	0.02	0.79	1.22	0.91	1.79	3.50	2.02	3.68	1.01
Trench A												
n	16	18	17	18	16	18	16	16	17	16	16	16
Media	2.61	1.37	0.86	0.91	52.60	61.13	4.32	23.87	31.13	87.94	34.19	78.71
SD	0.10	0.06	0.05	0.05	1.46	3.14	1.71	4.60	8.82	3.59	9.02	1.32
Min	2.42	1.30	0.80	0.86	50.56	55.88	2.35	13.54	15.48	82.35	16.25	76.92
Max	2.75	1.50	0.96	1.00	54.55	66.67	9.64	32.94	50.59	95.24	52.56	80.52
i.c. 95%	0.05	0.03	0.02	0.02	0.72	1.45	0.84	2.25	4.19	1.76	4.42	0.65

Table 8
Pollen flora of both trenches A and F. Taxa only found in the moss sample are between brackets.

Trees and shrubs	*Abies alba*; *Acer campestre* type; *Alnus* cf. *glutinosa*; *Alnus* undiff.; *Betula*; *Carpinus betulus*; *Carpinus orientalis/Ostrya*; *Castanea sativa*; *Cedrus*; *Celtis*; *Chamaerops humilis*; (*Chamaecyparis*); *Cistus*; *Cornus mas*; *Corylus avellana*; *Cupressaceae* undiff.; *Cupressus* cf.; *Ephedra*; *Erica*; *Fagus sylvatica*; *Ficus carica*; *Fraxinus excelsior* type; *Fraxinus ornus*; *Genista*; *Helianthemum*; *Hippophae rhamnoides*; *Juglans regia*; *Juniperus* type; *Ligustrum vulgare*; *Liquidambar*; *Lonicera*; *Myrtus communis*; *Nerium oleander*; *Olea europaea*; *Ostrya carpinifolia*; *Phillyrea*; *Pinus* undiff.; *Pinus* cf. *halepensis*; *Pinus* cf. *pinea*; *Pistacia* cf. *lentiscus*; *Pistacia* cf. *terebinthus*; *Platanus orientalis*; *Planera*; *Populus*; *Prunus*; *Pyracantha*; *deciduous Quercus*; *Quercus ilex* type; *Rhamnus alaternus*; *Rubus*; *Sambucus*; *Sarcopoterium*; *Salix*; *Taxus baccata*; *Taxodium*; *Tilia cordata*; *Ulmus*; *Viburnum.*
Herbs	*Allium*; *Armeria maritima* type; *Artemisia*; *Asteroideae* undiff.; *Aster* type; *Beta*; *Capsella* cf. *bursa-pastoris*; *Carex*; Caryophyllaceae; *Centaurea nigra* type; Chenopodiaceae undiff; *Chenopodium*; Cichorioideae undiff.; *Cichorium intybus* type; *Cirsium;* Cruciferae undiff.; Cyperaceae; *Foeniculum* cf.; *Galium*; Gramineae wild group; *Hordeum* group.; *Hornungia* type; *Labiatae* undiff.; *Leguminosae* undiff.; *Liliaceae* undiff.; *Nymphaea alba*; *Lotus*; *Mentha* type; *Myriophyllum spicatum* type; *Phragmites australis*; *Plantago lanceolata* type; *Polygonum*; *Polygonum aviculare* group; *Primula*; *Ranunculaceae* undiff.; *Reseda*; *Rosaceae* undiff.; *Rumex*; *Serratula*; *Sinapis* type.; *Sparganium erectum*; *Typha angustifolia* type; Umbelliferae undiff.; *Urtica dioica* type; *Urtica pilulifera*; *Verbascum*; *Verbena*; *Vitis vinifera*; (*Zea mais*).

Plants useful for food were few. Among micro-charcoals, which have a low concentration (10^2), the small particles prevail and the particles of the two highest classes are absent.

Layer 7 (vertical structure): only 14 pollen grains were found: a few pines plus Cichorioideae, Gramineae and few other taxa. Hygrophytes are absent. Plants useful for food are absent. Micro-charcoals are more abundant than in the previous sample (10^4 m/g) and include particles > 125 μm.

Layer 5 (sand and silt): low forested landscape (woody plants = 43%) shaped by conifers, deciduous broadleaves, Mediterranean trees/shrubs, with the palm *Chamaerops*. Herbs are dominated by Cichorioideae and Gramineae accompanied by several taxa: *Aster* type, Chenopodiaceae, *Plantago*, etc. Plants useful for food are present. Plants of water communities are absent. Micro-charcoals are 10^4 m/g and include particles >125 μm.

Layer 4 (laminar sand and silt): similar to layer 7. Only 11 pollen grains were found: pines plus Cichorioideae, Gramineae and few other taxa. No plants of water communities nor plants useful for food were found. Micro-charcoals are similar as in layers 7 and 5: 10^4 m/g, with particles >125 μm.

Layer 3 – lower (sand and silt): more forested landscape (woody plants = ca 60%): conifers (*Abies*, *Pinus*) and deciduous broadleaves (*Castanea*, *Erica*, *Fagus*, *Genista*, *Juglans*, *Quercus*, *Ulmus*). There are traces of hygrophytes (*Alnus*). Herbs are quite various: besides Gramineae and Cichorioideae, several taxa were found (*Artemisia*, *Beta*, Caryophyllaceae, *Menta*, *Rumex*, *Thalicrum* etc.). Several plants useful for food were found. Micro-charcoals are 10^4 m/g and include particles >125 μm.

Layer 3 – top (sand and silt): the landscape is similar to the previous one, but less forested (woody plants = ca 40%): conifers, various deciduous broadleaves, Mediterranean trees/shrubs (*Q. ilex*). Hygrophilous plants are present in traces (*Salix*). Herbs show a rich flora. Micro-charcoals are 10^4 m/g and include particles >125 μm.

Layer 2 (breccia with bones): forested landscape (woody plants = ca 60%). Flora is quite rich, with various conifers and deciduous broadleaves plus some Mediterranean trees. A few records of hygro-hydrophytes, including *Nymphaea,* were found. Plants useful for food are numerous. Micro-charcoals are more abundant than previously (10^5 m/g) and include particles of the greatest size >250 μm.

Comparing pollen assemblages of the archaeological layers 2–8 of trench F with those of the archaeological unit **d** of trench A, although they in general show similar flora-vegetation, trench F has some peculiarities: 1) layer 8 shows a more forested landscape (82% versus max. 72% in unit **d** of trench A); 2) Mediterranean

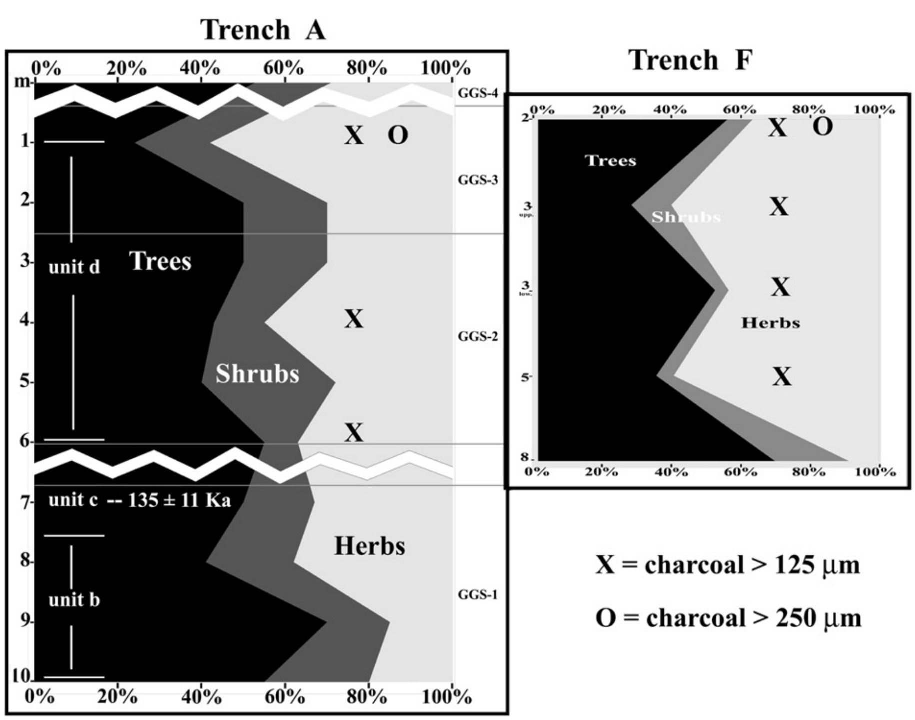


Fig. 12. Synthetic percentage pollen diagram of the trench A and F (trees, shrubs, herbs).

plants are more abundant (mean 8% versus 5% in A); 3) hygro-hydrophytes are lower (5% versus 12% in A); 4) The episodes of steppe vegetation spread (with Gramineae, Cichorioideae plus *Artemisia*, *Centaurea* and other Compositae, Liliaceae), observed in trench F (layer 7,5,4,3-upper), show some differences compared with the similar episodes in unit **d** of trench A: absence or scarcity of hygro-hydrophytes, and the occurrence of the Italian dwarf palm (*Chamaerops humilis),* which suggest stands of thermo-Mediterranean steppe-maquis. More abundant large-sized charcoals suggest fires near the cave. Therefore, without forgetting that the low pollen counts require caution, it can be inferred that: a) the highly forested layer 8F could be older than the archaeological unit **d** of trench A, according to the trend of opening of the landscape indicated by the much longer A-pollen diagram; b) in general, the climate of the archaeological layers of trench F appears a little warmer and drier than in the archaeological unit **d** of trench A (Fig. 12), due to the more abundant Mediterranean plants and the less abundant or absent hygro-hydrophytes; d) the episodes of steppe vegetation spreading in trench F are probably not contemporaneous to those of trench A and could have been caused by a warm and dry oscillation. On the whole, based on pollen flora-vegetation, humans left their traces in trench F, possibly sheltering themselves in the cave in different times compared to humans indicated in trench A. They lived in a good warm climate, with a yearly mean temperature around 15–18 °C, as suggested by the notable amount of Holly oak – *Q. ilex* and Olive – *O. europaea* and by the record of the Italian dwarf palm-*Chamaerops*, indicating communities of the meso- and thermo-Mediterranean vegetation belts (Pignatti, 1994), but had low availability of water, especially in the times of layers 8–4F, where pollen of hygro-hydrophytes were absent. Probably in those times only some "fiumaras" flew near the cave. On their beds grew the oleander (*Nerium oleander)* found in layer 7F, which most probably arrived in the cave as flowers brought by humans, a suggestive record of this poisonous plant in an ancient archaeological context. Subsequently the availability of water increased, with conditions more similar to unit **d** of trench A, where hygro-hydrophytes were always well represented.

Unfortunately, there is no pollen record in caves of this age in the Mediterranean vegetation zone of Italy. Some comparison can be made with the Cave de Payre (Ardèche, France), where levels representing human occupation near the transition from MIS 6 to MIS 5 were studied for pollen (Moncel *et al*., 1993; Valladas et al., 2008). Some similarities are apparent in flora-vegetation, but the landscape is always more open, some taxa are absent (e.g. *Olea*), and deciduous broadleaves are less various in flora. Other comparisons can be made with some long pollen records, completely or in part coeval (Wijmstra and Smit, 1976; Woillard, 1978; Follieri et al., 1988; Allen et al., 1999, 2000, Martrat et al., 2004; Tzedakis et al., 2001, 2002, 2006). The flora-vegetation of Grotta Grande is similar to those described in these records, but it is impossible to make strict correlations due to the different location, type of deposits and also very different pollen concentrations.

6. Conclusion

The archaeological and faunal records of Grotta Grande can be positioned within the climatic fluctuations prior to the warm interglacial MIS 5e peak. Only pollen occurred in the older series (units **b**–**c**) of the trench A. The base of this series (unit **a**) is a marine conglomerate probably correlated to the high stand of MIS 7 (Carobene et al., 1986; Gambassini and Ronchitelli, 1998). The landscape was forested (pollen zone GGSA1) with different vegetation belts (mainly mixed forest with conifers, deciduous broadleaves, Mediterranean evergreens) including also some "Tertiary" survivors (e.g. *Taxodium*). Some minor shift of vegetation belts forced by climatic oscillations occurred. The series is sealed by a stalagmite (unit **c**) in which the pollen record indicates local wetter conditions (increase of hygro-hydrophytes). Radiometric dating (^{230}Th/^{234}U: 135 ± 11 ka) places this stalagmite at the end of MIS 6. A marine transgression eroded the series **b**–**c** followed by a deposition of a marine conglomerate. The occurrence of *S. bubonius* in both trenches in a breccia at the very top of the conglomerate refers the transgressive phase to MIS 5e.

The overlying series in trenches A (unit **d)** and F record human presence and faunal remains. In these two series, the integration of faunal and botanical data suggest the following possible reconstruction of environment-climatic evolution.

The lower part of the series F (layers 11–6) records the more forested landscape of both trenches. The forest had a typical Mediterranean feature and developed during a warm temperate phase. Micromammals were characterised by abundant arboreal taxa and by few voles. Warm temperate climate is underlined by the occurrence of hippo and fallow deer. In layers 6–8, some interesting structures which reflect the organization of the living space have been discovered. In the upper part of the series (layer 5–2), pollen indicate that landscape evolved towards the spread of steppe vegetation, suggesting stands of thermo-Mediterranean steppe-maquis episodes. Micromammals reacted to this shift of environmental condition with a strong decrease of fat dormice, the disappearance of garden dormice, and the spread of Savi vole. Large mammals are very rare and prevent any consideration.

Unit **d** of trench A and the series of trench F are characterised by a similar flora-vegetation. Unit **d**, however, shows a lesser number of Mediterranean plants and more abundant hygro-hydrophytes, indicating wetter conditions than in trench F. The forest began to be cleared (GGSA2 pollen zone), and the landscape began to open. A steppe-like vegetation, characterised by plants of the grass and daisy family begun to spread, likely following a cold climatic oscillation (GGSA3 pollen zone), first wet, as shown by the increase in fresh water plants and then, dry, with the fall in fresh water plant communities and the general fall in woody plants (sample1). Mammal remains occur mainly in the upper part of GGSA2 – lower part GGSA3 pollen zones (Cuts 17–12). The faunal assemblage differs from that of series F, by the absence of the hippo and the strait tusked elephant, the occurrence of the roe deer and the narrow-nosed rhino, and the dominance of the ibex. Small mammals are characterised by the occurrence of significant frequency of Savi vole and water vole and by scarce glirids. The occurrences of Savi vole and of *Capreolus* confirm that clearings were present in the neighbourhood of the cave, while the water vole confirms the humid character of climate.

The occurrence of the Levallois system in both series (trenches F and A) support the chronological attribution. The Levallois method made its first occurrence in layers prior to MIS 5e in the series of Riparo del Poggio (Marina di Camerota, Salerno), close to Scario, where human occupation spans from MIS 6 to 5 (Boscato et al., 2009).

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References

Abbazzi L., Masini F., 1998. L'association faunique du sondage F à la Grotta Grande de Scario. In: Atti XIII Congresso UISPP. 2. Forlì, 157.

Allen, J.R.M., Brandt, U., Brauer, A., Hubberten, H.W., Huntley, B., Keller, J., Kraml, M., Mackensen, A., Mingram, J., Negendank, F.W., Nowaczyk, N.R., Oberansli, H., Watts, W.A., Wulf, S., Zolitschka, B., 1999. Rapid environmental changes in southern Europe during the last glacial period. Nature 400, 740–743.

Allen, J., Watts, W.A., Hunthley, B., 2000. Weichselian palynostratigraphy, palaeovegetation and palaeoenvironment; the record from Lago Grande di Monticchio, southern Italy. Quaternary International 73/74, 91–110.

Arobba, D., Boscato, P., Boschian, G., Falgueres, C., Fasani, L., Peretto, C., Sala, B., Thun Hohenstein, U., Tozzi, C., 2004. Paleoenvironmental analysis. Collegium Antropologicum 28 (1), 5–21.

Berglund, B.E., Ralska-Jasiewiczowa, M., 1986. Pollen analysis and pollen diagrams. In: Berglund, B.E. (Ed.), Handbook of Holocene Palaeoecology and Palaeohydrology. Wiley, Chichester, pp. 455–484.

Bertolino, S., Cordero Di Montezemolo, N., 2007. Garden dormouse (*Eliomys quercinus*) nest site selection in an alpine habitat. Ethology Ecology and Evolution 19, 51–60.

Boscato, P., Boschian, G., Caramia, F., Gambassini, P., 2009. Il Riparo del Poggio a Marina di Camerota (Salerno): culture ambiente. Rivista di Scienze Preistoriche, LIX, 5–40.

Boscato P., and Ronchitelli A., 2004. Paléosurfaces du Paléolithique moyen: l'exemple de Scario (Salerno – Italie du Sud). In: Actes du XIVème Congrès UISPP, Université de Liège, Section 5, BAR S1239, Oxford, 283-292.

Carobene, L., Dai Pra, G., Gewelt, M., 1986. Niveaux marins du Pléistocène moyen-supérieur de la côte tyrrhénienne de la Calabre (Italie méridionale). Datation ^{230}Th/^{234}U et tectonique récente. Zeitschrift für Geomorphologie 62, 141–158. Neue Folge.

Contoli, L., 1999. *Microtus savii* (de Sélys Longschamps, 1838). In: Mitchell-Jones, A.J., Amori, G., Bogdanowicz, W., Krystufek, B., Reijnders, P.J.H., Spitzenberger, F., Stubbe, M., Thissen, J.B.M., Vohralik, V., Zima, J. (Eds.), The Atlas of European Mammals. Natural History. Poyser T. e A.D., Academic Press, London, pp. 248–249.

Corbet, G.B., 1978. The Mammals of the Paleartic Region: a Taxonomic Review. British Museum (Natura1 History) and Cornell University Press, 314 pp.

Follieri, M., Magri, D., Sadori, L., 1988. 250,000-year pollen record from Valle di Castiglione Roma. Pollen et Spores 30, 329–356.

Fusco, V., 1961. Stazioni del Paleolitico medio in grotte costiere del golfo di Policastro. Rivista di Scienze Preistoriche XVI, 1–14.

Gambassini, P., Ronchitelli, A., 1998. Linee di sviluppo dei complessi del Paleolitico inferiore-medio nel Cilento. Rivista di Scienze Preistoriche XLIX, 357–378.

Harrison, D.L., Bates, P.J.J., 1991. The Mammals of Arabia. Harrison Zoological Museum, Kent, 354 pp.

Heinrich W.D., 1978. Zur biometrischen Erfassung eines Evolutionstrends bei Arvicola (Rodentia, Mammalia) aus dem Pleistozän Thüringens. Säugetierkdl. Informationen 2, 3–21.

Kotsakis, T., Abbazzi, L., Angelone, C., Argenti, P., Barisone, G., Fanfani, F., Masini, F., 2003. Plio-Pleistocene biogeography of Italian mainland Micromammals. Deinsea 10, 313–336.

Krystufek, B., 1999. Talpa caeca. In: Mitchell-Jones, A.J., Amori, G., Bogdanowicz, W., Krystufek, B., Reijnders, P.J.H., Spitzenberger, F., Stubbe, M., Thissen, J.B.M., Vohralìk, V., Zima, J. (Eds.), The Atlas of European Mammals. Natural History. Poyser T. e A.D., Academic Press, London, pp. 80–81.

Le Louarn, H., Spitz, F., 1974. Biologie et écologie du Lérot *Eliomys quercinus* L. dans les Hautes-Alpes. La Terre et la Vie 28, 544–563.

Libois, R., Ramalhinho, M.G., Fons, R., 1999. *Crocidura suaveolens* (Pallas, 1811). In: Mitchell-Jones, A.J., Amori, G., Bogdanowicz, W., Krystufek, B., Reijnders, P.J.H., Spitzenberger, F., Stubbe, M., Thissen, J.B.M., Vohralik, V., Zima, J. (Eds.), The Atlas of European Mammals. Natural History. Poyser T. e A.D., Academic Press, London, pp. 72–73.

Locatelli E., Masini F., Petruso D., Sala B., Surdi G. Osservazioni preliminari sulla tassonomia e la biogeografia di Microtus (Terricola) (MAMMALIA, RODENTIA) fossile della Sicilia. Biogeographia, in press.

Loy, A., 1999. *Talpa romana* Thomas, 1902. In: Mitchell-Jones, A.J., Amori, G., Bogdanowicz, W., Krystufek, B., Reijnders, P.J.H., Spitzenberger, F., Stubbe, M., Thissen, J.B.M., Vohralìk, V., Zima, J. (Eds.), The Atlas of European Mammals. Natural History. Poyser T. e A.D., Academic Press, London, pp. 86–87.

Macdonald, D.W., Barrett, P., 1993. Mammals of Britain and Europe. Harper Collins Publishers, London, 312 pp.

Martrat, B., Grimalt, J.O., Lopez Martinez, C., Cacho, I., Sierro, F.J., Flores, J.A., Zahn, R., Canals, M., Curtis, J.H., Hodell, D.A., 2004. Abrupt Temperature changes in the Western mediterranean over the past 250,000 years. Science 306, 1762–1765.

Masini F., Maul L.C., Abbazzi L., Petruso D., 2003. Independent Arvicola Lineages in Italy and Central Europe. European Mammalogy 2003. In: 4th European Congress of Mammalogy, Brno (Czech Republik), July 29–August 1, 2003, abstract vol.164.

Masini F., Maul L.C., Abbazzi L., Petruso D., 2007. New data on the morphological variation of extant and fossil European populations of Arvicola (Mammalia, Rodentia). In: V European Congress of Mammalogy. Siena. 21–26 September 2007. Hystrix N.S. 1, 125.

Maul, L., Masini, F., Abbazzi, L., Turner, A., 1998. The use of different morphometric data for absolute age calibration of some South and Middle European Arvicolid populations. Palaeontographia Italica 85, 111–151.

Moggi, G., 1960. Appunti sulla vegetazione del Monte Bulgheria nel Cilento (Appennino Lucano). Webbia 15, 455–461.

Moncel, M.H., Bhain, J.J., Falgue, C., El Hazzazi, N., Kalai, C., Majad, M., Patou-Mathis, M., Renault-Miskovsky, J., 1993. Le site de Payre (commune de Rompon, Ardèche). Un site Paleolithique moyen ancien dans un contexte d'abri effondré: premier bilan des études pluridisciplinaires: position chronologique. Paléoenvironnement, Paléoclimatology. Quaternaire 4, 159–173.

Niethammer, J., 1990. Talpa. In: Niethammer, J., Krapp, F. (Eds.), Handbuch der Säugetiere Europas. Insektenfresser, Herrentiere, vol. 3. AULA Verlag, Wiesbaden, pp. 93–161.

Peretto, C., Biagi, P., Boschian, G., Broglio, A., De Stefani, M., Fasani, L., Fontana, F., Grifoni, R., Guerreschi, A., Iacopini, A., Minelli, A., Pala, R., Peresani, M., Ronchitelli, A., Sarti, L., Thun Hoenstein, U., Tozzi, C., 2004. Living-floors and structures from the lower Palaeolithic to the Bronze age in Italy. Collegium Antropologicum 28 (1), 63–88.

Pignatti, S., 1982. Flora D'Italia I, II, III. Edagricole, Bologna, 790, 732, 780 pp.

Pignatti, S., 1994. Ecologia del Paesaggio. Utet, Torino. 225.

Ronchitelli A., 1993. Paleosuperfici del Paleolitico medio al Molare di Scario (Salerno). In: Atti XXX Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria, Firenze, 233–246.

Ronchitelli A., 1998. Structures d'habitat dans la Grotta Grande de Scario (S. Giovanni a Piro – Salerno – Italie). In: Atti XIII Congresso UISPP, 2(5), A.B.A.C.O. Edizioni, Forlì, 153–164.

Ronchitelli A., Abbazzi L., Accorsi C.A., Bandini Mazzanti M., Bernardi M., Masini F., Mercuri A., Mezzabotta C., Rook L., 1998. Palethnological, Palynological and Paleontological data on the Grotta Grande of Scario – Salerno (Campania Southern Italy, 40°02'21"N/15°28'31"E). In: Proceedings of 1st International Congress on: Science and technology for the safeguard of cultural heritage in the Mediterranean Basin, November 27-December 2, 1995, Catania, Siracusa, Italy, Palermo, 1529–1535.

Shenbrot, G.I., Krasnov, B.R., 2005. An Atlas of the Geographic Distribution of the Arvicoline Rodents of the World (Rodentia, Muridae: Arvicolinae). Pensoft, Sofia, 336 pp.

Stewart, J.R., 2007. Neanderthal extinction as part of the faunal change in Europe during Oxygen Isotope Stage 3. Acta Zoologica Cracoviensia 50A (1–2), 93–124.

Surdi G., 2007. I micromammiferi del Pleistocene Superiore della grotta Grande di Scario (Salerno, Italia). Tesi di laurea in Scienze Geologiche dell'Università degli Studi di Palermo, 1–200.

Torri P., Accorsi C.A., Bosi G., Forlani L., Montecchi M.C., 2009. Un metodo per contare i microcarboni nei preparati pollinici. In: Abstracts 104° Congresso S.B.I., Campobasso, 16–19 September 2009, 278.

Tzedakis, P.C., Frogley, M.R., Heaton, T.H.E., 2002. Duration of last Interglacialconditions in northwestern Greece. Quaternary Research 58, 53–55.

Tzedakis, P.C., Andrien, V., Birks, H.J.B., De Beaulieu, J.-L., Crowhurst, S., Follieri, M., Hooghiemstra, H., Magri, D., Reille, M., Sadori, L., Shackleton, N.J., Wijmstra, T.A., 2001. Establishing a terrestrial chronological framework as a basis for biostratigraphical comparisons. Quaternary Science Reviews 20, 1583–1592.

Tzedakis, P.C., Hooghiemstra, H., Palike, H., 2006. The last 1.35 million years at Tenaghi Philippon: revised chronostratigraphy and long-term vegetation trends. Quaternary Science Reviews 25, 3416–3430.

Valladas, H., Merciera, N., Ayliffeb, L.K., Falgue, C., Bahainc, J.-J., Dolod, J.M., Frogeta, L., Jorone, J.-L., Masaudic, H., Reyssa, J.-L., Moncel, M.-H., 2008. Radiometric dates for the middle Palaeolithic sequence of Payre(Arde`che, France). Quaternary Geochronology 3, 377–389.

Vaterlaus C., 1998. Der Gartenschläfer (Eliomys quercinus L.). Ökologie, Populationsstruktur und die Verbreitung in der Schweiz. PhD thesis, University of Basel.

Viro, P., Niethammer, J., 1982. *Clethrionomys glareolus* (Schreber, 1780) – Rotelmaus. In: Niethammer, J., Krapp, F. (Eds.), Handbuch der Saugetiere Europas. Rodentia I, vol. 2. AULA Verlag, Wiesbaden, pp. 109–146.

Vlasak, P., Niethammer, J., 1990. Crocidura suaveolens (Pallas, 1811) – Gartenspitzmaus. In: Niethammer, J., Krapp, A.N.D.F. (Eds.), Handbuch der Saugetiere Europas. Insektenfresser, Herrentiere, vol. 3/1. AULA Verlag, Wiesbaden, pp. 397–428.

Wilson Don, E., Reeder Dee Ann, M., 2005. Mammal Species of the World. A Taxonomic and Geographic Reference, vol. 2. Johns Hopkins University Press, 142 pp.

Wijmstra, T.A., Smit, A., 1976. Palynology of the middle part (30–78 m) of the 120 m deep section in northern Greece (Macedonia). Acta Botanica Neerlandica 25, 297–312.

Woillard, G.M., 1978. Grande Pile peat bog: a continuous pollen record for the last 140,000 years. Quaternary Research 9, 1–21.

Wust Saucy A.G., 1998. Polymorphisme Genetique et Phylogeographie du campagnol terrestre Arvicola terrestris. PhD Dissertation, Universite Neuchatel, Lausanne. 178 p.