

Holocene bats from the Cocci Cave (Narni, Central Italy): palaeoecological and palaeobiogeographical implications

Leonardo SALARI¹

Abstract

In this paper the bat remains collected from Cocci Cave (Narni, Southern Umbria) are described. The archaeological excavations revealed two main horizons of human presence: the oldest referred to the early Neolithic (last centuries of VI millennium BC), the latest to early and middle Bronze Age (late III to first half of II millennium BC). The bat remains of 10 taxa, divided into 3 families and 4 genera, dates from the middle Holocene, an important moment in the changes of mammal faunas towards the modern patterns we observe today. The relative abundance of bat remains is evidence of particular moments in which the humans have abandoned or rarely frequented the cave. The ecological requirements of bats allow reconstructing the environment around Narni during middle Holocene, outlining a composite landscape with forests and grasslands interspersed by scrubland areas, rocky bands and wetlands; probably more forested in the Bronze Age. The occurrence of *Rhinolophus mehelyi* MATSCHIE, 1901 adds new information for the understanding of the limited and discontinuous distribution of this Mediterranean species, considered declining in many countries and today extinct in the Italian peninsula.

Keyword

Chiroptera, Umbria, Italy, Neolithic, Bronze Age, Palaeoecology, Local extinctions.

Résumé

Les chauves-souris holocènes de la Grotta dei Cocci (Narni, Italie centrale): implications paléocéologiques et paléobiogéographiques. - Des informations sur les restes osseux des chauves-souris de la Grotta dei Cocci (Narni, Ombrie du Sud) sont exposés. Des fouilles archéologiques ont révélé deux importants moments de la présence humaine : un horizon inférieur se réfère au Néolithique ancien (derniers siècles du VI^e millénaire avant J.-C.), et un horizon supérieur se réfère à l'âge du Bronze ancien et moyen (fin III^e à la première moitié du II^e millénaire avant J.-C.). Dix taxa, répartis en 3 familles et 4 genres ont été identifiés, de l'Holocène moyen, un moment important dans les changements des faunes de Mammifères vers les modèles modernes que nous observons aujourd'hui. L'abondance relative des restes de chauves-souris montrent des moments d'abandon ou de fréquentation occasionnelle de la grotte par l'homme. Les exigences écologiques de ces taxa permettent de reconstituer l'environnement près de Narni dans l'Holocène moyen, et décrivent un paysage composite avec des forêts et des prairies entrecoupées de zones arbustives, et de zones humides et rocheuses ; il y avait probablement plus des forêts à l'âge du Bronze. La présence de *Rhinolophus mehelyi* MATSCHIE, 1901 ajoute de nouvelles informations pour comprendre la répartition limitée et discontinue de cette espèce méditerranéenne, considérée en déclin dans plusieurs pays et éteinte aujourd'hui dans la péninsule italienne.

Mots-clés

Chiroptères, Ombrie, Italie, Néolithique, Âge du Bronze, Paléocéologie, Extinction locale.

I. INTRODUCTION

The remains of bats collected in the Neolithic and Bronze Age layers of the Cocci Cave in the archaeological excavations carried out by the "Soprintendenza per i Beni Archeologici dell'Umbria" in the years 1989-2001, directed by M.C. DE ANGELIS, are described in this paper. The Cocci Cave leans out on the right slope of the Nera River gorges, facing the old town of Narni (Terni, Umbria, Central Italy) and it opens at about 70 m above the river level (Fig. 1). This karst cavity is carved in the "Calcare Massiccio" formation (Lias) (CHIOCCHINI *et*

al., 1975) on the eastern slope of Santa Croce Mountain (428 m), in the Amerini Mounts.

Today the entrance is only accessible by ropes. At the end of a short and low duct, there is the room 1 with roughly triangular plan (about 6 x 8 m); the posterior wall with boulders falling is cluttered and behind which leads to a long and low tunnel. On the left of the room 1 there are some smaller rooms (Fig. 2a). The archaeological excavations of the room 1 (Fig. 2b) revealed two main horizons of human presence: the latest referred to the early and middle Bronze Age (late III to first half of II millennium BC, Subboreal chronozone), the oldest

¹ Collaboratore scientifico esterno del Dipartimento Scienze della Terra, "Sapienza" Università di Roma, Viale Aldo Moro, 5, I-00185 Roma, Italy. E-mail: leonardosalari@virgilio.it

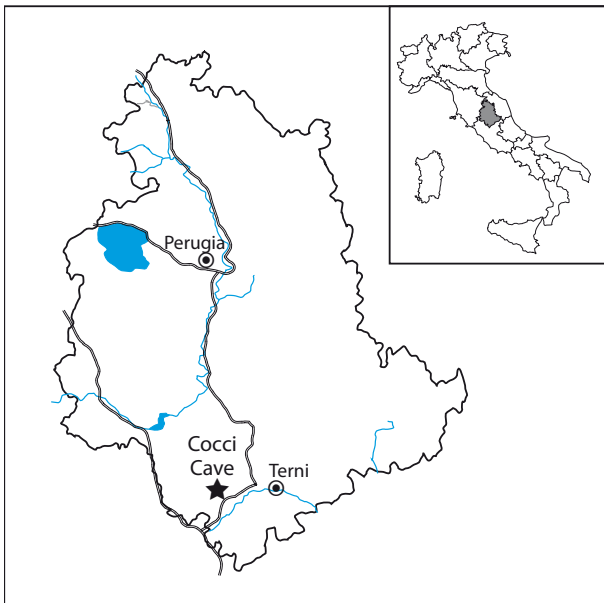


Fig. 1: Cocci Cave: location of the site.

to the early Neolithic (last centuries of VI millennium BC, Atlantic chronozone). The Bronze Age layers only pottery materials and bone faunal remains scattered on the ground have been found, without apparent connections between them. In the Neolithic layers, instead, some evidences and complex structures have been found. They are arranged at different heights and with the pottery materials, the faunal and floral remains, disarticulated human bones, and the lithic and bone artefacts are associated (DE ANGELIS, 1998; SALARI, 1998; MORONI LANFREDINI, 2002; D'AMICO & DE ANGELIS, 2009; SALARI *et al.*, in press a).

A preliminary report on the vertebrate and invertebrate remains (1989-95 excavations) described *Crocidura leucodon*, *Erinaceus europaeus*, *Talpa* sp., *Rhinolophus ferrumequinum*, *R. euryale*, *Myotis myotis*, *M. blythii*, *M. capaccinii*, *Miniopterus schreibersii*, *Glis glis*, *Eliomys quercinus*, *Muscardinus avellanarius*, *Apodemus* (*Sylvaemus*) sp., *Rattus rattus*, *Microtus* gr. *arvalis-agrestis*, *Lepus europaeus*, *Vulpes vulpes*, *Mustela putorius*, *Martes martes*, *Meles meles*, *Felis silvestris*, *Cervus elaphus*, *Sus scrofa*, *Sus domesticus*, *Bos taurus*, *Ovis aries*, *Capra hircus* and *Canis familiaris*, and also freshwater Bivalvia, continental Gastropoda, undetermined Pisces and undetermined Aves (SALARI, 1998). Subsequently, the archaeozoological aspects of the Neolithic mammal fauna (1989-2001 excavations) and their environmental, economic and cultural implications were studied (SALARI *et al.*, in press a). A first analysis of the other micromammal remains (1997-2001 excavations) has also identified *Sorex* cf. *araneus*, *Arvicola amphibius*, *Apodemus sylvaticus*, *A. flavicollis*, *M. (Microtus) arvalis*, *M. (Terricola) savii*, *Microtus* sp. and *Myodes glareolus* (DI CANZIO com.pers.).

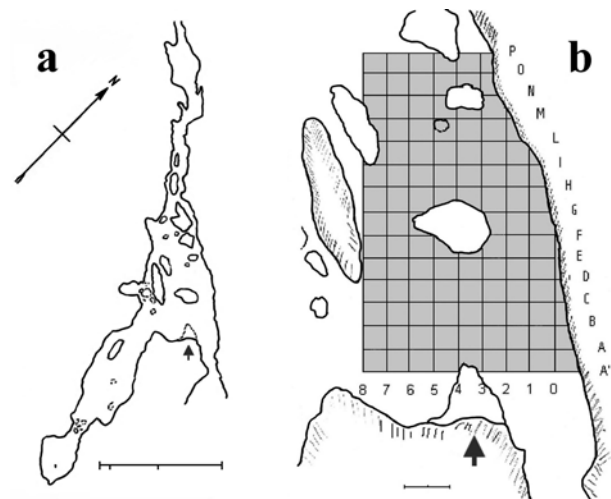


Fig. 2: Cocci Cave: a) plan of the cave; b) plan of the excavation area (room 1). The arrow indicates the cave entrance.

The bat remains described in this paper dates from the middle Holocene, an important moment in the changes of the landscape and of the mammal faunas towards the modern patterns we observe in Europe today. The early and middle Holocene bat fauna is not well known in Italy, regrettably, there are only few sites for comparison (SALARI & DI CANZIO, 2009 with references; SALARI & KOTSAKIS, in press), and in various cases include undetermined Chiroptera or just the species of large size (*R. ferrumequinum*, *M. myotis*, *M. blythii*), however this study gives evidence of changes of the geographic distribution of a species.

II. MATERIALS AND METHODS

The bat remains have been compared with osteological material, both fossil and recent, stored in the Department of Earth Sciences of the University of Rome "Sapienza", in the Department of Geological Sciences of the "Roma Tre" University and in the Laboratory of Quaternary Palaeontology and Archaeozoology of the National Museum of Prehistory and Ethnography "Pigorini" of Rome. The morphological and morphometrical observations and the measures given by MILLER (1912), LANZA (1959), TOPÁL & TUSNADI (1963), MENU & SIGÉ (1971), FELTEN *et al.* (1973), SEVILLA GARCÍA (1988), RUEDI *et al.* (1990), BENDA *et al.* (2003), CSORBA *et al.* (2003) and SALARI (2004) were also considered. Holocene chronostratigraphy is according to OROMBELLI & RAVAZZI (1996), supplemented by RAVAZZI (2003). The morphological and morphometrical observations were performed with a stereoscopic microscope. The analyzed material was chosen on the basis of its

systematic importance and consists of some skulls and cranial fragments, some maxillaries, several mandibles and mandible fragments, numerous humeri and distal portions of humeri. Other skeletal parts (e.g. radii, scapulae, coxal) while identify at family or genus level or even at a species level (about 40 specimens), were not considered because it would altered the statistical processing at the expense of the small sized species,

probably under-represented for taphonomic reasons. Their small and fragile skeletal elements, in fact, are more frequently subject to the processes of differential destruction than those of larger species.

Each taxon was quantified both in numbers of identified specimens (NISP) (Tab. 1) and in the minimum number of individuals (MNI) (Tab. 2) and, whenever possible, osteometrical data and the size of the populations are

Table 1: Cocci Cave, middle Holocene, Chiroptera: numbers of identified specimens (NISP).

| Age | early Neolithic | | early-middle Bronze Age | | Bronze / Neolithic | | Total | Total |
|------------------------------------|-----------------|-------|-------------------------|-------|--------------------|-------|------------|--------------|
| | NISP | % | NISP | % | NISP | % | | |
| <i>Rhinolophus ferrumequinum</i> | 27 | 13.04 | 9 | 18.00 | 4 | 50.00 | 40 | 15.09 |
| <i>Rhinolophus euryale</i> | 48 | 23.19 | 19 | 38.00 | 2 | 25.00 | 69 | 26.04 |
| <i>Rhinolophus mehelyi</i> | 7 | 3.38 | | | | | 7 | 2.64 |
| <i>Rhinolophus euryale/mehelyi</i> | 2 | 0.97 | | | | | 2 | 0.75 |
| <i>Rhinolophus hipposideros</i> | 4 | 1.93 | | | | | 4 | 1.51 |
| <i>Myotis myotis</i> | 19 | 9.18 | 3 | 6.00 | 1 | 12.50 | 23 | 8.68 |
| <i>Myotis blythii</i> | 63 | 30.43 | 11 | 22.00 | | | 74 | 27.92 |
| <i>Myotis myotis/blythii</i> | 3 | 1.45 | | | | | 3 | 1.13 |
| <i>Myotis capaccinii</i> | 8 | 3.86 | 4 | 8.00 | | | 12 | 4.53 |
| <i>Myotis emarginatus</i> | | | 1 | 2.00 | | | 1 | 0.38 |
| <i>Plecotus auritus s.l.</i> | 1 | 0.48 | | | | | 1 | 0.38 |
| <i>Miniopterus schreibersii</i> | 25 | 12.08 | 3 | 6.00 | 1 | 12.50 | 29 | 10.94 |
| Total | 207 | | 50 | | 8 | | 265 | |

Table 2: Cocci Cave, middle Holocene, Chiroptera: minimum number of individuals (MNI). Few remains of uncertain stratigraphic position (Bronze/Neolithic, see Table 1) are not considered.

| Age | early Neolithic | | early-middle Bronze Age | | Bronze / Neolithic | | Total | Total |
|------------------------------------|-----------------|-------|-------------------------|-------|--------------------|---|------------|--------------|
| | MNI | % | MNI | % | MNI | % | | |
| <i>Rhinolophus ferrumequinum</i> | 12 | 14.81 | 3 | 13.04 | | | 15 | 14.42 |
| <i>Rhinolophus euryale</i> | 17 | 20.99 | 8 | 34.78 | | | 25 | 24.04 |
| <i>Rhinolophus mehelyi</i> | 3 | 3.70 | | | | | 3 | 2.88 |
| <i>Rhinolophus euryale/mehelyi</i> | 2 | 2.47 | | | | | 2 | 1.92 |
| <i>Rhinolophus hipposideros</i> | 2 | 2.47 | | | | | 2 | 1.92 |
| <i>Myotis myotis</i> | 7 | 8.64 | 2 | 8.70 | | | 9 | 8.65 |
| <i>Myotis blythii</i> | 21 | 25.93 | 5 | 21.74 | | | 26 | 25.00 |
| <i>Myotis capaccinii</i> | 4 | 4.94 | 2 | 8.70 | | | 6 | 5.77 |
| <i>Myotis emarginatus</i> | | | 1 | 4.35 | | | 1 | 0.96 |
| <i>Plecotus auritus s.l.</i> | 1 | 1.23 | | | | | 1 | 0.96 |
| <i>Miniopterus schreibersii</i> | 12 | 14.81 | 2 | 8.70 | | | 14 | 13.46 |
| Total | 81 | | 23 | | | | 104 | |

given. Since most of the maxillas and mandibles only preserved the molar teeth, alveolar measurements are also given.

III. SYSTEMATIC DESCRIPTION

Order Chiroptera BLUMENBACH, 1779

Suborder Microchiroptera DOBSON, 1875

Family Rhinolophidae GRAY, 1825

Genus *Rhinolophus* LACÉPÈDE, 1799

***Rhinolophus ferrumequinum* (SCHREBER, 1774)**

Pl. I, figs 1 and 9

Material: 3 sub-intact skulls, 2 maxillaries, 22 mandibles mostly fragmentary, 2 humeri and 11 distal portions of humeri.

Description and remarks: The morphology is typical of the genus *Rhinolophus*, the large size (Tab. 3) enables a definite attribution to the big horseshoe bat (see in particular FELTEN *et al.*, 1973; LANZA & AGNELLI, 2002; BENDA *et al.*, 2003).

R. ferrumequinum is a species of Mediterranean affinities and today's range of distribution includes Central Europe, extending from Southern England and the Mediterranean basin through Asia to Japan; in Italy this species occurs in all regions (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; CSORBA *et al.*, 2003; AGNELLI *et al.*, 2004).

The earliest records of fossils referred to *R. ferrumequinum* come from Early Pleistocene (middle Early Biharian, Late Villafranchian) (SALARI *et al.*, in press b). Remains of this species have been collected in several sites of Lateglacial in Italy (BON *et al.*, 1991; SALARI, 2009; 2010; SALARI & DI CANZIO, 2009; SALARI & KOTSAKIS, in press). During the less recent Holocene this species is recorted at Grobe Cave (SORBINI & DURANTE PASA, 1974), Lago Cave (TALIANA *et al.*, 1996), Sant'Angelo Cave (WILKENS, 1996), Continenza Cave, Mora Cavorso Cave, Mura Cave and Santuario della Madonna Cave (SALARI, 2009; SALARI & DI CANZIO, 2009) and Oliena Cave-shelter (AGOSTI, 1980), and in many localities in Spain, France, former Czechoslovakia and Hungary (JULLIEN, 1972; JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references).

***Rhinolophus euryale* BLASIUS, 1853**

Pl. I, figs 2 and 10

Material: 5 skulls mainly fragmentary, one maxillary, 25 mandibles mostly fragmentary, 10 humeri and 28 distal portions of humeri.

Description and remarks: The morphology of skulls, maxillary, mandibles and humeri is typical of the genus *Rhinolophus*. Some morphological features permit a secure attribution to *R. euryale* and not to other intermediate size species of the genus (*R. blasii* and *R. mehelyi*): the upper canine is robust, with trapezoidal

occlusal outline and with a clear longitudinal groove in labial view, the upper molars have a distal concave edge and the labial cingulum is very prominent; p4 is trapezoidal with a slight cusp, the cingulum shows two convexities of similar height in labial view, and the mental foramen of the mandible is placed under p2 (see SEVILLA GARCÍA, 1988; CSORBA *et al.*, 2003); the relatively long and thin styloid process of the humerus is slightly dorsally inclined in lateral view (see FELTEN *et al.*, 1973). The dimensions (Tab. 3) fall within the variability of living species (see in particular FELTEN *et al.*, 1973; LANZA & AGNELLI, 2002; BENDA *et al.*, 2003). *R. euryale* is a species of strict Mediterranean affinities, typically troglophilous; today's range of distribution includes Southern Europe, South-Western Asia and North-Western Africa; in Italy this species occurs throughout the territory with the exception of some northern regions (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; CSORBA *et al.*, 2003; AGNELLI *et al.*, 2004).

Fossil bats referred to *Rhinolophus* gr. *R. euryale* are known from the Early Pliocene (Late Ruscinian) (SALARI *et al.*, in press b). The Mediterranean horseshoe bat is present in some Lateglacial sites in Italy (SALARI & DI CANZIO, 2009 with references; SALARI, 2010; SALARI & KOTSAKIS, in press). During the early and middle Holocene this species is reported at Sant'Angelo Cave (WILKENS, 1996) and Continenza Cave (SALARI & DI CANZIO, 2009), and in several sites in Spain, France, Hungary, former Czechoslovakia and Malta (JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references).

***Rhinolophus mehelyi* MATSCHIE, 1901**

Pl. I, figs 3 and 11

Material: one maxillary, 2 mandibles and 4 distal portions of humeri.

Description and remarks: This material has the typical form of the genus *Rhinolophus*. Some morphological features permit a secure attribution to *R. mehelyi* and not to other intermediate size species of the genus (*R. blasii* and *R. euryale*): the upper canine without longitudinal grooves in labial view, the upper molars with distal edge slightly concave and labial cingula accentuated; p4 is robust and subrectangular with a pyramidal cusp, the cingulum shows two convexities separated by a shallow concavity in labial view, and mental foramen of the mandible placed under the anterior part of p2 (see SEVILLA GARCÍA, 1988; CSORBA *et al.*, 2003); the styloid process is parallel to the axis of the humerus (see FELTEN *et al.*, 1973). The dimensions of the material assigned to Mehely's horseshoe bat (Tab. 3) agree with the variability of the living species (see in particular FELTEN *et al.*, 1973; BENDA *et al.*, 2003).

A species of strict Mediterranean affinities, with apparently similar habits to those of *R. euryale*, today's

Table 3: Cocci Cave, middle Holocene, Chiroptera: osteometric measurements (mm). Abbreviations for skull, mandible and humerus dimensions: L. = maximum length; C-C = rostral width between upper canines (incl.); M3-M3 = rostral width between third upper molars (incl.); C-M3 = length of upper tooth-row between CM3 (incl.); M1-M3 = length of upper molars (incl.); c-m3 = length of lower tooth-row between cm3 (incl.); m1-m3 = length of lower molars (incl.); Bd = distal breadth. Other abbreviations: min = minimum; max = maximum; mea = mean; s.d. = standard deviation.

| | | <i>Rhinolophus ferrumequinum</i> | | | | | <i>Rhinolophus euryale</i> | | | | |
|----------|-------|----------------------------------|------|------|------|------|---------------------------------|------|------|------|------|
| | | n. | min | mea | max | s.d. | n. | min | mea | max | s.d. |
| skull | L. | 1 | | 22.2 | | | 1 | | 16.4 | | |
| | C-C | 3 | 6.2 | 6.4 | 6.6 | 0.21 | 3 | 4.2 | 4.3 | 4.5 | 0.17 |
| | M3-M3 | 3 | 8.2 | 8.4 | 8.6 | 0.21 | 3 | 6.2 | 6.3 | 6.5 | 0.17 |
| | C-M3 | 3 | 8.4 | 8.5 | 8.6 | 0.11 | 4 | 6.2 | 6.3 | 6.4 | 0.10 |
| | M1-M3 | 6 | 4.9 | 5.2 | 5.3 | 0.13 | 6 | 3.6 | 3.8 | 3.9 | 0.11 |
| mandible | L. | 4 | 14.4 | 15.2 | 15.5 | 0.38 | 7 | 11.2 | 11.6 | 12.0 | 0.30 |
| | c-m3 | 13 | 8.7 | 9.2 | 9.6 | 0.35 | 14 | 6.2 | 6.5 | 7.0 | 0.18 |
| | m1-m3 | 20 | 5.8 | 6.1 | 6.5 | 0.29 | 22 | 4.2 | 4.5 | 4.7 | 0.25 |
| humerus | L. | 2 | | 33.2 | | | 10 | 25.9 | 26.9 | 28.2 | 0.78 |
| | Bd | 13 | 4.9 | 5.1 | 5.2 | 0.14 | 38 | 4.1 | 4.3 | 4.4 | 0.09 |
| | | <i>Rhinolophus mehelyi</i> | | | | | <i>Rhinolophus hipposideros</i> | | | | |
| | | n. | min | mea | max | s.d. | n. | min | mea | max | s.d. |
| mandible | L. | 1 | | 12.1 | | | | | | | |
| | c-m3 | 1 | | 7.3 | | | | | | | |
| | m1-m3 | 2 | | 4.7 | | | | | | | |
| humerus | L. | | | | | | 1 | | 23.1 | | |
| | Bd | 4 | 4.4 | 4.6 | 4.7 | 0.13 | 4 | 3.0 | 3.1 | 3.3 | 0.13 |

range of distribution is limited and discontinuous, and extends through Southern Europe, Northern Africa and South-Western Asia (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; CSORBA *et al.*, 2003). In Italy it occurs only in Sardinia and Sicily (AGNELLI *et al.*, 2004; MUCEDDA *et al.*, 2009).

This species is known with certainty from the Middle Pleistocene (Early Toringian, Middle Galerian) (SALARI *et al.*, in press b). During the Lateglacial *R. mehelyi* is reported in a few sites in Italy (SALARI & DI CANZIO, 2009; SALARI, 2010; and references in those papers). During the early and middle Holocene this species is reported only in the Mesolithic layers of Continenza Cave (SALARI & DI CANZIO, 2009), and in a few sites in Spain and France (ALCOVER, 2003; JEANNET & VITAL, 2009).

***Rhinolophus euryale* BLASIUS, 1853 *vel* *Rhinolophus mehelyi* MATSCHIE, 1901**

Material: 2 distal portions of humeri without styloid process.

Description and remarks: Not being able to appreciate the inclination of the styloid process and the size (4.4 mm) overlap in the range of size variability between *R. euryale* and *R. mehelyi*, this material could not be attributed with certainty to either of the two species.

During Late Pleistocene and less recent Holocene, fossil

remains related to *R. euryale vel mehelyi* are reported in France, Spain, Italy and a few other sites in the Western Palaearctic (JULLIEN, 1972; ALCOVER, 2003; SALARI & DI CANZIO, 2009 with references; SALARI, 2010; SALARI & KOTSAKIS, in press).

***Rhinolophus hipposideros* (BECHSTEIN, 1800)
Pl. I, fig. 12**

Material: one humerus and 3 distal portions of humeri.

Description and remarks: The morphology is typical of the genus *Rhinolophus*, the small size (Tab. 3) allows a safe assignment to the lesser horseshoe bat (see FELTEN *et al.*, 1973).

A species of Mediterranean affinities, this species is now distributed through Central and Southern Europe, England and Ireland, South-Central Asia to Kashmir and in North Africa; in Italy it occurs in all regions (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; CSORBA *et al.*, 2003; AGNELLI *et al.*, 2004).

R. hipposideros is known from the Early Pleistocene (late Early Biharian, Early Galerian); remains of this species have been collected in few sites of Lateglacial in Italy (BON *et al.*, 1991; SALARI & DI CANZIO, 2009; SALARI, 2010; SALARI & KOTSAKIS, in press). During the early and middle Holocene this species is reported at Ernesto Cave (BARTOLOMEI, 1991), Continenza Cave and Mora Cavorso Cave (SALARI & DI CANZIO, 2009; SALARI &

KOTSAKIS, in press) and Oliena Cave-shelter (AGOSTI, 1980), and in many localities in Spain, France, England, Switzerland, Germany, Poland, former Czechoslovakia, Hungary, Greece and Malta (SYMEONIDIS *et al.*, 1973; YALDEN, 1986; ALCOVER, 2003; POSTAWA, 2004; OBUCH, 2006; JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references; BLANT *et al.*, 2010).

Family Vespertilionidae GRAY, 1821

Genus *Myotis* KAUP, 1829

Subgenus *Myotis* KAUP, 1829

***Myotis (Myotis) myotis* (BORKHAUSEN, 1797)**

Pl. I, figs 4 and 13

Material: One sub-intact skull, 7 mandibles mostly fragmentary, 4 humeri and 11 distal portions of the humeri.

Description and remarks: The general features of the skull, jaw and dental morphologies relate these anatomical portions to a large sized species of the genus *Myotis*. The only morphological difference between the teeth of *M. myotis* and *M. blythii* is observed on the talonid of m3, that is more reduced in *M. myotis* (TOPÁL & TUSNADI, 1963; SEVILLA GARCÍA, 1988); the talonid of m3 in our fossil sample is similar to that of fossil and living *M. myotis* and more reduced than in living and fossil *M. blythii*: the mean of m3 length is 2.14 mm, the mean of talonid width is 0.94 mm and the values of the talonid reduction index (talonid width x 100/tooth length - see MEIN, 1975) are always less than 0.45. The great dimensions of this material (Tab. 4) support the attribution to greater mouse-eared bat (see in particular RUEDI *et al.*, 1990; LANZA & AGNELLI, 2002; BENDA *et al.*, 2003). Concerning the humeri, of equal morphology (FELTEN *et al.*, 1973), discrimination between the two species mainly relied on the distal epiphysis, ascribing to *M. myotis* only the larger ones and of more robust aspect and all the remaining material was assigned to *M. blythii*. A species of Mediterranean affinities, thermophilous, the recent range includes Eastern, Southern and Central Europe, reaching Southern England, and from the Mediterranean basin through Western Asia to the West Turkestan (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002); in Italy this species occurs in all regions, but most likely the specimens of Sardinia should be ascribed to *M. punicus* (AGNELLI *et al.*, 2004).

The greater mouse-eared bat is known from the Early Pleistocene (Early Biharian, Late Villafranchian) (SEVILLA GARCÍA, 1988). This species during Lateglacial is quite common in several localities of Italy (BON *et al.*, 1991; SALARI, 2009; 2010; SALARI & DI CANZIO, 2009; SALARI & KOTSAKIS, in press). During the early and middle Holocene this species is reported at Ernesto Cave (BARTOLOMEI, 1991), Sant'Angelo Cave (WILKENS, 1996), Santuario della Madonna Cave and Continenza Cave (SALARI, 2009; SALARI & DI CANZIO, 2009) and Cavallo Cave (CIMÒ *et al.*, 2005), and in many localities

in Spain, France, Switzerland, Germany, Poland, former Czechoslovakia, Hungary and Greece (SYMEONIDIS *et al.*, 1973; PIKSA & WOŁOSZYN, 2001; ALCOVER, 2003; POSTAWA, 2004; OBUCH, 2006; JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references; BLANT *et al.*, 2010).

***Myotis (Myotis) blythii* (TOMES, 1857)**

Pl. I, figs 5 and 14

Material: 2 fragmentary skulls, 4 fragmentary maxillaries, 35 mandibles mostly fragmentary, 12 humeri and 24 distal portions of humeri.

Description and remarks: The general features of the skull and jaw, dental and distal humerus morphologies relate these anatomical portions to a large sized species of the genus *Myotis*. The only morphological difference between the teeth of *M. myotis* and *M. blythii* is observed on the talonid of m3, that is more reduced in *M. myotis* (TOPÁL & TUSNADI, 1963; SEVILLA GARCÍA, 1988); the talonid of m3 in our fossil sample is similar to that of fossil and recent *M. blythii* and less reduced than in recent and fossil *M. myotis*: the mean of m3 length is 1.84 mm, the mean of talonid width is 0.94 mm and the values of the talonid reduction index (see MEIN, 1975) are generally close to 0.50. The relatively small size of this material (Tab. 4) supports the attribution to the lesser mouse-eared bat (see in particular RUEDI *et al.*, 1990; LANZA & AGNELLI, 2002; BENDA *et al.*, 2003).

It is a species of Mediterranean affinities, thermophilous, the recent range of the species includes Southern Europe, the southern part of the Central Europe, east to China and Mongolia; in Italy this species occurs in all regions with the possible exception of Sardinia (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; AGNELLI *et al.*, 2004).

The earliest records of fossils referred to *Myotis* cf. *M. blythii* come from Pliocene (Early Ruscinian) (SALARI *et al.*, in press b). The lesser mouse-eared bat in Lateglacial is quite common in Italy (BON *et al.*, 1991; SALARI, 2009; 2010; SALARI & DI CANZIO, 2009; SALARI & KOTSAKIS, in press). During the early and middle Holocene this species is reported at Arena Hole (SORBINI & DURANTE PASA, 1974), Continenza Cave, Santuario della Madonna Cave and Mora Cavorso Cave (SALARI, 2009; SALARI & DI CANZIO, 2009), and in several sites in Spain, France, Switzerland, former Czechoslovakia and Greece (OBUCH, 2006; JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references; BLANT *et al.*, 2010).

***Myotis (Myotis) myotis* (BORKHAUSEN, 1797) vel**

***Myotis (Myotis) blythii* (TOMES, 1857)**

Material: 3 distal portions of humeri with damaged epiphyses.

Description and remarks: Not being able to appreciate the dimension, this material could not be attributed with certainty to either of the two species.

Table 4: Cocci Cave, middle Holocene, Chiroptera: osteometric measurements (mm). Abbreviations, see caption of Table 3.

| | | <i>Myotis myotis</i> | | | | | <i>Myotis blythii</i> | | | | | <i>Miniopterus schreibersii</i> | | | | |
|----------|-------|--------------------------|------|------|------|------|---------------------------|------|------|------|------|---------------------------------|------|------|------|------|
| | | n. | min | mea | max | s.d. | n. | min | mea | max | s.d. | n. | min | mea | max | s.d. |
| skull | L. | 1 | | 22.0 | | | | | | | | | | | | |
| | C-C | 1 | | 6.1 | | | 1 | | 6.2 | | | | | | | |
| | M3-M3 | 1 | | 9.7 | | | 2 | | 9.2 | | | 1 | | 6.2 | | |
| | C-M3 | 2 | | 9.8 | | | 3 | 8.9 | 9.1 | 9.2 | 0.15 | 1 | | 5.8 | | |
| | M1-M3 | 2 | | 5.6 | | | 6 | 5.0 | 5.1 | 5.4 | 0.16 | 2 | | 3.2 | | |
| mandible | L. | 2 | | 17.4 | | | 12 | 14.7 | 15.4 | 17.0 | 0.75 | 3 | 10.9 | 11.0 | 11.2 | 0.17 |
| | c-m3 | 5 | 10.5 | 10.8 | 11.1 | 0.25 | 21 | 9.8 | 9.9 | 10.2 | 0.18 | 4 | 6.2 | 6.3 | 6.4 | 0.12 |
| | m1-m3 | 7 | 6.2 | 6.4 | 6.6 | 0.21 | 32 | 5.4 | 5.6 | 6.1 | 0.26 | 5 | 3.6 | 3.8 | 3.9 | 0.13 |
| humerus | L. | 4 | 34.2 | 34.4 | 34.6 | 0.16 | 12 | 31.9 | 32.1 | 32.4 | 0.27 | 11 | 25.2 | 25.8 | 26.4 | 0.63 |
| | Bd | 15 | 4.4 | 4.5 | 4.6 | 0.07 | 36 | 3.9 | 4.2 | 4.3 | 0.11 | 21 | 2.6 | 2.7 | 2.8 | 0.11 |
| | | <i>Myotis capaccinii</i> | | | | | <i>Myotis emarginatus</i> | | | | | <i>Plecotus auritus s.l.</i> | | | | |
| | | n. | min | mea | max | s.d. | n. | min | mea | max | s.d. | n. | min | mea | max | d.s. |
| mandible | L | | | | | | | | | | | | | | | |
| | c-m3 | 1 | | 6.2 | | | 1 | | 6.9 | | | | | | | |
| | m1-m3 | 1 | | 3.7 | | | 1 | | 4.1 | | | | | | | |
| humerus | L. | 2 | | 23.5 | | | | | | | | | | | | |
| | Bd | 11 | 2.7 | 2.8 | 3.0 | 0.12 | | | | | | 1 | | 2.8 | | |

Bone remains attributed to *M. myotis vel blythii* are also from early and middle Holocene layers of Continenza Cave, Santuario della Madonna Cave and Mora Cavorso Cave and in some sites related to the Late Pleistocene and Holocene in Spain, France, Germany and other Western Palearctic localities (JULLIEN, 1972; SALARI, 2009; SALARI & DI CANZIO, 2009 with references; SALARI & KOTSAKIS, in press).

Subgenus *Leuconoe* BOIE, 1830

Myotis (Leuconoe) capaccinii (BONAPARTE, 1837)

Pl. I, figs 6 and 15

Material: one mandible, 2 humeri and 9 distal portions of humeri.

Description and remarks: Both the morphology and the dimensions (Tab. 4) of the mandible and the distal epiphysis of these humeri agree very well with those of living species (see in particular FELTEN *et al.*, 1973; BENDA *et al.*, 2003).

A species of strict Mediterranean affinities, typically troglophilous; the current range includes the Mediterranean basin, South-Western Asia to Iran and Uzbekistan; in Italy this species occurs in all regions (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; AGNELLI *et al.*, 2004).

The oldest fossils of the long-fingered bat are known since Early Pleistocene (middle Early Biharian, Late Villafranchian - Early Galerian) (SALARI *et al.*, in press b). It is found in some Lateglacial sites from Central and Southern Italy and other circum-Mediterranean localities,

invariably represented by few remains, whereas in Northern Italy and in the remaining Western Palearctic it is rarely reported (SALARI, 2009; 2010; SALARI & DI CANZIO, 2009 with references; SALARI & KOTSAKIS, in press). During the early and middle Holocene this species is reported in few sites of France, Switzerland and Hungary (JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references) and in Italy only in Mesolithic and Neolithic of Continenza Cave (SALARI & DI CANZIO, 2009).

Subgenus *Selysius* BONAPARTE, 1841

Myotis (Selysius) emarginatus (GEOFFROY, 1806)

Pl. I, fig. 7

Material: One mandible.

Description and remarks: Both the shape and the size (Tab. 4) of the mandible are very similar to the extant species (see in particular BENDA *et al.*, 2003).

M. emarginatus as a thermophilous species of Mediterranean affinities; the current range includes Southern and Central Europe, South-Western Asia and North-Western Africa; in Italy this species occurs in all regions (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; AGNELLI *et al.*, 2004).

The oldest records of the notch-eared bat are from the Early Pleistocene (Early Biharian, Late Villafranchian); in the Lateglacial the species is reported in several localities in Central and Eastern Europe, always represented by few remains, whereas in Italian peninsula and circum-Mediterranean regions it is rare (SALARI & DI CANZIO, 2009 with references; SALARI, 2010;

SALARI & KOTSAKIS, in press). During the early and middle Holocene this species is reported in several sites of Spain, Switzerland, Poland and Hungary (ALCOVER, 2003; POSTAWA, 2004; SALARI & DI CANZIO, 2009 with references; BLANT *et al.*, 2010) and in Italy only in Mesolithic layers of Continenza Cave (SALARI & DI CANZIO, 2009).

Genus *Plecotus* GEOFFROY, 1818
***Plecotus auritus* (LINNAEUS, 1758) vel *Plecotus macrobullaris* (KUZJAKIN, 1965)**
Pl. I, figs 16a, 16b

Material: A distal portion of humerus.

Description and remarks: The morphology and dimensions (Tab. 4) of the distal humerus are very similar to the extant *P. auritus* (FELTEN *et al.*, 1973). Recent research including modern techniques of molecular biology and bioacoustics, flanked also by the classical techniques based on morphological and morphometric criteria, modified the status of certain subspecies and/or geographical races to specific level (SPITZENBERGER *et al.*, 2003 and 2006); this concerns *P. macrobullaris*, a species distributed in Northern Italy, still poorly known, and possibly with similar ecological needs as *P. auritus*, but considered of a more Boreal nature (see AGNELLI *et al.*, 2004). Considering these reasons, we have preferred to ascribe this distal portion of humerus to *P. auritus s.l.* (= *P. auritus vel P. macrobullaris*).

The brown long-eared bat is a Boreal species, it is a species relatively resistant to cold temperatures, and currently occurs in Europe and most of Asia to Japan and the Himalayan region (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; SPITZENBERGER *et al.*, 2006); in Italy this species has only been reported in the northern and central regions, and in Sardinia, where it is in sympatry with its congeneric *P. sardus* (AGNELLI *et al.*, 2004).

The distribution and ecology of the alpine long-eared bat is less known, though the use of the habitat is supposed to be similar to the brown long-eared bat, with a preference for slightly lower altitudes; in Italy this species occurs in almost all northern regions (SPITZENBERGER *et al.*, 2003; AGNELLI *et al.*, 2004).

The earliest material described as *Plecotus* aff. *auritus* is reported in the Early Pleistocene (Late Villanyan, Middle Villafranchian); during Lateglacial the brown long-eared bat is recorded at several localities from Central and Eastern Europe, whereas in circum-Mediterranean regions it is quite rare (FLADERER, 2000; SALARI & DI CANZIO, 2009 with references) and in Italy it is recorded only at Pozzo Cave and Arene Candide Cave (SALARI & DI CANZIO, 2009; SALARI, 2010). During the less recent Holocene this species is reported in many localities of Spain, France, England, Germany, Poland, Russia, former Czechoslovakia and Hungary (JULLIEN, 1972; YALDEN, 1986; PIKSA & WOŁOSZYN, 2001; POSTAWA, 2004; OBUCH, 2006; HORÁČEK, 2007; FADEEVA &

KRUSKOP, 2008; JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references). *P. auritus vel austriacus* is recorded in some Late Pleistocene and less recent Holocene sites in Spain and Austria (SEVILLA GARCÍA, 1988; DÖPPES & FRANK, 1997).

Family *Miniopteridae* DOBSON, 1875
Genus *Miniopterus* BONAPARTE, 1837
***Miniopterus schreibersii* (KUHL, 1817)**
Pl. I, figs 8 and 17

Material: One fragmented skull, 6 mandibles two of which are fragmentary, 11 humeri and 11 distal portions of humeri.

Description and remarks: Both the morphology and size (Tab. 4) are similar to living *M. schreibersii* (see in particular FELTEN *et al.*, 1973; LANZA & AGNELLI, 2002; BENDA *et al.*, 2003).

The Schreiber's bat is a species of strict Mediterranean affinities, typically troglophilous; the current range comprises all populations living from Southern Europe and Morocco to sub-Saharan Africa, Madagascar and through Southern Asia to Oceania; in Italy this species occurs throughout to the whole country (HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; AGNELLI *et al.*, 2004).

M. schreibersii are known since the Early Pleistocene (Late Villanyan, Middle Villafranchian) (SALARI *et al.*, in press b). The species in Lateglacial is relatively abundant, particularly in Italy and circum-Mediterranean regions (SALARI, 2009; 2010; SALARI & DI CANZIO, 2009 with references; SALARI & KOTSAKIS, in press). During the less recent Holocene this species is reported in several sites of Spain, France, former Czechoslovakia and Hungary (JULLIEN, 1972; OBUCH, 2006; JEANNET & VITAL, 2009; SALARI & DI CANZIO, 2009 with references), and in Italy at Lonza Cave (BON *et al.*, 1991), Sant'Angelo Cave (WILKENS, 1996), Santuario della Madonna Cave and Continenza Cave (SALARI 2009; SALARI & DI CANZIO 2009).

IV. RESULTS AND DISCUSSION

The early Neolithic and early and middle Bronze Age layers of Cocci Cave have yielded a total number of 265 identified specimens, referable to at least 104 individuals (Tabs 1-2). This material is clearly a natural thanatocoenosis represented by the bones of bats that probably died due to low temperatures or to the lack of subcutaneous fat reserves during hibernation. If it is not exclusively for differential destruction, the absence of juvenile remains excludes the possibility of a thanatocoenosis built under a breeding colony; we can remember that in the early Neolithic and early and middle Bronze Age of Cocci Cave have been found many juvenile specimens of *G. glis*, *Apodemus* (*Sylvaemus*) sp. and *Microtus* sp., and foetal and/or neonatal remains

of domestic animals (SALARI, 1998; SALARI *et al.*, in press a).

During the middle Holocene the Cocci Cave hosted a diversity of bats, with *M. blythii* and *R. euryale* the more numerous species in this assemblage. The percentages of the first species are 30.4% in the Neolithic layers and 22.0% in the Bronze Age layers if number of identified specimens is considered, and 25.9% and 21.7% considering number of individuals. The percentages of the second species are 23.2% and 38.0% of the identified specimens, and 21.0% and 34.8% of the individuals. The next most abundant species is *R. ferrumequinum* (13.0% and 18.0% of identified specimens and 14.8% and 13.0% of individuals), followed by *M. schreibersii* (12.1% and 6.0% of identified specimens and 14.8% and 8.7% of individuals) and *M. myotis* (9.2% and 6.0% of identified specimens and 8.6% and 8.7% of individuals). *M. capaccinii* and *R. mehelyi* appear as accidental

species, and finally, the remaining three taxa occur occasionally. Thus, the bat assemblage is composed by species of Mediterranean affinities (*sensu lato* and *sensu stricto* - see HORÁČEK *et al.*, 2000) (Tab. 5), except for the occasional occurrence of *P. auritus s.l.* in the early Neolithic. Various mixed colonies with rhinolophids and *M. schreibersii* and/or the large and small sized species of genus *Myotis* are currently known (LANZA & AGNELLI, 2002; CSORBA *et al.*, 2003; AGNELLI *et al.*, 2004).

The taxa found in the early Neolithic and early and middle Bronze Age of Cocci Cave are half of the current bat fauna of Umbria (Tab. 5). All the taxa identified in this locality are currently distributed in Umbria and in Italian peninsula, except for *R. mehelyi* (see AGNELLI *et al.*, 2004; MUCEDDA *et al.*, 2009; SPILINGA *et al.*, 2009). This species is a cave-dwelling bat particularly sensitive to human disturbance, and in Italy presently limited in its distribution to Sardinia and Sicily, but previous to

Table 5: Comparison between middle Holocene taxa from Cocci Cave and current bat fauna of Umbria, and schematic synthesis of some ecological features of the bats (data from HORÁČEK *et al.*, 2000; LANZA & AGNELLI, 2002; AGNELLI *et al.*, 2004; SPILINGA *et al.*, 2009); s.l.: *sensu lato*, s.s.: *sensu stricto*.

| | Cocci Cave | Umbria today | hibernacula | temperatures of hibernation | foraging environment | zoogeographical patterns |
|---------------------------------------|------------|--------------|--------------------------|-----------------------------|--------------------------|--------------------------|
| <i>Rhinolophus ferrumequinum</i> | X | X | caves | 7 - 12 °C | mixed | Mediterranean s.l. |
| <i>Rhinolophus euryale</i> | X | X | caves | 10 - 12 °C | woods | Mediterranean s.s. |
| <i>Rhinolophus mehelyi</i> | X | | caves | 11 - 13 °C | woods | Mediterranean s.s. |
| <i>Rhinolophus hipposideros</i> | X | X | caves | 4 - 12 °C | mixed | Mediterranean s.l. |
| <i>Myotis myotis</i> | X | X | caves | 2 - 12 °C | woods | Mediterranean s.l. |
| <i>Myotis blythii</i> | X | X | caves | 4 - 14 °C | open | Mediterranean s.l. |
| <i>Myotis capaccinii</i> | X | X | caves | 4 - 15 °C | woods | Mediterranean s.s. |
| <i>Myotis daubentonii</i> | | X | caves | 0 - 10 °C | forests | Boreal |
| <i>Myotis bechsteinii</i> | | X | hollow trees, caves | 1 - 10 °C | woods | Nemoral |
| <i>Myotis emarginatus</i> | X | X | caves | 5 - 9 °C | various | Mediterranean s.l. |
| <i>Myotis mystacinus</i> | | X | caves | 2 - 8 °C | various | Nemoral |
| <i>Myotis nattereri</i> | | X | caves | 2 - 8 °C | woods | Nemoral |
| <i>Pipistrellus kuhlii</i> | | X | buildings, rock fissures | ? | various, anthropophilous | Mediterranean s.s. |
| <i>Pipistrellus pipistrellus s.l.</i> | | X | buildings, hollow trees | 0 - 6 °C | woods, anthropophilous | Mediterranean s.l. |
| <i>Hypsugo savii</i> | | X | buildings, caves | ? | various, anthropophilous | Mediterranean s.s. |
| <i>Eptesicus serotinus</i> | | X | buildings, caves | 2 - 4 °C | various | Mediterranean s.l. |
| <i>Nyctalus leisleri</i> | | X | hollow trees | ? | woods | Nemoral |
| <i>Plecotus auritus s.l.</i> | X | X | hollow trees, caves | 2 - 5 °C | forests | Boreal |
| <i>Plecotus austriacus</i> | | X | caves, hollow trees | 2 - 12 °C | woods | Mediterranean s.l. |
| <i>Miniopterus schreibersii</i> | X | X | caves | 4 - 12 °C | various | Mediterranean s.s. |
| <i>Tadarida teniotis</i> | | X | rock fissures | 0 - 10 °C | rocky | Mediterranean s.s. |

1980 it was also reported in Apulia (AGNELLI *et al.*, 2004; MUCEDDA *et al.*, 2009). The only sure continental records previous to 1980 are restricted to Castellana Cave and Zinzulusa Cave (Apulia), both open to the tourism, whereas the past and the recent records in Calabria and Campania have been subsequently not confirmed (MUCEDDA *et al.*, 2009). In all range of distribution *R. mehelyi* is today considered endangered (vulnerable), probably because of the recent habitat modifications, primarily for the use of pesticides, deforestation and other human activity such as hypogean tourism and vandalism (HUTSON *et al.*, 2001; AGNELLI *et al.*, 2004). It is considered declining in many countries: close to extinction in France and already extinct in Croatia and Corsica, it is numerically even regressed in the Iberian peninsula, where it is relatively more abundant (MUCEDDA *et al.*, 2009 with references).

During the Lateglacial *R. mehelyi* is reported in few sites of Mediterranean Europe and Caucasus, and in Italy at Arene Candide Cave and Palmaria Island (Liguria), Broion Cave (Veneto), Continenza Cave (Abruzzi) (SALARI & DI CANZIO, 2009; SALARI, 2010; and references in those papers) and Paglicci Cave (Apulia) (unpublished data). Among the Holocene Italian sites analysed, it is recorded only in the Mesolithic layers of Continenza Cave (SALARI & DI CANZIO, 2009). Cocci Cave can be considered as the latest occurrence of *R. mehelyi* fossil in Italy, previous to the observations of zoologists of the 20th centuries in Apulia. The change of the geographic distribution and the decline of this species in Italy seem to have proceeded from north to south, but only new data can establish. Being the Mehely's horseshoe bat linked to a certain extent to forested areas, these records might indicate a reduction of initially wider ranges caused by the reduction of woodland (for natural or human causes) in great part of the Italian territory during the Holocene. Concerning the palaeoenvironment that might be inferred from the bat assemblage, taking in account habitat preferences, palaeoenvironmental indications, *M. schreibersii*, *R. ferrumequinum* and *M. emarginatus* frequent a variety of environments, from forest to open landscapes; the first species also found in steppe habitats, the other in areas close to wetlands. *M. blythii* is linked to open grassland and steppes, avoiding both the dry and denuded areas as well as any type of woodland and forest. *M. myotis* prefers forest environments with sparse undergrowth and also in open and semi-arid environments, but not far from woody areas. On the other hand, the other rhinolophid species, *M. capaccinii* and *P. auritus* occur preferably in wooded areas, including those developed in the vicinity of wetlands or watercourses. Considering these preferences, the percentages of the identified taxa and the territory morphology around Narni, one can reconstruct a composite landscape, in some points not so different to the current, with forests and grasslands interspersed by scrubland areas, rocky bands and wetlands. This environment reconstruction is in agreement with the indications of the other mammals

and the continental gastropods (SALARI, 1998; SALARI *et al.*, in press a). The Santa Croce Mountain sides overlooking the Nera River gorges are currently covered with thermoxerophile woods, dominant holm oak (*Quercus ilex* LINNAEUS, 1753), with localized scrubland areas, rocky bands and scree slopes; instead the upper part of the mountain includes a plateau with meadows and pastures, wooded and scrubland areas (CATORCI *et al.*, 2006).

Considering the percentage changes in the time, in the early and middle Bronze Age there are a lesser numerous of taxa, but the forest species increase and *M. blythii*, indicating open environments, decrease (Fig. 3): in all probability there was a larger extension of woods and forests during the early and middle Bronze Age than the early Neolithic.

The great majority of bat remains collected in the site belong to troglophilous species, forming reproductive and/or hibernating colonies in caves, in a higher proportion compared to the bats currently distributed in Umbria (see Tab. 5). *P. auritus s.l.* do not hibernates solely in caves, but also in hollow trees. Other hibernating tree-roosting bats, those that are more distinctly anthropophilous and those that hibernate in rocky fissures are not represented in this assemblage (see Tab. 5). These data also corroborate that the bat remains are an autochthonous thanatocoenosis (see SEVILLA GARCÍA, 1988; KOWALSKI, 1995).

According to the environmental conditions of the hibernacula of the species present in the assemblage (Tab. 5), varying conditions during the winter may be inferred for Cocci Cave (or at least for the room 1, surrounding area of excavation) during the middle Holocene. The temperature seems to have remained nearly constant around 10-12 °C, albeit with some fluctuations around these values; although these are a few remains, cannot be excluded that there might have been however some punctual events with the lower values of the minimum temperature considering the presence of *P. auritus s.l.* (Neolithic) and *M. emarginatus* (Bronze Age). Concerning the humidity, generally these troglophilous bats favour roosts with humidity values close to saturation, except

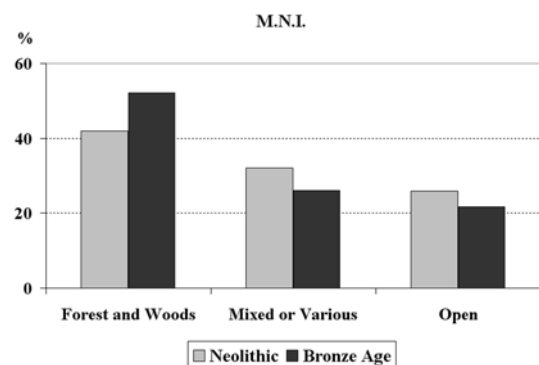


Fig. 3: Cocci Cave, middle Holocene: percent ratio of the Chiroptera (MNI) according to foraging environment (see caption of Table 5).

for *M. schreibersii* which prefers roosts that do 70-98% in humidity.

If we analyse the relation between human presence in the caves and the richness of the bat tanathocoenosis, it is important to point out that it is not common to find remains of bats in sites where humans are the main agent responsible for the accumulation of animal bones. The noise, the light and the heat caused by the human presence the hypogean environments change. The smoke from fires lit by humans is particular source of disturbance to bats, and may also alter the microclimate of the caves. The disturbance is greater if the intrusion occurs in winter or during the breeding season, causing the displacement and dispersal of the colonies on the territory in search of other caves suitable for their needs.

The troglophilous bats are wild and are not commensal to humans, frequently abandoning the caves when human occupation is important. It does not seem reasonable to consider these small flying mammals were used as food supply or other purposes. As to the possibility of having been prey to Strigiform birds, it must be pointed out that generally bat remains in the pellets of these birds represent values under a 1% since they feed mainly on rodents, small birds and insectivores (CHALINE *et al.*, 1974; SEVILLA GARCÍA, 1988; KOWALSKI, 1990, 1995; VERNIER, 1993; OBUCH, 2006). However, even the Strigiform birds abandon the caves occupied by humans. Moreover the skeletal remains described in this paper are about 35% of the micromammal and 22% of the vertebrate remains, and therefore evidently record the time intervals during which the cave was rarely frequented or even unoccupied by humans or made a seasonal use of it, particularly during the summer, since the assemblages lack juvenile specimens (if it is not exclusively for differential destruction) and thus represent thanatocoenoses originated during hibernations.

The lesser abundance of bats recorded in the Bronze Age layers (Tabs 1 and 2) is perhaps due to the more assiduous attendance of humans in the cave during this time interval. The data is confirmed by more numerous coprolites and coprolite fragments of goat and/or sheep in these layers (SALARI, 1998). During the early Neolithic, the cave was frequented occasionally for cultural and burial grounds (SALARI, 1998; D'AMICO & DE ANGELIS, 2009; SALARI *et al.*, in press a), and anyway numerous bone remains of bats in the upper part of the Neolithic sequence were collected, in the time interval between the latest Neolithic attendances and the later first Bronze Age presence.

V. CONCLUSIVE CONSIDERATIONS

In the early Neolithic and early and middle Bronze Age of Cocci Cave 10 taxa, of 4 genera and 3 families of bats have been identified (Tabs 1 and 2). The analysis of this bat assemblage contributes with new data to increase our knowledge on the history of the bat fauna of Italy,

particularly of middle Holocene, an important moment in the changes of mammal faunas towards the modern patterns we observe today.

The relative richness of bone remains of Chiroptera are without doubt evidence of particular moments in which the humans have abandoned or rarely frequented the cave. Additional interpretations concerning the microclimate of the cave (at least the room 1) are inferred from the particular requirements of the species represented in the assemblage. Thus, the humidity had near to values close to saturation, whereas the temperature remained relatively constant around 10-12 °C, probably with some punctual fluctuations around these values. The foraging environments preferred by the identified species in the assemblage also provide information to infer characteristics of the environment surrounding the cave during the middle Holocene, outlining a composite landscape in some points not so different to the current, with forests and grasslands interspersed by scrubland areas, rocky bands and wetlands; in all probability more forested during the early and middle Bronze Age.

Finally, a new record of *R. mehelyi* adds new information for the understanding of the limited and discontinuous distribution of this species in the past, previous to the recent decline, and which is extinct today in the Italian peninsula.

ACKNOWLEDGEMENTS

I am grateful to the “Soprintendenza per i Beni Archeologici dell’Umbria”, in particular Maria Cristina DE ANGELIS, which allowed the access to the fossils. I thank also Elsa GLIOZZI, Tassos KOTSAKIS and Carmelo PETRONIO, for their support.

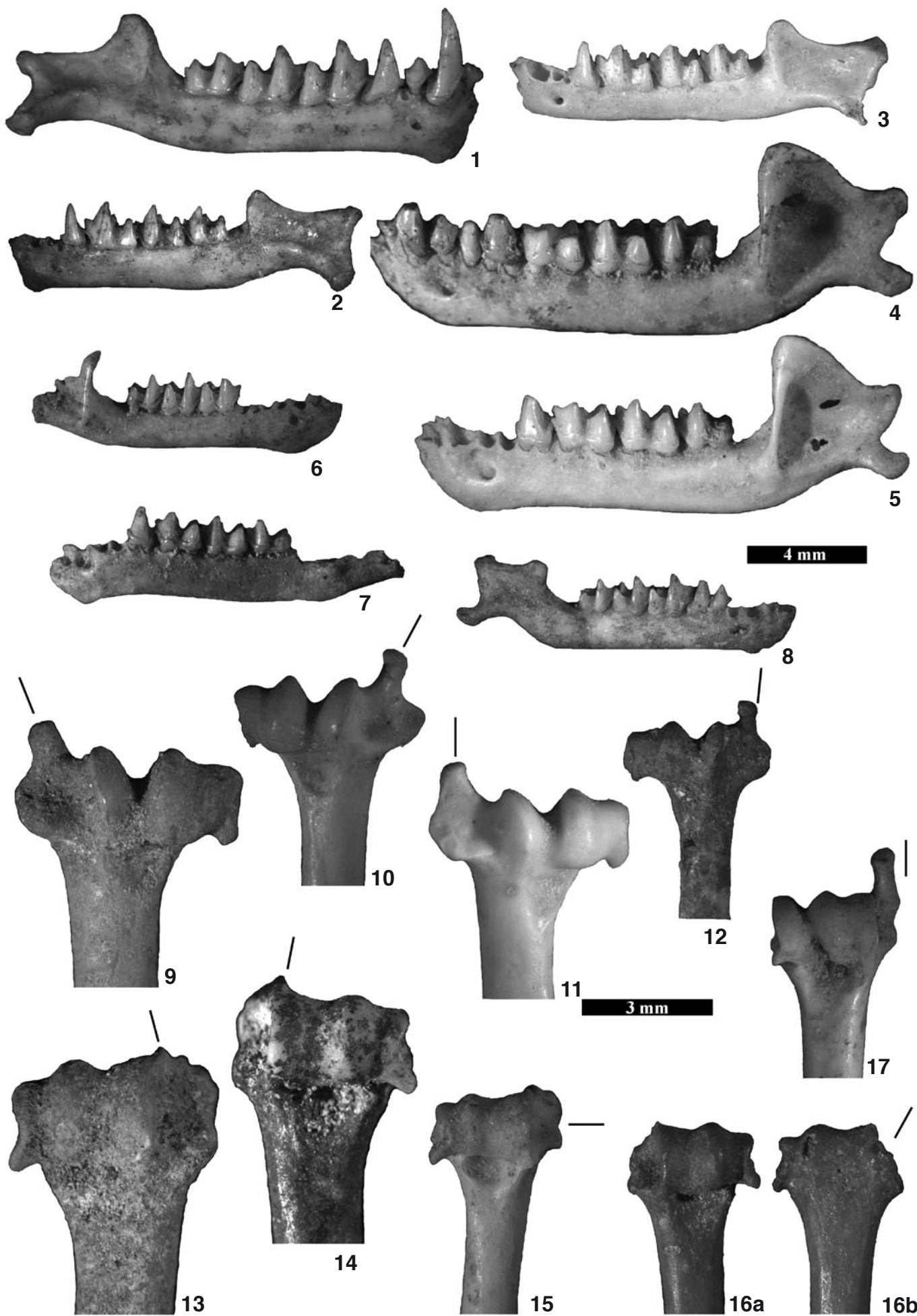
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Plate I

Fig. 1: *R. ferrumequinum*, mandible; fig. 2: *R. euryale*, mandible; fig. 3: *R. mehelyi*, mandible; fig. 4: *Myotis myotis*, mandible; fig. 5: *M. Blythii*, mandible; fig. 6: *M. capaccinii*, mandible; fig. 7: *M. emarginatus*, mandible; fig. 8: *Miniopterus schreibersii*, mandible, (Scale bar = 4 mm); fig. 9: *R. ferrumequinum*, distal humerus; fig. 10: *R. euryale*, distal humerus; fig. 11: *R. mehelyi*, distal humerus; fig. 12: *R. hipposideros*, distal humerus; fig. 13: *Myotis myotis*, distal humerus; fig. 14: *M. Blythii*, distal humerus; fig. 15: *M. capaccinii*, distal humerus; fig. 16a: *P. auritus s.l.*, distal humerus (external view); fig. 16b: *P. auritus s.l.*, distal humerus (internal view); fig. 17: *Miniopterus schreibersii*, distal humerus, (Scale bar = 3 mm).



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