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REASSESSING THE FAUNAL ASSEMBLAGES OF THE LATE PLEISTOCENE STRATIFIED KARST FILLING FROM AVETRANA (APULIA, SOUTHERN ITALY): THE BED 8, PALAEOENVIRONMENT AND BIOCHRONOLOGY

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ABSTRACT: The late Quaternary vertebrate deposit of the stratified karst filling from Avetrana (Apulia, Italy) was the subject of an intensive excavation campaign in 2003, followed by numerous subsequent investigations and collections of fossil remains. In this work, the biochronological implications and the palaeoenvironmental reconstruction of the area in the Late Pleistocene are updated and improved based on the more recent observations (2012-2013). In particular, the faunal assemblage found in the uppermost stratum (bed 8) of the fossiliferous deposit is analysed where the proportion of wolf remains increases sharply against the underlying layers. A synthesis and a recapitulation of the vertebrate assemblages recovered in the entire stratified karst filling are also given.

New observations on the preservation of the bone remains and population analyses of representative mammal species (*Canis lupus*, *Bos primigenius*, *Cervus elaphus*, *Dama dama* and *Sus scrofa*) show that bed 8 displays features indicating its origination in sedimentary, climatic and environmental conditions quite different from those of underlying beds. Up to bed 7, the stratified karst filling and its faunal assemblages were generated by a succession of catastrophic mass mortality events in a very short time alternated with moments of quiet deposition, during the early Late Pleistocene (MIS 5e). Instead, bed 8 deposited over a longer time span, probably to be placed between the beginning of last glacial period and early MIS 3, when a puddle of water or a pond was likely at the top of the residual cavity filling.

Lithic artefacts recovered in bed 8 and in bed 6 only testifies the attendance of Neanderthal humans in the surrounding of Avetrana.

Keywords: Late Pleistocene, southern Italy, population analysis, palaeoenvironment, biochronology.

1. INTRODUCTION

The vertebrate assemblage found out near Avetrana (Taranto, Apulia, southern Italy; Fig. 1A), in an abandoned quarry at La Grave locality, has been the subject of an intensive campaign of excavations carried out by researchers of "Sapienza" University of Rome, in agreement with the "Soprintendenza Archeologia, Belle Arti e Paesaggio" of Apulia, in October 2003, followed by numerous subsequent investigations and collections of fossil remains (Sardella et al., 2005; Petronio et al., 2008; Salari & Sardella, 2009; Pandolfi et al., 2011, 2013a; Bertè & Pandolfi, 2014; Kotsakis et al., in press).

Apulia is well known for the presence of karst cavities containing palaeontological and archaeological deposits with rich bone assemblages of Late Pleistocene. Therefore, this region represents an important repository of data for reconstructing the evolution of past environments during the recent Quaternary in southern Europe (Petronio et al., 2007; Pandolfi et al., 2017a). Abundant faunal remains have been recovered in different karstic cavities of Apulia, mainly in cave deposits in which the main accumulation agents were the Middle and Upper Palaeolithic humans (Palma di Cesnola, 2001; Mussi, 2002). Only in a few sites, such as Ingarano in the Gargano peninsula (Petronio et al., 1996), in the so-called "ventarole" of Salento peninsula (De Giuli, 1983; Bologna et al., 1994; Rustioni et al., 1994; Pandolfi et al., 2017a) and at Avetrana on the Ionic side of the region, the vertebrate bone remains can be considered of natural supply. These sites are represented by sub-vertical or funnel-shaped cavities within limestone formations, sinkholes filled mainly with residual clays of karst activity, other sediments and pebbles. They have presumably functioned as traps for living fauna in the environs and/or as reservoirs for waters that

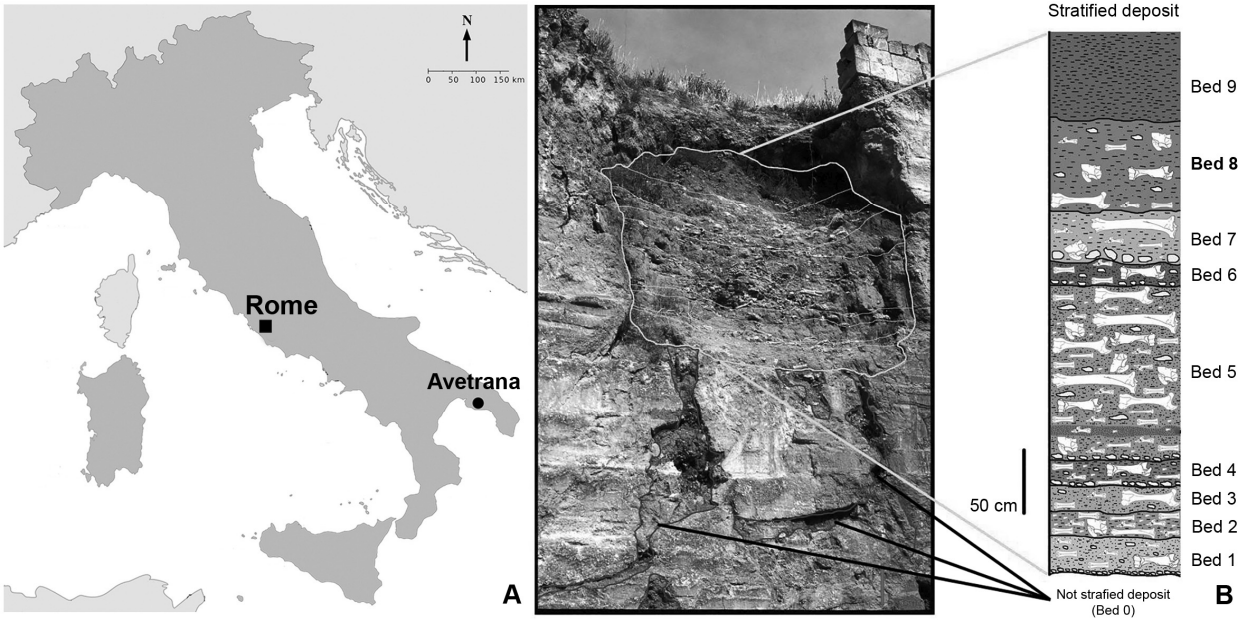

Fig. 1 - Avetrana (southern Italy), Late Pleistocene: A) location of the site; B) stratigraphy of the karst filling in La Grave locality (by Petronio et al., 2008, redrawn).

transported what they found (sediments, pebbles, bones) in the surrounding areas (De Giuli, 1983; Bologna et al., 1994; Rustioni et al., 1994; Petronio et al., 2008; Pandolfi et al., 2013a, 2017a).

In these karst cavities, the vertebrate remains are generally in a good state of preservation and are commonly located at the base and/or at the top of these karstic infills, without signs of long-distance transport (Bologna et al., 1994; Petronio et al., 2008; Pandolfi et al., 2013a, 2017a). In addition, remains are chaotically scattered and lacking specific taphonomic signatures or traces of human activity, and sometimes parts of the same skeletal element occur at different depths (De Giuli, 1983; Bologna et al., 1994). These karst infills were probably accumulated rapidly and each bone assemblage within them usually appear as coeval in age (Bologna et al., 1994; but see Pandolfi et al., 2017a). Among these karst fillings, only the deposit of Avetrana show a stratigraphic succession.

As described by Sardella et al. (2005) and Petronio et al. (2008), the Late Pleistocene fossiliferous deposit from Avetrana is found in an open-air sub-vertical karst cavity within Early Pleistocene limestone ("Calcareniti di Gravina" formation). Very abundant remains of large and small mammals, birds, other vertebrates and fine sediments with sparse calcareous pebbles constitute the cavity infilling. According to Petronio et al. (2008) several layers, or beds, recognized in the site of Avetrana (Fig. 1B), probably deposited rapidly during a short time span (from a geological point of view) by exceptional events, resulting in the rapid incorporation of carcasses and isolated vertebrate remains in the karst cavity. The abundance of the remains, many still in articulation, their state of preservation, the rarity of skulls and the population analysis of some representative mammal species strongly have suggested to Pandolfi et al. (2013a) that a significant part of the bone remains were accumulated by water during several catastrophic events in the area. In particular, beds 2, 5 and 7, which contain abundant fossil remains and sparse clay-sandy matrix, were deposited over a very short time and probably each represent a single depositional event; in contrast, beds 1, 3, 4, 6 and 8, which are characterized by abundant clay-sandy matrix and sparse fossil remains, have been probably deposited by water and gravity over a longer time span.

The population analyses of the taxa recovered from the site supports the hypothesis of rapid infilling of the cavity through heavy rainfall and flash floods. In particular, aurochs, fallow deer and red deer have provided useful information about the season of death and consequently the probable time span of the aggradations. In beds 5 and 7, the estimated season of death of these three species, particularly for the young animals, has suggested probable catastrophic depositions between the autumn and the winter (Pandolfi et al., 2013a).

So far, the entire mammal assemblage was referred to the early Late Pleistocene (Sardella et al., 2005) and related to Melpignano Faunal Unit (Petronio et al., 2008). Later, Pandolfi et al. (2013a) tentatively restricted the time interval to Marine Isotope Stage 5e (=MIS 5e). Nevertheless, with respect to the others, the eighth and uppermost bed shows some peculiar features. In this bed, the percentage of damaged and concreted bones is relatively high, compared to underlying beds. Furthermore, in bed 8 there is a very high percentage of carnivore remains, in particular wolf (Pandolfi et al., 2013a; Bertè & Pandolfi, 2014; Mecozzi & Bartolini Lucenti, 2018).

Pandolfi et al. (2013a) have underlined these particularities of bed 8, but not adequately investigated.

During the 2012 and 2013 surveys at the site of Avetrana, new fossil remains were collected and important new stratigraphic observations, particularly related to the small vertebrates found in all layers (Kotsakis et al., in press) and to the faunal assemblage of bed 8 and a lithic artefact found in this bed, were made.

The aim of this additional work on the stratified fossiliferous deposit of Avetrana is therefore to analyse the faunal assemblage found in bed 8, comparing it with the faunal assemblages of the underlying layers, in order to update and improve the biochronological implications and the palaeoenvironmental reconstruction of the area in the Late Pleistocene.

2. STRATIGRAPHIC NOTES

Sardella et al. (2005) and Petronio et al. (2008) recognized several levels in the depositional sequence of Avetrana karst filling (Fig. 1B). The deposit was divided into nine beds in the main sub-vertical karst cavity (about 4.5 m thick) and two discrete basal infillings, or pockets, that are described below, from the bottom to the top, according to the previous works (Sardella et al., 2005; Petronio et al., 2008; Pandolfi et al., 2013a; Kotsakis et al., in press) and the recent observations.

At the bottom of the sequence, there are two small and irregular fissures, named bed 0, which are filled by orange-yellow non-laminated sandy clays rich in small fossil vertebrate remains (Tab.1), probably because it was the only material that could pass through the small karstic fissures.

Bed 1 is composed of an uninterrupted stratum of calcareous pebbles, overlain by a thin deposit (30 cm) of argillaceous sand containing rare and altered clayey pebbles and a few fossil bones.

Bed 2 comprises a thin (20 cm) deposit of sandy clay including numerous bone remains.

Bed 3 consists of 20 cm of argillaceous sand with only a few bones.

Bed 4, equally around 20 cm thick, is separated from the underlying layer by a discontinuity, marked by a stratum containing calcareous pebbles, and it is formed by clayey sands including fragmentary remains.

Bed 5, around 140 cm thick, contain rare calcareous pebbles at the bottom followed upwards by thousands of bones, especially of *B. primigenius*, and scarce argillaceous sand matrix.

The following bed 6 is formed by about 20 cm of argillaceous sandy matrix and yielded several mammal remains. A single Mousterian lithic artefact was discovered in this layer.

In bed 7, around 40 cm thick, the abundance of fossil remains and the scarcity of sandy clay matrix are similar to that in bed 5, but the remains of small vertebrates are practically absent.

Bed 8 is formed by about 75 cm of sandy clays sediments with calcareous pebbles and scattered remains of large and small vertebrates. A single lithic artefact was also discovered in this bed.

The covering deposit (Bed 9 in Fig. 1B) is a clayey soil about 70 cm thick with very rare and decalcified bones.

3. MATERIALS AND METHODS

The fossils found out at locality La Grave near Avetrana in the intensive campaign of excavations carried out in October 2003 are housed at the "Soprintendenza Archeologia, Belle Arti e Paesaggio" of Apulia in Taranto. The fossil remains collected in the subsequent survey campaigns are temporarily stored in the Earth Sciences Department of "Sapienza" University of Rome (large mammals), in the Section of Bioarchaeology of the Civilizations Museum of Rome (birds), and in the Sciences Department of "Roma Tre" University (small vertebrates), pending the decision of

Beds	Taxa
Bed 8	*Bufo bufo*, *Bufotes* gr. *B. viridis*, *Hyla* gr. *H. arborea*, *Testudo hermanni*, *Podarcis* sp., Serpentes indet., *Columba* sp., *Columba livia*, *Aquila* sp., *Pyrrhocorax* sp., *Pyrrhocorax pyrrhocorax*, *Erinaceus europaeus Crocidura suaveolens*, *Arvicola italicus*, *Microtus (Microtus) arvalis*, *Microtus (Terricola) savii*, *Hystrix vinogradovi*, *Oryctolagus cuniculus*, *Lepus corsicanus*, *Vulpes vulpes*, *Canis lupus*, *Mustela putorius*, *Martes* sp., *Meles meles*, *Felis silvestris*, *Lynx* sp., *Panthera spelaea*, *Crocuta crocuta*, *Stephanorhinus hemitoechus*, *Sus scrofa*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*
Bed 7	*Columba livia*, *Hystrix vinogradovi*, *Oryctolagus cuniculus*, *Vulpes vulpes*, *Canis lupus*, *Crocuta crocuta*, *Stephanorhinus hemitoechus*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*
Bed 6	*Columba livia*, *Microtus (Terricola) savii*, *Oryctolagus cuniculus*, *Vulpes vulpes*, *Canis lupus*, *Stephanorhinus hemitoechus*, *Hippopotamus amphibius*, *Sus scrofa*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*
Bed 5	*Bufotes* gr. *B. viridis*, *Rana (s.l.)* sp., *Zamenis* gr. *Z. longissimus*, *Natrix natrix*, *Columba livia*, *Erinaceus europaeus*, *Crocidura suaveolens*, *Arvicola italicus*, *Microtus (Terricola) savii*, *Apodemus* gr. *A. sylvaticus - A. flavicollis*, *Hystrix vinogradovi*, *Oryctolagus cuniculus*, *Lepus corsicanus*, *Vulpes vulpes*, *Canis lupus*, *Meles meles*, *Crocuta crocuta*, *Lynx lynx*, *Hippopotamus amphibius*, *Sus scrofa*, *Capreolus capreolus*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*
Bed 4	*Columba livia*, *Oryctolagus cuniculus*, *Vulpes vulpes*, *Canis lupus*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*
Bed 3	*Columba livia*, *Oryctolagus cuniculus*, *Vulpes vulpes*, *Canis lupus*, *Meles meles*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*
Bed 2	Testudinata indet., *Otis tarda*, *Columba livia*, *Aquila* sp., *Pyrrhocorax pyrrhocorax*, *Pyrrhocorax graculus*, *Hystrix vinogradovi*, Leporidae indet., *Vulpes vulpes*, *Canis lupus*, *Meles meles*, *Crocuta crocuta*, *Lynx lynx*, *Stephanorhinus hemitoechus*, *Hippopotamus amphibius*, *Sus scrofa*, *Dama dama*, *Cervus elaphus*, *Bos primigenius*
Bed 1	*Erinaceus europaeus*, *Microtus (Terricola) savii*, *Hystrix vinogradovi*, *Bos primigenius*
Bed 0	*Perdix perdix*, *Columba livia*, *Athene noctua*, *Pyrrhocorax graculus*, *Erinaceus europaeus*, *Microtus (Terricola) savii*, *Hystrix vinogradovi*, *Oryctolagus cuniculus*, *Lepus corsicanus*, *Felis silvestris*

Tab. 1 - Avetrana (southern Italy), Late Pleistocene: faunal lists reporting all the vertebrate taxa recovered in each bed.

"Soprintendenza Archeologia, Belle Arti e Paesaggio" of Apulia for the final ubication. In 2012-2013 field surveys, hand collection of the fossil remains of medium and large mammals (particularly from bed 8) was carried out. During the 2013 was also made a sampling in all the layers in search of small vertebrates, sifting several kg of sediments.

The vertebrate remains were compared with osteological material, both fossil and recent, stored in the Earth Sciences Department of the "Sapienza" University of Rome, in the Section of Bioarchaeology of the Civilizations Museum of Rome and in the Sciences Department of the "Roma Tre" University.

The methodologies of study of medium and large mammals are the same as in Pandolfi et al. (2013a). Together, the most recent and previous stratigraphic observations of the karst filling described above, taking into account the position and orientation of the bones in the bed 8, their preservation state (concreted, very or little damaged, well preserved; concreted bones were counted only once, regardless if they were well preserved or damaged) and the possible modifications to the bone surfaces, represent the first stage in reconstructing the depositional events. Furthermore, population analyses of some representative species may be used to obtain possible information about the time span of depositional events, the seasonality of such events and biochronological and palaeoenvironmental indications. The above, was compared to the preservation status of the bone remains and the population analyses of the underlying beds.

For this purpose, the fossil remains were quantified both in number of identified specimens (=NISP) and in the minimum number of individuals (=MNI). The MNI was calculated taking into consideration the side of each bone (right or left) and the most frequent skeletal element from only one side. The results were integrated with the analysis of the metrical characters, sex and age profiles of the other skeletal elements.

The estimated age of death was calculated according to the stage of fusion of the long bone epiphyses, and tooth eruption, replacement and wear stages according to Gipson et al. (2000) for North American wolves, Bull & Payne (1982) for *S. scrofa* from Turkey, Mariezkurrena (1983) for *C. elaphus* from Cantabria (Spain) (for red deer and fallow deer), and Barone (1974, 1981) and Grant (1982) for present-day domestic cattle (as a proxy for *B. primigenius*).

The estimate of the withers height was carried out by multiplying the maximum length of long bones, taken according to Driesch (1976), by the coefficients of Harcourt (1974) and Clark (1995) for prehistoric dog (as a proxy for *C. lupus*), of Teichert (1969) for present domestic pig (as a proxy for *S. scrofa*), of Matolcsi (1969) for present domestic cattle (as a proxy for *B. primigenius*) and those reported by Wilkens (1989) for prehistoric red deer.

Even if the biology and ontogeny of the Pleistocene mammals may be different from present-day domestic cattle, domestic pig, prehistoric dog and modern wolf, wild boar and red deer, the estimated relative ages and withers height can be reconstructed with confidence, and they are probably similar.

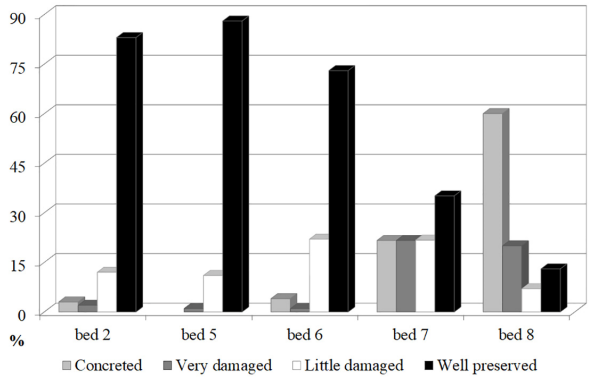

Fig. 2 - Avetrana (southern Italy), Late Pleistocene: percentages of preservation of the fossil bones of large mammals recovered in the different beds.

Finally, several sediment samples from all layers have been washed through a 125μm mesh sieve looking for ostracods, but these have not been found.

4. RESULTS

4.1. Preservation status of the bone remains

The recent observations substantially confirm what reported by Pandolfi et al. (2013a). Except for bed 0 and 1 where there is little to be observed, in all the beds 2-7 the bones of large mammals are generally chaotically disposed, with the long bones lying mainly parallel to the stratigraphic surface but without a predominant orientation.

Also in bed 8, the same spatial disposition was observed, but the long bones parallel to the stratigraphic surface were mostly at the bottom of the stratum. In this bed, there are a few well preserved remains that represent about 13% of the large mammal assemblage from this horizon. Concreted remains are abundant (about 60%), as well as the very damaged remains (about 20%) (Fig. 2). Observation of the bone surfaces in search of possible modifications is very difficult, especially for the presence of calcareous concretions. However, on the surface of the well preserved bones no clear evidences of human activity and of gnaw-marks by carnivores have been observed.

According to Pandolfi et al. (2013a), the preservation status of the bone remains of the large mammals in the underlying layers is as follows. The majority of the bed 2 remains (about 83%) are very well preserved, and a modest number of remains (about 12%) are slightly damaged through crushing or pressure and occasional bones have calcareous concretions (about 3%). In the beds 3 and 4 the bone remains are in not good conditions of preservation, but are not concreted. Instead, most of the remains of bed 5 are in a very good state of preservation (about 88%), several bones are still articulated and only about 11% of the remains are slightly crushed. In bed 6 the bones in a good state of preservation (about 73%) are fewer than in the previous bed, whereas there is an increase in the percentage of dam-

Taxa	NISP	%	NMI	%
Canis lupus Linnaeus, 1758	135	24,3	14	23,7
Vulpes vulpes (Linnaeus, 1758)	18	3,2	3	5,1
Mustela putorius (Linnaeus, 1758)	1	0,2	1	1,7
Martes sp.	1	0,2	1	1,7
Meles meles (Linnaeus, 1758)	2	0,4	1	1,7
Felis silvestris Schreber, 1777	4	0,7	2	3,4
Lynx sp.	5	0,9	2	3,4
Panthera spelaea (Goldfuss, 1810)	2	0,4	1	1,7
Crocuta crocuta (Erxleben, 1777)	13	2,3	3	5,1
Stephanorhinus hemitoechus (Falconer, 1859)	3	0,5	2	3,4
Sus scrofa Linnaeus, 1758	37	6,7	6	10,2
Cervus elaphus Linnaeus, 1758	71	12,8	6	10,2
Dama dama (Linnaeus, 1758)	45	8,1	5	8,5
Bos primigenius Bojanus, 1827	219	39,4	12	20,3
Total	556	100	59	100

Tab. 2 - Avetrana (southern Italy), bed 8, Late Pleistocene: number of identified specimens (NISP) and minimum number of individuals (NMI) of carnivores and ungulates.

aged, and those concreted reappear. The well preserved bones is relatively low (about 35%) in bed 7, and there is an increase in the percentage of damaged and concreted bones (Fig. 2), although some are in anatomical connection.

Concerning the possible modifications on the bone surfaces, were noticed only a probable intentional fracture on a humerus of hippopotamus from bed 6 (Petronio et al., 2008) and a pair of cut-marks on the aurochs phalanges from the same horizon, whereas clear evidences of gnaw-marks by carnivores are very rare.

4.2. Population analysis of representative mammal species

Population analyses were undertaken on certain mammal species well represented in the bed 8, often by both young and adult individuals. These are wolf, wild boar, red deer, fallow deer and aurochs. For the other mammal species we will only provide a description of representative remains. Carnivore and ungulate remains of bed 8 considered here are over 550 identified specimens (Tab. 2).

4.2.1. *Canis lupus*

The wolf occurs in all the beds, invariably represented by few fossil remains, except for beds 0 and 1, where it is absent (Petronio et al., 2008; Pandolfi et al., 2013a), and bed 8, where it is one of the species with the greatest NISP (Tabs 2-3).

In this bed, *C. lupus* is represented almost only by teeth, isolated or associated with mandible and maxilla portions (Fig. 3A-C) or fragments, and by several post-cranial bones (Tab. 3). In extant wolves, the permanent teeth replace the deciduous ones between weeks 16 and 26, and the epiphyseal cartilage of the long bones calcifies around the 12th month (Mech, 1974). Among the wolf remains from bed 8, all the isolated teeth and the maxillary and mandibular teeth are permanent, and all the post-cranial bones have the epiphyses fused. Thus, the MNI, calculated by the lower carnassial (m1), is 14 adult individuals and therefore, according to this computation, the wolf is the best represented species (Tabs 2 and 4). All the m1 have the occlusal surfaces slightly or not worn, indicating a death age between 6-8 months and 6 years, except for an individual of about 8 years (Fig. 3C).

The long bones are often fragmented and it was then possible to estimate the withers height only by a small-sized femur and a second metatarsus: the withers height is 64.2 and 67.7 cm, respectively.

Concerning the size, based on the upper and lower carnassial teeth compared with those of south-western Europe wolves, *C. lupus* from Avetrana bed 8 falling within the variability of the MIS 3 French wolves and to the largest late Middle and Late Pleistocene Italian wolves (Bertè & Pandolfi, 2014; Sansalone et al., 2015; Salari et al., 2017).

Using the coefficients by Boudadi-Maligne (2010, tabs 20 and 21), based on lower carnassial surface (length x breadth of m1), Salari et al. (2017) estimated also the body mass and the body length for the Avetrana wolves. According to this calculation too, *C. lupus* from bed 8 is among the largest wolf from late Middle and Late Pleistocene of Italy, with body mass up to 43.1 Kg, mean 37.4 Kg, and body length up to 167 cm, mean 157 cm. Instead, the wolf from bed 5 and bed 6 are smaller in size, with body mass of 32.3 and 29.8 Kg and body length of 153 and 149 cm, respectively.

4.2.2. *Sus scrofa*

In the Avetrana succession, *S. scrofa* is poorly represented, being present only in the beds 2, 5 and 6 with a few fossil remains, and bed 8 (Petronio et al., 2008; Pandolfi et al., 2013a). In bed 8, the species with 37 identified specimens (Tabs 2-3) is better represented than in the underlying beds. Wild boar remains are a maxilla and four mandibles with deciduous and permanent teeth, and some post-cranial bones with fused and unfused epiphyses referable to at least 6 individuals (Tabs 3-4): a very young of about three months, represented by an isolated and slightly worn lower fourth deciduous tooth (d4; Fig. 3D), a young individual of about one year, represented by a portion of mandible with worn d4 and second molar (m2) erupting, a young-adult and three adult individuals. These occur with a

skeletal elements	*C. lupus*	*S. scrofa*	*C. elaphus*	*D. dama*	*B. primi genius*
Horn/Antler			3		1
Skull					
Maxilla	8	1		2	4
Upper teeth	13	6	5	1	33
Mandible	42	4	2	3	7
Lower teeth	11	7	4	10	58
Atlas			1		
Axis			1		
Scapula			2	3	
Humerus	4	3	4		5
Radius	5		3	3	3
Ulna		1			
Carpal bones			1	2	16
Metacarpus	4	2	9	1	11
Pelvis		2	1		
Femur	1	4	8		5
Patella			1		1
Tibia	4		4	3	5
Fibula					
Astragalus	8		2	2	6
Calcaneus	3		3		5
Other tarsal bones					2
Metatarsus	1		6	2	7
Metapodial bones	7	1		3	4
Sesamoids	3				15
Phalanx I	10		7	4	12
Phalanx II	11	4	3	4	12
Phalanx III		2	1	2	7
Total	**135**	**37**	**71**	**45**	**219**
%	**24,3**	**6,7**	**12,8**	**8,1**	**39,4**

Tab. 3 - Avetrana (southern Italy), bed 8, Late Pleistocene: skeletal elements of the most representative mammals.

portion of maxilla and two incomplete mandibles (Fig. 3E) with unworn upper and lower third molars (about two years in age) and three with upper third molar (M3) at different wear stages (older than two years).

By a well-preserved astragalus was estimated the withers height, that is 104 cm, very similar to those of *S. scrofa* from bed 5 (104 and 102 cm, by third metatarsus and astragalus, respectively).

4.2.3. *Cervus elaphus*

Remains of young and adult red deer were recovered in all the beds 2-7, always with percentages between 7 and 9.9% in NISP (Petronio et al., 2008; Pandolfi et al., 2013a).

According to the NISP (Tab. 2), in the bed 8 *C. elaphus* is the third represented species (12.8%). Unlike other species, the red deer is best represented by long bones rather than by teeth (Tab. 3; Fig. 3F), and these fossil remains can be referred to at least 6 individuals, including 2 adults, a young-adult and 3 young (Tab. 4). Two young individuals have an estimated age of 18-24 months old, represented particularly by femurs of different sizes with unfused epiphyses, whereas a slightly worn d4 indicates the presence of a young of about 8 months in age. Two right metatarsal bones with the epiphyses fused attest the presence of two adult individuals, whereas humerus and femur with the epiphyses fused, but with the epiphyseal suture well appreciable in the proximal end, indicate the occurrence of at least a young-adult of about 32 months old.

In this bed, the long bones are often fragmented or belonging to young individuals and it was not possible to estimate the withers height. Instead, in the levels below it was possible to perform this estimate that, for example, it result 120 cm by metatarsus and 114 cm by calcaneus, in the beds 5 and 7, respectively. Dimensional comparison is possible by the only well preserved skeletal element from bed 8, an astragalus similar in size (greater lateral length, GLl: 54.3 mm) to those of the underlying beds (GLl from 51.3 to 56.7 mm, mean 54.4 mm).

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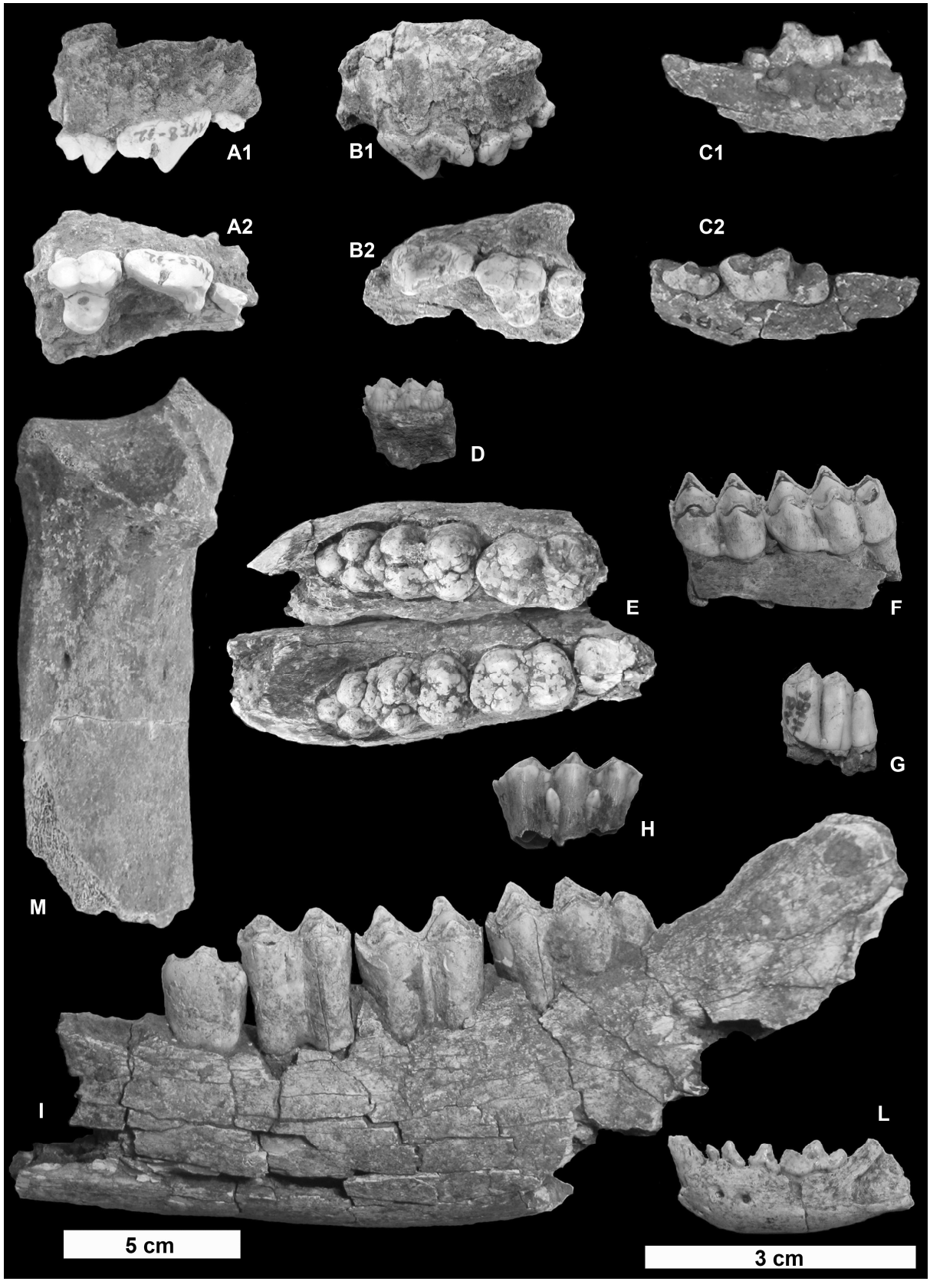
Fig. 3 - Avetrana (southern Italy), bed 8, Late Pleistocene: *Canis lupus*: maxillary portions, A1) and B1) labial view, A2 and B2) occlusal view; mandible fragment, C1) lingual view, C2) labial view; *Sus scrofa*: D) lower fourth deciduous; E) mandible portions in occlusal view; *Cervus elaphus*: F) mandible portion in lingual view; *Dama dama*: G) lower third molar; *Bos primigenius*: H) lower fourth deciduous; I) mandible portion in labial view; *Mustela putorius*: L) sub-intact mandible in labial view; *Stephanorhinus hemitoechus*: M) proximal third metacarpal. Scale bar = 5 cm, except for L) = 3 cm.


A1
B1
C1
A2
B2
C2
D
E
F
G
H
M
I
L
5 cm
3 cm

4.2.4. *Dama dama*

The fallow deer is the second most abundant species, after *B. primigenius*, in the beds 2 -7 with percentages of about 10-15%, and it is especially frequent in beds 5 and 7 (Petronio et al., 2008; Pandolfi et al., 2013a).

In the bed 8, instead, it is the fourth species with 8.1% in NISP (Tabs 2-3). The wear stages of teeth allow the recognition of two adults of different estimated ages according to the third lobe of the third lower molar (Fig. 3G), which has different wear stages, and three young individuals (Tab. 4). These are represented by left d4, which show different wear stages, and in particular one with an estimated age younger than 8 months and two with an estimated age about 20 months old.

	yy	y	y-a	a	o	total
C. lupus				14		**14**
S. scrofa	1	1	1	3		**6**
C. elaphus		3	1	2		**6**
D. dama		3		2		**5**
B. primigenius	1	3	1	6	1	**12**
total	**2**	**10**	**3**	**27**	**1**	**43**

Tab. 4 - Avetrana (southern Italy), bed 8, Late Pleistocene: minimum number of individuals of the most representative mammals; yy: very young; y: young; y-a: young-adult, a: adult; o: old.

Regarding the sizes, also for *D. dama* the only well preserved skeletal element is the astragalus showing similar dimensions (GLl: 42.4 and 44.4 mm) to those of the underlying layers (e.g., GLl: 42.7 and 44.7 in bed 5).

4.2.5. *Bos primigenius*

The aurochs is very well represented in the site of Avetrana: except for bed 0, in which it is absent, and bed 1, where it is the only large mammal, it accounts for about 60% of identified specimens (Pandolfi et al., 2013a). So far, were found remains of long bones, vertebrae, ribs, phalanges and teeth referable to at least 53 individuals (of which 5 from bed 8; see Pandolfi et al., 2013a, table 1), to ascribe to adult and subadult individuals, including very young individuals (Petronio et al., 2008; Pandolfi et al., 2011, 2013a).

According to the new data presented here, in the bed 8 the aurochs remains are fewer than the underlying beds. Indeed, *B. primigenius* is represented by 219 specimens (39.4%) referable to at least 12 individuals (Tabs 2-4): a very young calf, represented by an isolated unworn d4 (Fig. 3H), three calves represented by mandibles with d4 with light wear stage (two 4-5 months and one 6-8 months in age), a young adult with d4 very worn, two about 3-years adult individuals represented by fragmented mandibles with the third lobe of the lower third molar (m3) slightly or not worn, four about 4-years adult individuals with mandible portions with the m3 averagely worn (Fig. 3I), and an old individual represented by a mandible portion with very worn m3. Overall, there are the bone remains of at least 60 individuals in the fossiliferous deposit.

The long bones in bed 8 are many fragmented and it was then possible to estimate the withers height only by a metacarpus referable to an individual of indeterminate sex (DB/L index = 33.1; MB/L index = 18.1; see Howard, 1963). The withers height is 160.7 cm, which falls into the average of the withers height estimated by metacarpal bones of *B. primigenius* from the beds below (between 151.4 and 165.8 cm; Pandolfi et al., 2013a), which are among the largest in size of the Middle and Late Pleistocene aurochs of Italy (Pandolfi et al., 2011, 2013a).

4.2.6 Other carnivores and pachyderms

Among the other carnivores and ungulates, the most abundant is *Vulpes vulpes*. Remains of this species always occur in the beds 2-7, even though they are relatively scarce (Petronio et al., 2008). In bed 8 the fox is represented by 18 identified specimens (Tab. 2): isolated teeth (upper incisive, upper canine, upper and lower premolars and molars), maxilla fragment, almost complete mandible, proximal and distal humerus, distal femur, distal tibia, third metacarpus, third metatarsus and first phalanx referred to adult individuals; other remains are constituted by deciduous lower canine, fifth metacarpus and first phalanx with unfused epiphyses belonging to a cub.

Mustelid remains in the underlying beds are represented only by the badger, *Meles meles*, which occurs in the beds 2, 3 and 5, always with a few remains (Petronio et al., 2008). In bed 8, a sub-intact mandible attributed to the polecat, *Mustela putorius*, were found (Pandolfi et al., 2013a; Fig. 3L), together with a fragmented coxal referred to *Martes* sp., and first and second lower molars belonging to *M. meles* (Tab.2).

Regarding the Felids, *Lynx lynx* occurs in the bed 2 and 5, and *Felis sylvestris* in the bed 0, invariably with very scarce remains (Petronio et al., 2008). In the bed 8 the wild cat is present with a lower carnassial and two first phalanges belonging to an adult individual and with a proximal radius referred to a cub (Tab. 2). A premolar tooth is assigned to *L. lynx* by Petronio et al. (2008), instead another premolar and three small first phalanges can be referred to a small size lynx, such as *L. pardinus*, also attested in Italy (Rodríguez-Varela et al., 2015); for this reasons, these finds were prudently attributed to *Lynx* sp. (Tab. 2). Calcaneus and fourth metacarpus portions also attest the occurrence of *Panthera spelaea* in this bed.

Crocuta crocuta remains of a few adult individuals were collected in the beds 2, 5, 7 (Petronio et al., 2008) and 8, where the spotted hyena is represented by isolated teeth, fragmented maxilla and mandibles and a diaphysis of femur belonging to adult individuals (Tab. 2).

In addition, fossil remains belonging to a very young and an adult individual of steppe rhinoceros, *Stephanorhinus hemitoechus*, occur in the beds 2, 6 and 7 (Petronio et al., 2008; Pandolfi et al., 2013a), while *Hippopotamus amphibius* occurs with rare remains in the beds 2, 5 and 6. Moreover, a proximal third metacarpal (Fig. 3M), a juvenile third cuneiform and a fragment

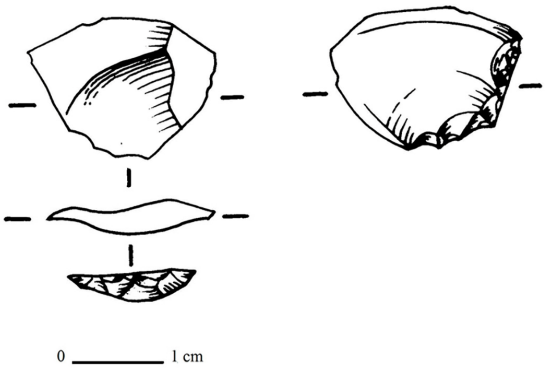


Fig. 4 - Avetrana (southern Italy), bed 8, Late Pleistocene: lithic artefact (drawn by Martina De Marzi).

of a third metatarsal attributed to *S. hemitoechus* (see Pandolfi et al., 2017b) were collected from bed 8.

4.3. Remarks on the other taxa

4.3.1 Small mammals

The small mammals of bed 8, *Erinaceus europaeus*, *Crocidura suaveolens, Arvicola italicus*, *Microtus (Microtus) arvalis*, *Hystrix vinogradovi*, *Oryctolagus cuniculus*, *Lepus corsicanus*, are studied in Kotsakis et al. (in press). In bed 8 are collected many dental remains of a large arvicolid that do not present diagnostic characters can however be attributed with great probability to the genus *Arvicola*, the only genus of the Late Pleistocene (and current) fauna of the Italian peninsula of this size. Pandolfi et al. (2013a) also report the occurrence of *Microtus (Terricola) savii*, which is present with few remains even in the beds 0, 1, 5 and 6 (Kotsakis et al., in press).

4.3.2. Birds

Bird remains are relatively scarce and are generally fragmented and in not good conditions of preservation. Only in the fissures at the bottom of the succession (bed 0) they are numerous and are chiefly represented by anterior limb bones belonging to *Perdix perdix, Columba livia, Athene noctua*, and *Pyrrhocorax graculus*. The most abundant in bed 0 is *C. livia* followed by *P. graculus*, while the other species are present with only one fossil remain (Sardella et al., 2005; Petronio et al., 2008). *Columba livia* was found in every bed, always represented by few remains; whereas *Aquila* sp., *Otis tarda* and *P. pyrrhocorax* were sporadically found and each taxon is represented by only one fossil remain (Petronio et al., 2008).

In bed 8 were recovered 18 bird remains, including a distal left tibiotarsus attributed to *Aquila* sp., two distal humeri and a sub-intact left ulna referred to *Columba* sp., several fragmented distal ulnae and a proximal right carpometacarpus of Corvidae which shown the features of genus *Pyrrhocorax*, but not attributable to species level, and a sub-intact left humerus, posterior phalanx, proximal and distal tibiotarsus and tarsometatarsus belonging to *P. pyrrhocorax*.

4.3.3. Amphibians and Reptiles

The fossil remains of amphibians and reptiles of bed 8, *Bufo bufo*, *Bufotes* gr. *B. viridis*, *Hyla* gr. *H. arborea*, *Testudo hermanni*, *Podarcis* sp., Serpentes indet., are studied together with the small mammals in Kotsakis et al. (in press). Bed 8 differs from the underlying beds by the abundant fragments of non-classifiable anurans.

5. LITHIC ARTEFACTS

In bed 8, a retouched hypermicro flake (< 2 cm) was found with simple and inverse retouching on the left side, faceted convex platform (Fig. 4). The artefact presents, on the right side, a recent detachment with glossy patina. Similar glossy patina, subsequent the production of the instrument, is present in the detachment of the retouching. The silex is of medium quality, with a light superficial usury patina. It is yellowish light brown in colour, 2.5 Y 6/4 according to the Munsell Soil Color Charts (Munsell Color Company, 1994); with a height of 17 mm, a width of 23 mm, and a thickness of 4 mm.

The evidence of a double patina suggests a reuse of the object after the production and its first use. The presence of the prepared platform and the retouching are not discriminant for a chronological attribution, moreover it is conceivable to date the object between the end of the Lower and the Middle Palaeolithic, very close to the Mousterian lithic industry. Similar artefacts are present also in the Upper Palaeolithic levels of the archaeological sites.

In addition to the one described above, a single Mousterian lithic artefact, a *déjeté* side-scraper, was also found in the bed 6 (Petronio et al., 2008).

6. DISCUSSION

6.1. Deposition of bed 8 and of the bone accumulation

Regarding the genesis of bed 8, the previous and recent observations made on the structure of the uppermost bed of the karst cavity filling, on the deposit sediments, on the physical status and spatial disposition of the fossil bones, suggest that water has been the main, if not the only one, depositional factor also for this bed.

In bed 8, there is a high percentage of damaged and concreted bone remains. Many bones are fractured, but no clear evidences of human activity and of gnaw-marks by carnivores have been identified.

In the underlying beds many bones are complete, some of them articulated, particularly those of *B. primigenius* from bed 2, 5 and 7, without clear signs of transport suggesting that they were probably deposited rapidly during a short time span by exceptional events, resulting in the rapid incorporation of carcasses and isolated vertebrate remains in the karst cavity (Petronio et al., 2008; Pandolfi et al., 2013a). Clear signs of gnaw-marks by carnivores are very rare, as well as cut-marks or other traces of human activity (Petronio et al., 2008).

The lithic artefact recovered in bed 8, as well as

the one found in bed 6 (Petronio et al., 2008), was probably transported by water and suggests the frequentation of humans in the surrounding of the area, but without an active role in the deposition. Mousterian lithic industries have been found in many Palaeolithic archaeological sites of Apulia (Palma di Cesnola, 2001). Only on the Ionic side of the region, can one recall Grotta di Uluzzo C (Borzatti von Löwerstern & Magaldi, 1969), Grotta di Capelvenere (Giusti, 1980), Grotta di Serra Cicora (Campetti, 1986), Grotta del Cavallo (Sarti & Martini, 2008) and Grotta Bernardini (Carmignani & Romagnoli, 2017) around Nardò, and Riparo dell'Oscurusciuto near Ginosa (Boscato et al., 2011); a few Mousterian stone tool are also reported at Cava Spagnuolo near Grottaglie (Mecozzi et al., 2018).

The result of population analyses of some representative mammal species from bed 8 does not show a precise time interval for the deposition of the bone remains. The wolves are all adults, the young of *S. scrofa* show ages of three months and one year, those of *C. elaphus* and *D. dama* around 8 and 20 months and, finally, the young of *B. primigenius* have an estimated age of 1, 4-5 and 6-8 months old. In wild boar the births occur during spring, in red deer the births usually occur in late spring or early summer, in fallow deer the births occur usually from late May to early June, and the aurochs calves were presumably born in spring, as in the majority of modern free-range domestic cattle (Hopf, 1979; Feldhamer et al., 1988; Nowak & Paradiso, 1991; Patent, 1993; Boitani et al., 2003). Thus, the age of death particularly of young animals suggests that these bones have been accumulated throughout all the year.

Instead, in some underlying beds, and particularly in beds 5 and 7, the age of young animals pinpoints the time of death between late autumn and winter. In these beds, the young of *C. elaphus* and *D. dama* have an estimated age around 8 or younger than 24 months old, and the vast majority of *B. primigenius* individuals show an age around 6, 18 and 30 months (Pandolfi et al., 2013a).

New observations on the preservation of the bone remains and population analyses tend to confirm that bed 8 was probably deposited over a long time span, with frequently stagnant water (Pandolfi et al., 2013a), also suggested by the occurrences of *A. italicus* and several species of Anura (Kotsakis et al., in press) and the presence of many calcareous concretions on the fossil bones.

Except for very few specimens in bed 2, concreted bones appear in bed 6, increase in number and percentage in bed 7 and are the majority of large mammal remains in bed 8 (Fig. 2). Probably there was a good drainage of water in the cavity up to a certain level. Then, after the catastrophic event of bed 5, from bed 6 water began to stagnate on the surface of the deposit. At the time of deposition of bed 8, a puddle of water or a pond was likely at the top of the cavity filling. Any downpours would have transported animal carcasses and scattered bones, allowing them to accumulate in the pond, or puddle of water, at the top of the karst cavity filling.

As for the high percentage of carnivore remains,

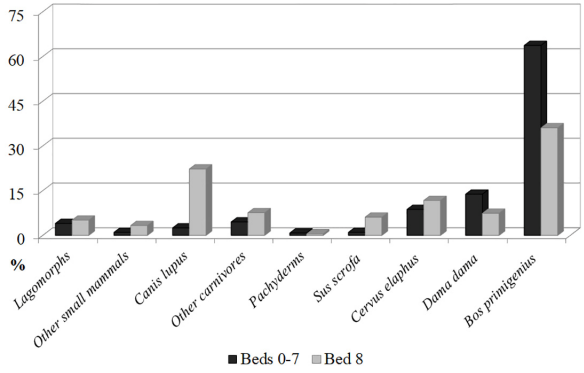


Fig. 5 - Avetrana (southern Italy), Late Pleistocene: percentage changes of mammal fossils (NISP).

above all of wolf, in the bed 8, Pandolfi et al. (2013a) supposed that may be due to the presence of dens and/or to the common attendance in the area of this canid, or that the cavity worked like a trap. The non-appearance of obvious gnaw-marks on the bones together with the absence of coprolites and of cub remains of wolf and spotted hyena (although absence of evidence is not evidence of absence) tend to exclude that this part of cavity was utilized as den by the large carnivores (see Sutcliffe, 1970; Egeland et al., 2008; Yravedra et al., 2011, 2012). In fact, the very few remains of young carnivores belong to medium-small size species, such as wild cat and fox, which do not accumulate bones of large herbivores. Therefore, the role of a natural trap of the residual cavity, where the carnivores, especially physically adult wolves, but not experienced yet, could have been attracted by the presence of animal carcasses, seems to be the most likely hypothesis.

6.2. Palaeoenvironmental considerations

The faunal assemblages recovered from the sequence provide useful information on the evolution of the environment in response to climate changes.

The bird and small mammal remains from the two fissures, or pockets, at the bottom (bed 0), if these were not filled only by small osteological materials which could pass through the small karstic fissures, suggest the presence of a poorly forested environment characterized by ample spaces with the presence of rocky outcrops. This aspect is indicated by the occurrence of *M. (T.) savii*, *H. vinogradovi*, and the lagomorphs and particularly by the avifauna. In fact, the fossil remains of birds found in bed 0 belong to a few species linked to an open environment with rocky outcrops. *Columba livia* prefers rocky environments and sea-cliffs, and avoids areas of tall and dense vegetation (Gibbs et al., 2001), *P. perdix* inhabits steppe regions and open areas in temperate zone, and *P. graculus*, the most abundant bird after *C. livia*, attends high-altitude mountain pastures with rocky ravines and cliff faces (BirdLife International, 2018). The recent distribution range of this corvid today includes the Alpine arc and the central and northern Apennine (BirdLife International, 2018), however in Corsica it goes down to sea-cliffs (Louchart, 2002). The occurrence of *P. graculus*, rather than indicating mo-

ments of climatic deterioration, would testify to the presence of rocky outcrops in the surrounding of the site or of crags in the near coast (today a few kilometres from Avetrana).

Regarding the beds 1-7, the ecological requirements of the large mammals allow reconstruction of the palaeoenvironment around Avetrana during the early Late Pleistocene. The climate was probably characterized by temperate-warm conditions, with dominance of woodland with different vegetation that suggests the occurrence of rainy winters and dry summers (Pandolfi et al., 2013a). The great quantity of aurochs, the presence of fallow deer more abundant than red deer (Fig. 5), and scarce rhinoceros, suggest a landscape with large wooded areas, rich in glades or localised open spaces (or diffuse Mediterranean scrub); wild boar and hippopotamus (less than 2%) suggest the presence of more water bodies than today (Petronio et al., 2008; Pandolfi et al., 2013a). In this phase, peak maximum vegetation cover can be recorded in bed 7 (maximum frequency of cervids; Pandolfi et al., 2013a, table 4) and bed 5 (occurrence of *Capreolus capreolus*).

The faunal assemblage from bed 8 consists of the same herbivores of the underlying layers, but the aurochs decrease, wild boar increase, red deer is more numerous than the fallow deer (Fig. 5) and lacks the hippopotamus (Tabs 1-2). There are also abundant wolves, and among the small rodents, *M. (M.) arvalis* appears (Kotsakis et al., in press).

The increase of *S. scrofa* up to 6.7%, widely compensating the absence of the hippopotamus, suggests more water bodies than the underlying beds, as attested also by the abundance of water vole and frogs (Kotsakis et al., in press). The largest percentage of *C. elaphus* compared to *D. dama* seems to indicate an environment with forests alternating with glades, but with less warm climate than in the beds 2-7. The common vole, *M. (M.) arvalis*, is a typical rodent of open areas with poor herbaceous cover, and it currently occurs in continental Europe and northern Italy (Paolucci & Amori, 2008), but it is relatively frequent in the fossil mammal assemblages since the late Middle Pleistocene also in central and southern Italy, except for the last interglacial and the late Holocene (Kotsakis et al., 2003, in press; Kotsakis, 2008; Salari, 2014).

These evidences, along with the above observations on the genesis of the bed 8, suggest a climate deterioration and an environment somewhat similar, but with more water bodies, and likely wider open spaces (also indicated by lagomorphs), than that suggested by the mammal assemblages from the underlying beds. Palaeoenvironmental indications are generally compliant with those derived from the study of small vertebrates (Kotsakis et al., in press), which suggest the presence of a coastal plain with marshes bordered by wooded areas, open spaces and with rocky coastal areas nearby.

6.3. Biochronological implications

So far, the entire mammal assemblage of the stratified deposit from Avetrana was referred to Melpignano Faunal Unit and related it to the early Late Pleistocene, MIS 5, or restricted to MIS 5e, on the basis of palaeoenviromental and biochronological considerations (Petronio et al., 2008; Pandolfi et al., 2013a). In particular, these authors have pointed out the occurrence in the site of the modern forms of *C. elaphus* and *D. dama*, that occur for the first time in Italy at the beginning of the Late Pleistocene (Petronio et al., 2007, 2011), of *H. amphibius* and *H. vinogradovi*, that occur for the first time in Western Europe in the Middle Pleistocene and are relatively frequent during MIS 5 to become then progressively rarer in MIS 4 and MIS 3, until their extinction (Salari & Sardella, 2009, 2011; Pandolfi and Petronio, 2015), and the large size of long bones of *B. primigenius*. In fact, this species occurs for the first time in Southern Europe in the Middle Pleistocene with small-sized specimens, tends to increase in body size during the late Middle and early Late Pleistocene and then decreases in body size during the second part of the Late Pleistocene and in the Holocene (Pandolfi et al., 2011, 2013a). For the chronological attribution, Pandolfi et al. (2013a, with references and discussion) made additional comparisons with pollen diagrams of central and southern Italy (e.g., Follieri et al., 1995), with sapropel levels recorded in the marine stratigraphy of Mediterranean basin, and in particular with the sapropel levels S5, S4 and S3 that mark the warm peaks of MIS 5 (5e, 5c and 5a respectively) in the western Mediterranean Sea (e.g., Capotondi & Vigliotti, 1999), and with other early Late Pleistocene sites (or parts of stratigraphic sequences) of Apulia, such as Cava Nuzzo, San Sidero 3, Grotta del Cavallo, Grotta di Uluzzo C, Grotta delle Striare, Grotta del Sarcofago etc.

The biochronology of micromammals also support these chronological indications. Indeed, all the species found in the Avetrana karst filling first appear in Italy since the Middle Pleistocene, except for *A. italicus* and *C. suaveolens*, recorded only since the Late Pleistocene (Kotsakis et al., 2003, in press; Kotsakis, 2008; Gatta et al., 2019).

In bed 8, the large mammals are almost the same to the underlying beds (Tab. 1), but with a very high percentage of carnivore remains (Fig. 5) and with significant variations in percentage and/or in body size, particularly for the wolf. Moreover, among the cervids, the red deer is more abundant than the fallow deer.

According to Bertè & Pandolfi (2014) the relatively great size of the wolf from Avetrana bed 8 suggest a new dispersal event of *C. lupus* in Italy (the so-called "glacial wolves" in Mecozzi & Bartolini Lucenti, 2018, or the "Würmian wolves" *Auctorum*), rather than a local adaptation or a body size increase due to climate changes. The dimensions clearly separate them from the older small-sized wolves from Melpignano area, Grotta Romanelli and Ingarano (the so-called "Apulian wolves"; Sardella et. al., 2014). Maybe it is no coincidence that the body length and body mass of the wolf from the underlying beds 5 and 6 of Avetrana are smaller than that of bed 8. Indeed, body length and body mass of the wolf from beds 5 and 6 are close to the medium values of *C. lupus* from San Sidero 3 (De Giuli 1983; Salari et al. 2017), referred to MIS 5e (Conti et al., 2010; Masini & Sala, 2011), that seems to prelude to the following re-

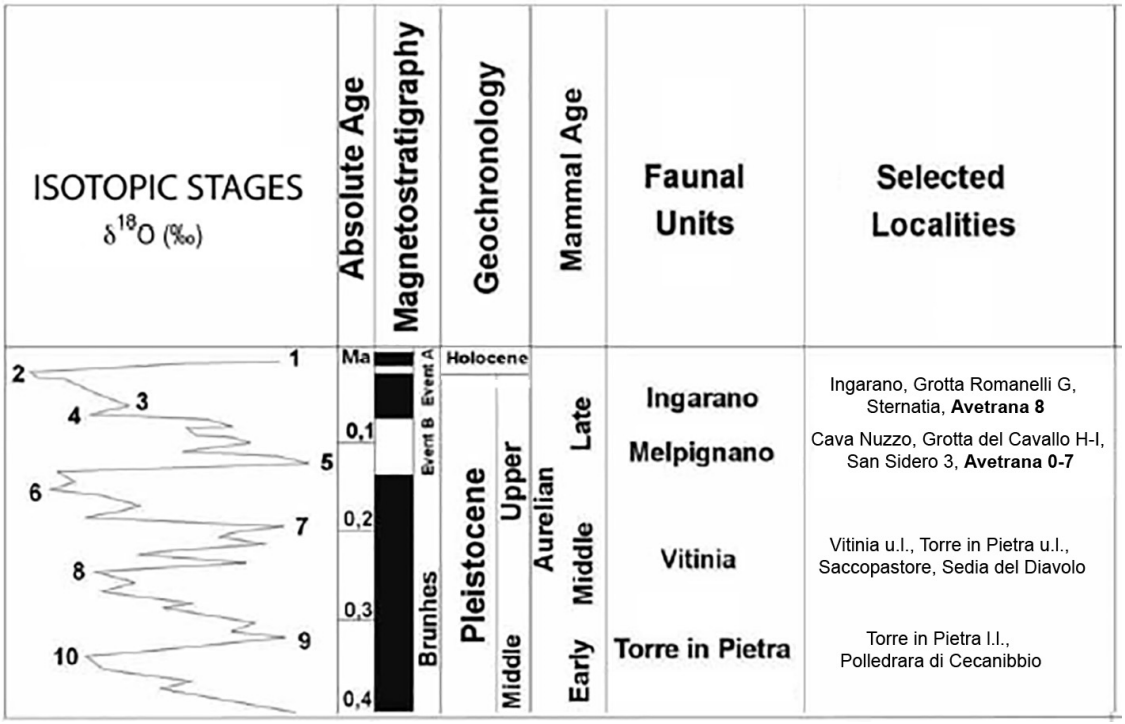


Fig. 6 - Approximate position of the two mammal assemblages from Avetrana karst filling in relation to the biochronological scheme for the Aurelian Mammal Age (late Middle to Late Pleistocene).

duction in size of the aforementioned so-called “Apulian wolves”, between MIS 5c-a and MIS 3 (Bertè and Pandolfi, 2014; Sardella et al., 2014; Salari et al., 2017).

Furthermore, among the small rodents *M. (T.) savii* persist and *M. (M.) arvalis* occurs (Pandolfi et al., 2013a; Kotsakis et al., in press), and among the pachyderms *H. amphibius* lack while *S. hemitoechus* persists (Tabs 1 - 2). As mentioned above, *M. (M.) arvalis* occurs in Italy since the late Middle Pleistocene, only being absent in central and southern part of the Peninsula during the last interglacial and the late Holocene, and is currently found only in northern Italy where it is abundant in the fossil record (Kotsakis et al., 2003, in press; Kotsakis, 2008; Paolucci & Amori, 2008; Salari, 2014). On the other hand, the steppe rhinoceros, *S. hemitoechus*, occurs in Italy since MIS 13 (Pandolfi et al., 2013b; Pandolfi & Marra, 2015; Pandolfi & Tagliacozzo, 2015) and it was present at least until 41 ka cal. BP, MIS 3 (Pandolfi et al., 2017b).

The great size of wolf, the red deer more numerous than the fallow deer, together to the aforementioned considerations on the palaeoenvironment reconstruction and, above all, the concomitant occurrence of *M. (M.) arvalis* and *S. hemitoechus* suggest that the mammal assemblage from bed 8 of the Avetrana karst filling is younger in age than that of the beds below, and can be referred to an undefined time span between the first climatic deterioration of the last glacial period and the early MIS 3, and it is attributable to the Ingarano Faunal Unit (Fig. 6).

7. CONCLUSIONS

The population analyses of some representative mammal species and the remarks on the preservation of the bone remains showed that bed 8, at the top of the sequence of the stratified fossiliferous deposit from La Grave near Avetrana (Apulia, Italy), displays features indicating its origination in sedimentary, climatic and environmental conditions quite different from those of underlying beds.

The sedimentological characteristics, the physical status and the spatial disposition of the fossil bones of bed 8, suggest the presence of abundant water in the highest part of the sub-vertical karst cavity and in the surrounding of the site, at the time of its deposition. Stagnant water did not promote a good bone remains conservation and many calcareous concretions are observed on the bone surfaces. The abundance of stagnant water is also showed by the occurrence of numerous fossil remains of several species of Anura and of *Arvicola italicus*.

The ecological features and the percentage ratios of mammal species found in the bed 8, indicate a moment of climate deterioration and an environment somewhat similar, but with more water bodies, and likely wider open spaces, than that suggested by the mammal assemblages from the underlying beds.

Most of the stratified karst filling (up to bed 7) and its mammal assemblages can be attributed to the early Late Pleistocene, MIS 5e, Melpignano Faunal Unit. However, significant variations in percentage and/or in body size of some species (particularly *Canis lupus*) and

the concomitant occurrence of *Stephanorhinus hemitoechus* and *Microtus (Microtus) arvalis* suggest that the mammal assemblage from bed 8 is younger in age than that of underlying beds, even if it is not possible to identify, at the moment, a precise time interval, presumably between the onset of the last glacial period and the early MIS 3. Therefore, the mammal assemblage of bed 8 can be referred to the Ingarano Faunal Unit.

The high percentage of wolf in the bed 8, indicate that the residual cavity probably worked like a trap for adult wolves, attracted by the presence of animal carcasses. Finally, the lithic artefacts recovered in bed 8 and in bed 6 only testify the attendance of Neanderthal humans in the surrounding of La Grave at Avetrana.

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