The Late Pleistocene mammal fauna from Montemerano - Manciano (Grosseto, central Italy)

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Abstract

The Late Pleistocene mammal fauna from Montemerano – Manciano (Grosseto, central Italy) – *Several fossil mammal remains have been recovered in a karst cavity near Montemerano (Manciano, Grosseto, Central Italy). The cavity was developed in the upper travertine deposits outcropping in the area and chronologically referred to a time span between the late Middle and the Late Pleistocene. The paleontological analysis of the mammal remains allows to recognize different taxa as* Panthera spelaea, Canis lupus, Stephanorhinus *cf.* S. hemitoechus, Equus ferus, Sus scrofa, Bison *sp.,* Bos primigenius, Megaloceros giganteus, Cervus elaphus, Dama dama *and some coprolites of Hyaenidae. However, only the occurrence of an evolved form of* Dama dama *in the assemblage provides useful biochronological information. The fallow deer is represented by several remains, in particular by a fragmentary mandible with the molars. The mandible shows morphological and morphometrical features closer to the Late Pleistocene populations of the fallow deer than to the archaic* Dama clactoniana *and* D. dama tiberina. *The evolved forms of the fallow deer were typical and abundant during the early Late Pleistocene. Nevertheless, they were very rare during the late Late Pleistocene and became extinct in Italy during the Last Glacial Maximum, probably due to the climate changes. Finally, a preliminary analysis of the sediment including the mammal remains shows a significant decrease of the volcanic elements coming from the Vulsino Volcanic District (VVD). This character can be related with the end of the VVD activity and can be chronologically referred to an age younger than the Middle-Late Pleistocene transition. This result is in accordance with the biochronological time span obtained from the paleontological analysis.*
***Key words**: Mammal fauna,* Dama dama, *Late Pleistocene, Manciano, central Italy.*

Riassunto

La fauna a mammiferi del Pleistocene Superiore di Montemerano – Manciano (Grosseto, Italia centrale) – L'analisi dei resti di una mammalofauna rinvenuta in una cavità carsica nella parte più superficiale di una Formazione di Travertino nei pressi di Montemerano (Manciano, Grosseto, Italia centrale), attraverso l'analisi biocronologica, consente di restringere l'intervallo cronologico dato dalla sola indagine geo-petrografica. L'età di tale formazione di travertini è infatti controversa, ma comunque compresa fra il Pleistocene Medio e il Pleistocene Superiore. Lo studio dei resti ossei e dentari di *Panthera spelaea*, *Canis lupus*, *Equus ferus*, *Sus scrofa*, *Bison* sp., *Bos primigenius*, *Megaloceros giganteus*, *Cervus elaphus* e alcuni coproliti di Hyaenidae, non dà più precise e/o ristrette indicazioni temporali, ad eccezione di *Dama dama*. In particolare la morfologia di una porzione mandibolare e dei molari permette di escludere l'attribuzione alle forme di *Dama* diffuse nel Pleistocene medio, quali *Dama clactoniana* e *D. dama tiberina*. La forma moderna di daino è tipica delle associazioni faunistiche della prima parte del Pleistocene superiore, dove spesso è uno degli elementi più abbondanti; esso diventa sempre più raro nella seconda parte del Pleistocene superiore, risentendo più di altre forme degli avvicendamenti climatici di questo periodo, fino a scomparire del tutto. L'osservazione preliminare della matrice arenacea inglobante i resti fossili evidenzia del resto un particolare impoverimento della componente vulcanica proveniente dal distretto Vulsino. Tale caratteristica rafforza il quadro stratigrafico emerso dai dati paleontologici relativi al genere *Dama* collocando il deposito in un range di età ≤120 ka.
Parole chiave: Mammiferi, *Dama dama*, Pleistocene superiore, Manciano, Italia centrale.

Introduction

Back in the '70s, some mammal fossil remains from the travertine quarry "Saturnia" in Montemerano, near the town of Manciano (Grosseto, central Italy) (Fig. 1), have been delivered to the Paleontological Museum of the "Sapienza" University of Rome. The faunal remains were found in yellowish arenaceus sediments sometimes hardly cemented, and they constituted in many postcranial bones, often fragmented, without any anatomical connection. The arenaceus deposit arises from the percolation of superficial water rich in carbonate into the karst cavities originated in the compact travertine which occurs in the area (Fig. 2). The bone remains have been dragged by the water and fossilized in such karst cavities originated in the more superficial part of the travertine.

According to some Authors (Martelli et al., 1989; Bosi et al., 1996, Zanchi and Tozzi, 2001), the travertines in the Montemerano-Manciano area have been deposited in a time span from the Messinan (Tr5) to the early Late Pleistocene (Tr1). Bosi et al. (1996) particularly studied the structural and depositional pattern of the oldest travertines (Tr3 and Tr4 laying on a Pliocene substrate and Tr5 laying directly on a Messinian one) and the deposition of the more recent travertines (Tr1 e Tr2) occurring on some Pleistocene terraces of different order. In particular, according to Bosi et al., (1996), the travertine terraces near Montemerano are defined as Tr2 and could be referable to the late Middle Pleistocene or, at the latest, to the early Late Pleistocene. This interval also corresponds to the largest spreading of the volcanic materials from the Vulsine. As previously mentioned, the most superficial and fractured part of travertine Tr2 from Montemerano is characterized by the excavation of karst funnel-like cavities which were filled in a second time by an arenaceus deposit lacking of volcanic materials. The bone remains studied in this paper were collected by workers from one of these cavities, at present day destroyed by the work of the quarry.

The biochronological analysis of the taxa collected and of the whole faunal association could help to define better the time of the deposition of the travertine but also to draw a paleoenviromental sketch of the area.

Material and methods

All the studied specimens are stored at Museum of Palaeontology, Sapienza, University of Rome (MPUR). The specimens of wolf, horse, wild boar, auroch, red deer and fallow deer are dimensionally compared with those collected from several late Middle and Late Pleistocene Italian and Southern European localities to investigate the size variations of the species.

Fig. 1. Site location.

The remains of wolf are dimensionally compared with the specimens stored at MPUR and collected at Melpignano-S. Sidero (Apulia, early Late Pleistocene; Petronio et al., 1994) and Ingarano (Apulia, MIS4; Petronio and Sardella, 1998), with the data given by Boudadi-Maligne (2010, 2012) for the latest Middle and Late Pleistocene localities of Juarens, La Fage, Aven de l'Arquet and Coudoulous I (France), and with the specimens collected at Grotta Mora Cavorso (Latium, MIS 2; Salari et al., 2011 and unpublished data) and Grotta Sant'Agostino (Latium, MIS4-3; Tozzi, 1970).

The measures of the horse remains were compared with the corresponding average size of Middle and Late Pleistocene horses from Central-Southern Italy (see Conti et al., 2010). The osteometric measures were taken according to the methods proposed by Eisenmann (1980, 1986); the estimate of the withers height was performed by multiplying the lengths of metacarpal and metatarsal bones for the coefficients indicated by Eisenmann (2003), while the estimate of the weight was calculated from the width of the distal metacarpal, according to the methodology proposed by Eisenmann and Sondaar (1998); comparison data of central-south-

Fig. 2. Saturnia quarry from Montemerano-Manciano at present days. a) arenaceus level with decomposing travertine blocks; b) travertine compact level.

ern Italy *E. ferus* were made available by the Dot.ssa Conti, whom we thank, those of the Przewalski horse are taken from Eisenmann (1986) and those of the Tarpan are taken from the site www.vera-eisenmann.com (LG521VE and LG521).

The remains of the wild boar are dimensionally compared with the specimens from Taubach (Thuringia, early Late Pleistocene) given by Hünermann (1977), Orgnac 3 (Ardèche, late Middle Pleistocene) given by Aouraghe (1992), form Italian and European Holocene localities given by Tagliacozzo (1993, 2000) and Albarella et al. (2009) and from the dimensional range given by Guérin and Faure (1997).

The metapodial bones of auroch from Manciano are dimensionally compared with the specimens from Avetrana (Apulia, early Late Pleistocene), Via Aurelia (Rome, late Middle Pleistocene) and Romanelli (Apulia, late Late Pleistocene) reported by Pandolfi et al. (2011), Barche and S.M. Selva (Holocene) reported by Wilkens (1987) and Riedel (1976), from Lunel-Viel (late Middle Pleistocene) given by Brugal (1984) and from Holocene of Denmark given by Degerbol and Fredskild (1970) and Burgarchisee (Switzerland) given by Cerilli and Petronio (1992).

The remains of red deer are dimensionally compared with the specimens of *Cervus elaphus* ssp. from Avetrana and Ingarano stored at MPUR (Apulia, Late Pleistocene; Petronio et al., 2008; Pandolfi et al., 2013), from Romanelli (Southern Italy, late Late Pleistocene) and Sora (Central Italy, Late Pleistocene) stored at Museo Nazionale Preistorico Etnografico Luigi Pigorini (Rome), Parignana (Central Italy, late Late Pleistocene, given by Caterini, 1921). Finally they are compared with the specimens of *C. elaphus rianensis* from Riano (Central Italy, late Middle Pleistocene; data from Leonardi and Petronio 1974) and *C. elaphus aretinus* from Val di Chiana (Central Italy, late Middle Pleistocene; unpublished data Di Stefano and Petronio).

The remains of fallow deer are dimensionally compared with the specimens of *Dama dama dama* from Romanelli,

Melpignano and Cucigliana (data from Di Stefano,1994) and with *D. dama tiberina* from Vitinia, Grays Thurrock and Tiber River deposits (data from Di Stefano, 1994).

Abbreviations: M = molar; N = number of specimens; BL = buccal length; B = maximal breadth; L = maximal length; PTD = proximal transverse diameter; PAPD = proximal antero-posterior diameter; DTD = distal transverse diameter; DTDaa = distal transverse diameter above the distal articular surface; DAPD = distal antero-posterior diameter.

Analisys of the fossil remains

The fossil remains from Montemerano are rather well preserved and are almost completely covered by more or less cemented sands. The distal epiphysis of deer femur, show signs of carnivore teeth. Some coprolites testify the presence of hyena in the area. Furthermore, some bone specimens show signs of gnawing in the articulation areas probably attesting the activity of the hyena.

However, the general status of the remains allows to exclude that hyenas played some rule in the accumulation of the bones.

The taxa recognized are the following:
Erinaceus europaeus
Lepus cf. *L. europaeus*
Canis lupus
Panthera spelaea
Stephanorhinus cf. *S. hemitoechus*
Equus ferus
Sus scrofa
Bison sp.
Bos primigenius
Megaloceros giganteus
Cervus elaphus
Capreolus capreolus
Dama dama

Erinaceus europaeus (Fig. 3, 7)

The presence of the western hedgehog is shown by a short and strong humerus (MPUR 5/2; L = 46,28 mm, DTD = 12,77 mm), and a left hemimandible with I_1, P_4 and M_2 (MPUR 5/1). The hemimandible is short and strong, the ascending ramus has high and narrow coronoid apophysis slightly tilted backwards, broad and transversely flattened articular condylus and strong angular apophysis.

Lepus cf. *europaeus* (Fig. 3, 8)

The hare is represented by a distal portion of femur (MPUR 5/4; DTD = 20,62 mm) and a complete femur (MPUR 5/3; L = 127,80 mm, DTD = 19,41 mm) with the trochanter majus projected beyond the articulation and the third trochanter very pronounced and proximally more advanced. Due to the relatively large size, the remains can be referred to *Lepus* cf. *europaeus*: the ratio of the maximum length and the distal transverse diameter (*Lepus europaeus*: range L = 121.6 - 140.0 mm, range DTD = 19.2 - 20.5 mm; *Lepus timidus*: range L = 117.8 - 134.0 mm, range DTD = 16.9 - 18.3 mm; date from De Marfà, 2009; Miracle and Brajković, 2010; but the data of *Lepus corsicanus* are still scarce, see Trocchi and Riga, 2001) does not allow a reliable taxonomic attribution.

Canis lupus

The wolf is represented by an anterior portion of left hemimandible with the damaged canine and the premolars (MPUR 5/40) and by a fragment of upper M1/ with the metacone and paracone (MPUR 5/5). The hemimandible is in a bad state of preservation and the scarce morphometric data are not useful for a biochronological purpose. P/4 (L = 16.50 mm) is slightly longer than those from La Fage (L = 14.2-16.2) and Coudoulous I (L = 14.8-16.3) and falls into the range of the specimens from l'Arquet (L = 14.2-18) and Juarens (L = 14.8-17.6): data from Boudadi-Maligne (2010, 2012). The buccal length of the upper M1/ (BL = 16.40 mm) falls into the range variation of the specimens from Jaurens (BL = 16-17.5 mm) and from Aven de l'Arquet (BL = 14.7-17.9 mm), data from Boudadi-Maligne (2010). It is longer than the specimens from Melpignano-San Sidero (N = 5, range BL = 13-14.1 mm), Ingarano (N = 4, range BL = 14.7-15 mm), La Fage (BL = 14.4-15.4 mm;) and Coudoulous I (BL = 13.8-14.8 mm) (data from Boudadi-Maligne, 2010, 2012). Finally, the specimen from Manciano is slightly shorter than those from Central Italian localities chronologically related with MIS3 and MIS2 (Grotta Mora Cavorso and Grotta Sant'Agostino).

Panthera spelaea (Fig. 3, 6)

Only an upper right carnassial tooth (P4) (MPUR 5/41), about 40 mm long, lacking or with slightly developed small cingular preparastyle, large parastyle, and protocone bulge with small protocone cusp, can be attributed to the Pleistocene lion. The tooth is partially covered by calcareous crust and other morphometric values cannot be considered.

Stephanorhinus cf. *S. hemitoechus* (Fig. 3, 9)

The rhinoceros is represented by three complete upper deciduous teeth; one D3/ (MPUR 5/16),one D4/

Fig. 3. *Megaloceros giganteus*: 1a), 1b) metatarsus; *Cervus elaphus*: 2a), 2b) metatarsus; *Bos primigenius*: 3) metatarsus; *Bison* sp.: 4) metatarsus; *Dama dama*: 5a) metatarsus; 5b) mandible; *Panthera spelaea*: 6) upper carnassial; *Erinaceus europaeus*: 7) mandible; *Lepus* cf. *L. europaeus*: 8) femur; *Stephanorhinus* cf. *S. hemitoechus*: 9) upper molar; *Equus ferus*: 10a) first phalanx; 10b) metacarpus; 10c) metatarsus.

(MPUR 5/17), one P3/ (MPUR 5/15) a fragment of an upper molar (probably M1/, MPUR 5/18) and a fragment of an upper tooth (MPUR 5/19). D3/ and D/4 are relatively worn and are rather morphologically similar; the crochet is single and well developed; crista and antecrochet are absent, a strong mesial cingulum is present. The profile of the vestibular wall is wavy; in D3/ the paracone fold is marked and in D4/ it is slightly wider than in D3/.

From a morphological point of view, the teeth are closer to the genus *Stephanorhinus* than to *Coeolodonta*. The profile of the vestibular wall in the two deciduous is morphologically closer to *S. hemitoechus* than to *S. kirchbergensis* in which the paracone fold appears wider and less marked (Guérin, 1980). The absence of crista in the deciduous of *S. hemitoechus* is reported by Guérin (1980) and it is also recognized in the two D4/ from Ingarano. P3/ has a small but marked paracone fold; the parastyle fold is deep and the metacone fold is weak, a strong cingulum occurs in the mesial seide of the tooth, a weak lingual cingulum is also present. Antecrochet and crochet are absent, the crista is double and well developed. The tooth is morphologically closer to *S. hemitoechus*; in *S. kirchbergensis* the profile of the vestibular wall is slightly convex without a marked fold and the crochet is always present (Guérin, 1980). The dimensions of the above-mentioned teeth are not useful to distinguish among the Pleistocene species (Guérin, 1980; Lacombat, 2005). The dimensions of the D4/ (L = 52; B = 54.4) are close to the maximal values given by Guérin (1980) from *S. hemitoechus* (L = 44-51.5; B = 41-56).

Equus ferus (Fig. 3, 10a, b, c)

The horse is the most abundant species in the Montemerano-Manciano fauna and it is represented by two upper molars (MPUR 5/53 and 5/54), one deciduous tooth (MPUR 5/48), one complete third metacarpus (MPUR 5/52), three proximal (MPUR 5/9, 5/10 and 5/11) and two distal portions (MPUR 5/8 and 5/51) of third metacarpus, one femur lacking the proximal epiphysis (MPUR 5/12), one complete third metatarsus (MPUR 5/49), three proximal parts (MPUR 5/44, 5/46, 5/47) and one diaphysis (MPUR 5/45) of third metatarsus and two complete (MPUR 5/13 and 5/14) and a proximal fragment (MPUR 5/50) of first phalanx. These remains can be referred at least to four individuals.

Both molars clearly show the plis caballin and long protocones (protocone index: M1/2 = 50.2; M3 = 51.5). The third metacarpus is medium-small sized, it has large proximal articulation, but the anterior articular facet for fourth os carpale (unciform) is reduced; it has a relatively large distal articulation considering the supra-articular breadth and, above all, the distal articular breadth. The third metatarsus is medium sized, both the epiphyses are slender, but the proximal articulation shows a relatively large articular facet for the fourth tarsal bone (cuboid). These features are close to the Tarpan and the Cardamone and Tana delle Iene horses. The estimated withers height (equation used in Eisenmann, 2003) is 142.2 cm, and the estimated body weight (equation used in Eisenmann and Sondaar, 1998) is 456.2 Kg. These measurements are close to those of the Late Pleistocene horses from Tana delle Iene, Cardamone and Melpignano, but they are smaller than those of the "gigantic horses" (*sensu* Eisenmann, 2003) from S. Sidero 3 and S. Sidero 6, and those of the late Middle Pleistocene horses from Torre in Pietra (Fig. 4) (see Conti et al., 2010).

Sus scrofa

A fragmentary hemimandible can be attributed to the wild boar (MPUR 5/42). The toothrow lacks of the third lower molar and the triangular section of the canine allows to refer the specimens to a male. The morphology of the molars and premolars cannot be observed because the fossilization of the specimens. The length and the breadth of the first (LM/1 = approx. 18 mm) and second lower molars (LM/2 = 25.05 mm; BM/2 = approx. 17) fall into the dimensional range of the Late Pleistocene wild boar from Taubach (LM/1 = 15-18, BM/1 = 12-12.8; LM/2 =22-25, BM/2 =16.6-18) and Orgnac 3 (LM/2 = 24-26.6) (Hünermann, 1977; Aouraghe, 1992), In addition, the length of the M/1 falls into the range of the early Middle and late Middle-Late Pleistocene wild boar given by Guérin and Faure (1997). Finally, the Manciano specimens are larger than those collected in the latest Late Pleistocene and Holocene localities (e.g. Grotta della Madonna, Praia; Tagliacozzo, 1993, 200; Albarella et al., 2009).

Bison sp. (Fig. 3, 4)

One distal epiphysis of a metatarsus can be referred to the bison. The value of the transverse diameter of distal articular surface (DTD = 59.68 mm) does not exceeded the values of the maximum transverse diameter taken above the distal articulation (DTDaa = 59.21 mm). This character is useful to distinguish between the bison and the auroch (see Sala, 1986). However, the morphometrical values of the metatarsus from Montemerano are smaller than those of late Middle and Late Pleistocene *Bison priscus* and those of the Middle Pleistocene *Bison schoetensacki* (see Sala, 1986; Vercoutère and Guérin, 2010). This feature allow to refer probably the specimen to a female individual.

Bos primigenius (Fig. 3, 3)

The auroch is represented by two upper molar (MPUR 5/20 and MPUR 5/21), one lower molar (MPUR 5/22), one juvenile calcaneus (MPUR 5/26), one semilunar (MPUR 5/23),one fragmentary naviculo-cuboid (MPUR 5/24), one second phalanx (MPUR 5/28), one proximal epiphysis of a metacarpus (MPUR 5/) and one distal epiphysis of metatarsus (MPUR 5/25). In dorsal view, the medial articular surface in the metacarpus has the typical quadrangular shape of the genus *Bos* (see Sala, 1986). The dimensions of the proximal epiphysis (PTD = 86.42; PAPD = 51.58) are slightly larger than those of the specimens from Avetrana (N = 14; range PTD = 65-84.10 mm, range PAPD = 42.50-50.60 mm) and are fall into the range of those from Via Aurelia (N = 5; range PTD = 70.60-89.60, range PAPD = 37.20-52). They are close to the maximal values of the females and the minimal values of the males from Lunel-Viel (range PTD males = 85-95.2, range PAPD males = 50.2-59.3; range PTD females = 69.6-88.5, range PAPD females = 41.7-54.9; data from Brugal 1984). Finally, the specimen from Manciano is larger than those from Grotta Romanelli (range PTD = 65.40-77.60, data from Tagliacozzo, 2003), Barche and S.M. Selva (range PTD = 69.9-85.6; data from Wilkens, 1987; Riedel, 1976) and is close to the maximal values of the males from Denmark (data from Degerbol and Fredskild, 1970). The value of the transverse diameter of distal articular surface exceeded the values of the maximum transverse diameter taken above the distal articulation (see Sala, 1986). Furthermore, the morphometric values of the distal epiphyses (DTD = 79.37; DAPD = 46.77) fall into the range of the females from Lunel Viel (range DTD = 70.7-81.7; range PAPD = 38.9-44.2 mm; data from Brugal, 1984) and of the specimens from Avetrana (range DTD = 74.6-95.40; range PAPD = 36.3-48.10 mm; data from Pandolfi et al., 2011). Finally, the specimens is close to the mean values of the specimens from Romanelli and the minimal values of the males from Denmark (data from Degerbol and Fredskild, 1970).

Capreolus capreolus

The roe deer is represented by one distal epiphysis of femur (MPUR 5/37; DTD = 41.20; PAPD = 53,80) and a fragmentary skull (MPUR 5/38) of a female individual. The latter specimen is well preserved and is represented by the neurocranial portion and part of the splancnocranium. The size of the specimen, the morphological features of the parietal bone and the suture angle between the parietal and the frontal bones allow to exclude the attribution to other cervid species.

Megaloceros giganteus (Fig. 3, 1a, b)

The giant deer is represented by one metatarsal bones (MPUR 5/72) lacking of the distal epiphyses. The morphometric values of the proximal epiphysis (PTD = 59.20; PAPD = 59.15) overlap those of the larger *Praemegacersos* and *Alces*.

In proximal view, the articular surface to the navicocuboid is more elongated backwards in the lateral side than in the genus *Alces*, as *M. giganteus*; furthermore, in the metatarsus from Montemerano-Manciano, the posterior articular surface with the navico-cuboid is shorter than *Alces* and *Praemegaceros* and the foramen on the proximal articular surfaces is larger and more elongated than the two above mentioned genera (see Azzaroli and Mazza, 1992, 1993; Abbazzi et al., 1999; Breda, 2005): these features are instead well represented in *M. giganteus*.

Cervus elaphus (Fig. 3, 2a, b)

The red deer is rather common in the Montemerano-Manciano faunal assemblage and it is represented by two distal epiphyses of humerus (MPUR 5/57 and 5/58) one fragmentary femur (MPUR 5/33), one femur of a young individual (MPUR 5/56), a fragment of calcaneum (MPUR 5/34), four proximal epiphysis (MPUR 5/59, 5/63, 5/65 and 5/67) and one diaphysis (MPUR 5/62) of metatarsus, one metatarsus of a young individual (MPUR 5/67), one cervical vertebra (MPUR 5/36, 5/39), a fragment of a first phalanx (MPUR 5/60), one lower deciduous tooth (MPUR 5/61), a second and third molar (MPUR 5/31 and 5/32), a fragment of maxillae with P3/ and P/4 (MPUR 5/30) and fragmented antlers (MPUR 5/29, 5/55). The antlers show the typical features of the species, with the brow tine and the bez tines just above the burr and with circular section. Furthermore, some teeth have been recovered. These latter can be referred to the same individual basing on worn status. The lower molars (M2 and M3) lack of developed entostylids (a very small entostylid can be osberved only in M3) and cingula (a poorly developed anterior cingulum is shown only by M3). The postcranial elements show morphological and morphometric features typical of the species and allow to distinguish from those of the genus *Dama* (in humerus: trochlea externally directed with a less acute angle; in metatarsus: shorter and less wide posterior articular surface with naviculo-cuboid than *Dama*, anterior articular surfaces with naviculo-cuboid and large cuneiform at about the same level) (see Di Stefano, 1995). The length and the breadth of the third lower molar (L = 31.90; B = 15.53) are comparable with those of the specimens from the Late Pleistocene

deposits of Avetrana (two specimens L = 35-35; B = 15-15,5) and Ingarano (two specimens L = 31.5-32; B = 15-16) and those from several Holocene Italian localities (see Di Stefano and Petronio 1992). They are larger than the specimens of *Cervus elaphus rianensis* from the late Middle Pleistocene of Riano (eight specimens: range L = 22.50-27.20 mm; range B = 12.90-13.20) and slightly larger or comparable with the specimens of *Cervus elaphus aretinus* from Val di Chiana (three specimens: range L = 27.80-32 mm; range B = 13.10-14). The Distal Transverse Diameter of the two humeri (DTD = 68 and 59.20 mm) are larger than the specimens from Holocene deposits (range of ten specimens: DTD = 48-58 mm) and are comparale with those of the late Middle Pleistocene *C. elaphus rianensis* and *C. elaphus aretinus* (N = 12: DTD = 55-63 mm). The proximal epiphyses of metatarsus (range PTD = 36.60-48.61 mm) are larger than the specimens from Avetrana (N = 5; range = 29-35) and Romanelli (N = 3; range PTD = 33.7-36.4) and are close to the maximal values of the specimens from Ingarano (N = 4; range PTD = 35.5-39.5) and Sora (N = 6; range PTD = 33.4-39). Finally they are also comparable with the values of the specimens from Grotta Parignana (PTD = 40-49; data from Caterini, 1921; Farina, 2009).

Dama dama (Fig. 3, 5a, b)

Some bones testify the presence of the fallow deer: one proximal epiphysis of a young (5/74) and one diaphysis (MPUR 5/70) of metatarsus, one distal epiphysis of metatarsus (MPUR 5/71), a fragmented frontal bone with pedicle, rose and broken brow tine (MPUR 5/73), one fallen antler with the brow tine brocken at the basis, a posterior tine (MPUR 5/64), one upper second molar (MPUR 5/68) and a fragmented hemimandible (MPUR 5/69). The articular surfaces of the proximal epiphysis of metatarsus clearly show the characteristics of the genus *Dama*, as the elongated surface of the articulation with the naviculo-cuboid (Di Stefano, 1995).

The specimen which allows a more precise diagnosis is the posterior part of the right hemimandible with M1-M3. The teeth are very interesting. An anterior cingulum is present only in M1 which also shows a short entostylid, unlike the other molars. The third lobe in M3 is rather small. The teeth seem rather wide, even though they are not very worn. The morphological features of the specimen allow to exclude the attribution to other *Dama*-like cervids which occur in Italy in the Pleistocene faunas: these latter, referred to the genus *Axis*, always show entostylids and cingula both in M1 and M2 (even if sometimes poorly developed) and the third lobe of M3 is almost always large and strong. The same morphological features of the teeth allow to exclude the attribution to other *Dama* species and/or subspecies occurring in the Middle Pleistocene faunal assemblages, like *D. clactoniana* and *D. dama tiberina*, see Di Stefano and Petronio, 1997. These forms, especially the first one, always show well developed entostylids and anterior cingula in the lower molars and, often, a posterior cingula especially in M1 (Di Stefano and Petronio, 1997). Therefore, all the characteristics observed allow to refer the fallow deer remains from Montemerano-Manciano to *D. dama dama*.

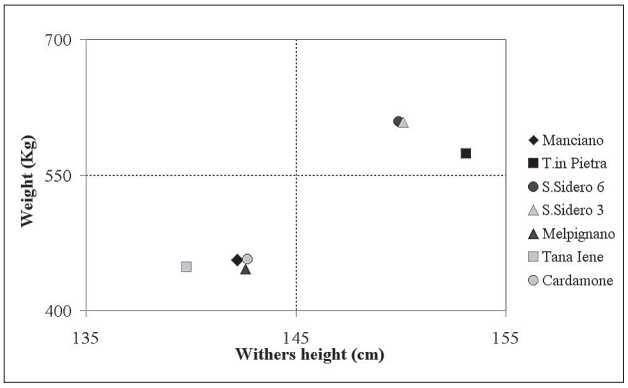

Fig. 4. Scattergram of mean withers height versus weight of *Equus ferus* from Montemerano-Manciano and some sites of the Middle-Late and Late Pleistocene of central and southern Italy.

The second upper molar (L = 19.62 mm) is slightly longer than the specimens from the lower levels of Grotta Romanelli (N = 10; range L = 16.40-18.90 mm) and is comparable with the largest specimens from Melpignano (N = 6; range L = 16.90-19.80 mm) and the specimens of *Dama dama tiberina* from Vitinia (N = 2; range L = 17.70-21.20) and Grays Thurrock (N = 8; range = 18.30-20.80 mm). The lower molars (LM = 60.10mm) are slightly longer than the specimens from Romanelli (N = 6; range L = 54.10-59.50 mm) and is comparable with those from Melpignano (N = 14; range L = 52.90-61.60 mm) and those of *D. dama tiberina* from Vitinia and the Tiber River deposits (N = 3; range L = 56.50-62.80 mm) and Grays Thurrock (N = 8; range L = 57.90-64.50 mm). The dimensions of the distal epiphysis of metatarsus (DTD = 29.24; DAPD = 19.62) are slightly smaller than the specimens from Melpignano (N = 16; DTD = 29.70-34.20, DAPD = 20.50-22.50) and *D. dama tiberina* (N = 7; DTD = 30.60-36.40, DAPD = 21.90-24.40; data from Di Stefano, 1994) and they are slightly close to the specimens from Romanelli and Cucigliana (DTD = 25.40-28.50; DAPD = 19-21.70).

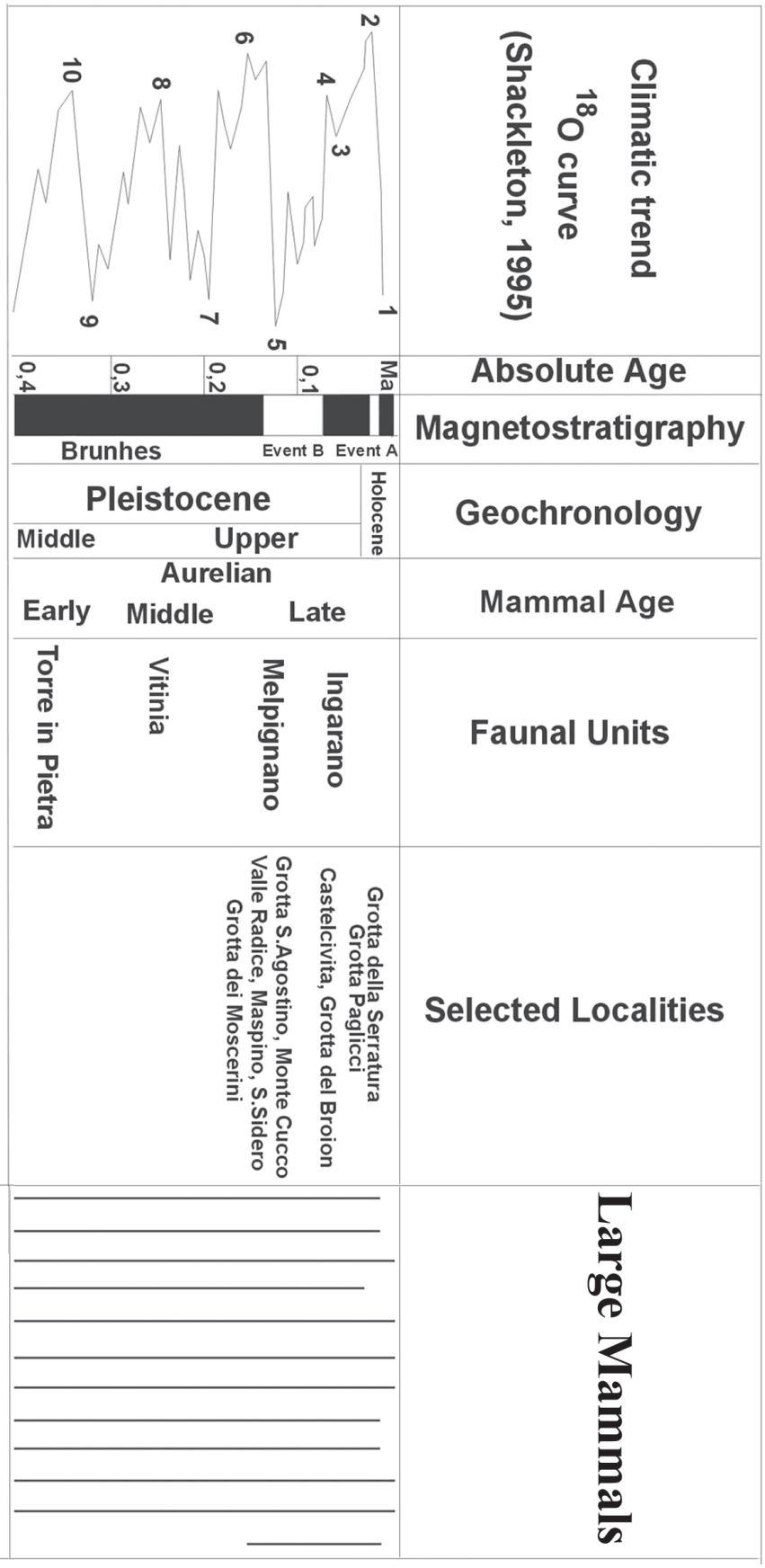

Fig. 5. Biochronological scheme of the Mammal fauna from Montemerano-Manciano.

Cervidae indet.

One second phalanx of a very young individual (MPUR 5/27) and a fragment of spur (MPUR 5/35) and a fragment of a diaphysis of metatarsus (MPUR 5/66) can be generally referred to Cervidae indet.

Discussion and conclusion

As it regards the biochronology of the Montemerano faunal assemblage (Fig. 5), most of the species collected from the karst cavity already occurred in Italy during the late Middle Pleistocene (Petronio et al. 2011). However, biochronological information can be obtained by a combination on the first and last occurrences of the species, evolutionary trends and in some case, dimensional trends. The latter appear to be a frequent phenomena during the life time span of some species and can be influenced by several factors. Nevertheless they can be used as a valid biochronological tool (Brugal, 1984; Eisenmann and David, 2002; Lacombat, 2009; Pandolfi et al., 2011; Brugal and Boudadi-Maligne, 2011).

The hedgehog, the hare, the wolf, the wild boar, the roe deer, the red deer and the aurcoch are still present in the modern Italian fauna; however, the faunal assemblages containing *Panthera spelaea*, *Equus ferus* and *Bos primigenius* which disappeared in the Italian peninsula during the earliest Holocene (Gliozzi et al., 1997; Petronio et al., 2011). The giant deer becomes extinct in Italy during the latest Pleistocene too but it seems not to occur further than the Padan Plain since the last part of MIS 3 (Masseti, 2003; Petronio et al., 2011).), when also the genus *Stephanorhinus* disappeared (Petronio et al., 2011; Pandolfi and Petronio, 2011; Pandolfi et al. 2013); finally, the fallow deer does not occur in Italy after the Last Glacial Maximum (MIS2) (Fg. 4) (see Di Stefano and Petronio 2002; Petronio et al., 2007; 2011).

The wolf is documented in the late Middle Pleistocene faunal assemblages of Central Italy (e.g. Torre in Pietra, La Polledrara; Petronio et al. 2011 and references therein) but it is common in the Late Pleistocene and Holocene fossiliferous localities (Petronio et al. 2007, 2011). Recently, Brugal and Boudadi-Maligne (2011) and Boudadi-Maligne (2012) described variations in the dimensions of the fossil remains of *Canis lupus* and Boudadi-Maligne (2012) ascribed the large-sized specimens of the late Late Pleistocene (MIS3-2) to the new subspecies *C. lupus maximus*. Small sized wolf were reported during the Middle Pleistocene (approx. MIS 10-7) while populations with an intermediate size were reported during the latest Middle and early Late Pleistocene (approx. MIS 6-4). In Italy a preliminary investigation on the dimensions of the teeth during the Late Pleistocene reveals the presence of populations with small-sized teeth during the MIS5 and MIS4 (e.g. Melpignano and Ingarano) and populations with relatively large-sized teeth during the late Late Pleistocene (e.g. Grotta Mora Cavorso and Sant'Agostino). The populations from Melpignano and Ingarano fall into the dimensional range of the small-sized Middle Pleistocene specimens from Coudoulous I and La Fage, ascribed to the subspecies *C. lupus lunellensis*. These preliminary results suggest that the biochronological scheme adopted by Boudadi-Maligne (2011) is not valid for Italian Peninsula probably because the role of "glacial refugia". The specimen from Manciano is larger than those from MIS5 and MIS4 from Italy and it is close to those of the Late Pleistocene *C. l. maximum* from Juarens (approx. 30 000 BP), *C. lupus santenaisiensis* from Aven de l'Arque (approx. 41 000 BP). This record suggests an age younger than the MIS4 to the faunal assemblage of Manciano.

Equus ferus occurs in Italy during the Middle Pleistocene (Petronio et al., 2011) and during the Late Pleistocene is represented by populations with different size (Conti et al., 2010). The dimensions of the metapodials of *E. ferus* from Manciano testify an intermediate evolutive degree between the horses from S. Sidero 3 and S. Sidero 6 and those smaller from various deposits referred to MIS 3 (see Conti et al., 2010). The ratio from the withers height and the weight shows that the horse from Montemarano is closer to those from Cardamone, Melpignano and Tana delle Iene, and smaller than the large-sized horses from S. Sidero and the ones from the late Middle Pleistocene of Torre in Pietra (see Conti et al., 2010).

Sus scrofa occurs for the first time in Italy at the end of the Early Pleistocene (at Slivia, Trieste; Ambrosetti et al., 1979) but the subspecies *S. scrofa scrofa* is recorded in fossiliferous localities of the latest Middle and Late Pleistocene. According to Faure and Guérin (1983), the wild boar is characterized by variations in size during the Pleistocene, following the Bergman rule. Albarella et al. (2009) recognized different size of *Sus scrofa* in Europe during the Holocene. The specimens from Manciano are close to the maximal values of the recent wild boar from Southern Europe. They are larger than those collected from several Mesolithic localities of the same area and are closer to those collected from Mesolithic localities of Central Europe (Albarella et al. 2009). This suggests an age of deposition for the Manciano karst filling related with a cool or cold period of the Pleistocene.

The auroch is recorded in Italy from the Middle Pleistocene to the Roman epoch (Pandolfi et al. 2011); however, it shows variations in the bone dimensions during the Pleistocene. Large-sized specimens are reported in late Middle and early Late Pleistocene localities of Southern Europe, while a decrease in size is recorded during the late Late Pleistocene and the Holocene (Brugal 1984; Pandolfi et al. 2011). The specimens from Manciano are relatively large and the dimensions of the metatarsus are closer to the specimens from Via Aurelia and Avetrana and they are larger than specimens from the late Late Pleistocene and Holocene Italian localities (e.g. Romanelli). This suggests an age for the Manciano faunal assemblage older than MIS3.

Megaloceros giganteus is relatively scarce in Central Italy and it is recorded only in few localities (Azzaroli, 1967; Caloi et al, 1986, Petronio et al., 2011). The earliest occurrence of the species is in the late Middle Pleistocene locality of Torre in Pietra (Caloi and Palombo, 1978) but it is more documented during the Late Pleistocene, in particular in Northern Italy. The specimen from Manciano is one of the southernmost occurrence of the species in the Peninsula and it testifies cold conditions in the area.

The remains of red deer, in particular the antlers, are morphological similar to the Late Pleistocene specimens collected in several localities and ascribed to an evolved form of *Cervus elaphus* (Di Stefano and Petronio, 2002; Petronio et al., 2007). Their dimensions are comparable to those of the specimens collected in fossiliferous localities referred to the beginning of MIS4 and MIS3 (e.g. Ingarano, Sora and Parignana). Indeed, specimens collected from early Late Pleistocene Italian deposits appear smaller than those collected from deposits of the last glaciation; this variations can be probably related with the Bergmann rule as well as in *Sus scrofa*. This result can be an important biochronological value and a more detailed investigation is needed to well define and investigate the size variations of the red deer in Italy.

The studied specimens of the fallow deer are morphological similar to those collected at Melpignano, Romanelli and other Late Pleistocene localities (Di Stefano, 1994). The dimensions of the teeth of the fallow deer are close to those of the specimens form Melpignano and to *D. dama tiberina*, while the dimensions of the post-cranium are close to the specimens from Romanelli and Cucigliana and are smaller than those from Melpignano and those ascribed to *D. dama tiberina*.

D. dama dama is a typical faunal element and often the most abundant one in the early Late Pleistocene deposits of Italian peninsula. The fallow deer becomes increasingly rare in the second part of the Late Pleistocene, because of the climate cooling of this period and it is not more present after the MIS2 (Di Stefano and Petronio, 2002; Petronio et al., 2007; 2011). The differences in the dimensions of the metapodial bones among the specimens from Melpignano and those from Romanelli and Cucigliana can be attributed to the climate changes, in particular to the cooling during the ending of the MIS5. Unfortunately the remains of fallow deer during the last glacial appear too scarce in Italy for an exhaustive morphometrical investigation. Moreover, the fallow deer populations living during the cool interval in the Late Pleistocene (MIS 4-2) (see for example the population from Ingarano, Apulia, Southern Italy, Petronio and Sardella, 1998) are in the average smaller than the population from MIS 5 (see for example the population from Melpignano, Apulia, Southern Italy).

The preliminar petrographical analysis of the arenaceus deposit covering the fossil remains shows a particular lacking in the volcanic elements coming from the Vulsine district (Gaeta, *pers. comm.*). This observation strengthens the biochronological picture arising from the paleontological data because it would refer the age of the deposit in a range younger than 120 ka.

The biochronological data and the morphometrical analysis, in particular of the red deer, the fallow deer, the horse and the wolf, strengthen and reduce the age of the Mammal assemblage from Montemerano to a time span chronologically related with a cool phase of the Late Pleistocene, probably with the ending of MIS 4 of an early phase of MIS3.

Aknowledgements

We wish to thank Mario Gaeta and Raffaele Sardella for the useful scientific information and discussions.

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