REDEFINING PONTE MOLLE (ROME, CENTRAL ITALY): AN IMPORTANT LOCALITY FOR MIDDLE PLEISTOCENE MAMMAL ASSEMBLAGES OF EUROPE.

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ABSTRACT: In this work, the Middle Pleistocene mammal assemblage from Ponte Molle, a historical locality of the urban area of Rome, has been revised together with a review of the stratigraphical succession of the deposit. This allows us to reconstruct the provenance of the fossil material and to provide chronological constrains trough the correlation with the lithostatigraphic and synthemic units of the national geological cartography and the geochronologically-constrained aggradational units of the Paleo-Tiber reported in literature. The paleontological study together with the geological and stratigraphical review allow us to redefine the Ponte Molle deposit and its Middle Pleistocene faunal assemblage. In its new look, the age of the faunal assemblage from Ponte Molle could be referred to a time span ranging from 550 ka to 450 ka.

Keywords: Fossil vertebrates, Biochronology, Galerian, Palaeoecology.

1. THE URBAN AREA OF ROME

The city of Rome lays in one of the most important sedimentary basins of Italy for the paleontological research, considering the very high number of fossiliferous findings. The city is crossed by the Tiber River, whose evolution is the result of complex geological processes including tectonic, volcanism and glacio-eustatic fluctuations (Conato et al., 1980; Milli; 1997; Karner et al., 2001; Giordano et al., 2003; Funiciello & Giordano, 2008a, b). The Tiber River fluvio-deltaic evolution (the "Paleo-Tiber" system), which commenced during the latest Early-earliest Middle Pleistocene (1.1-0.7 Ma; Milli et al., 2016), mainly includes sedimentation linked to sea-level rises during the Pleistocene glacial terminations (Pandolfi & Marra, 2015). What follows is a discontinuous stratigraphic record constituted by twelve low rank and high frequency (80-100 ka spaced) depositional sequences, complexly stacked within the basin and deposited by the start of MIS 32-31 (Marine Isotopic Stage) (late Early Pleistocene). In fact, forced by the eustatic and relative falls of the sea level, the Tiber River cyclically excavated the fluvial valleys and coastal plain incisions into the bedrock, later filled during the following transgressive and highstand phases with deposits often including pyroclastic products. These were sourced from the Alban Hills and Sabatini Mounts Volcanic Districts, with main activity spanning the 600-250 ka time interval (De Rita et al., 1993; Marra et al., 2009, 2014; Funiciello & Giordano, 2010). The presence of volcanic material, among which pumice and tephra interbedded with alluvial-deltaic sediments, is of consider-

able interest to obtain $^{40}Ar/^{39}Ar$ radiometric age dates and therefore to provide reliable geo-chronological constraints for the sediments (Marra & Florindo, 2014 and references therein). What makes this territory important for paleontological research is the exceptional number of remains recovered over the last 150 years from the alluvial deposits of the Paleo-Tiber River and its tributaries (e.g., Di Stefano et al., 1998; Petronio & Sardella, 1998, 1999; Milli et al., 2004). The first findings took place in the 1800s, when the fluvial deposits were investigated by eminent scientists of the time, such as Giuseppe Ponzi and Alessandro Portis (Funicello & Rosa, 1995; Funicello & Giordano, 2008b; Romano et al., 2021). The majority of the fossil remains was collected from deposits outcropping in the urban area of Rome and its periphery, due to the intense urbanization and quarry activities (e.g., Portis, 1893, 1896,1900). Many works focused on the description of these fossiliferous localities and their remains (e.g., Di Stefano et al., 1998; Petronio & Sardella, 1999), even if often most of them lacks exact stratigraphic constrains and is not always associated to a precise sedimentary level (gravel, sand, clay) (Pandolfi & Marra, 2015). Most of the historical collections from the area of Rome is stored at the "Museo Universitario di Scienze della Terra (MUST)" (Earth Science University Museum, Sapienza University of Rome) (including the former Museo di Paleontologia di Roma, MPUR). Unfortunately, the paleontological collections endured a series of misadventures, as for instance the overflow of the Tiber River in 1870 (Portis, 1893) or the bombardment that struck the Department of Earth Sciences of Sapienza University (Rome) carried out by the American Army
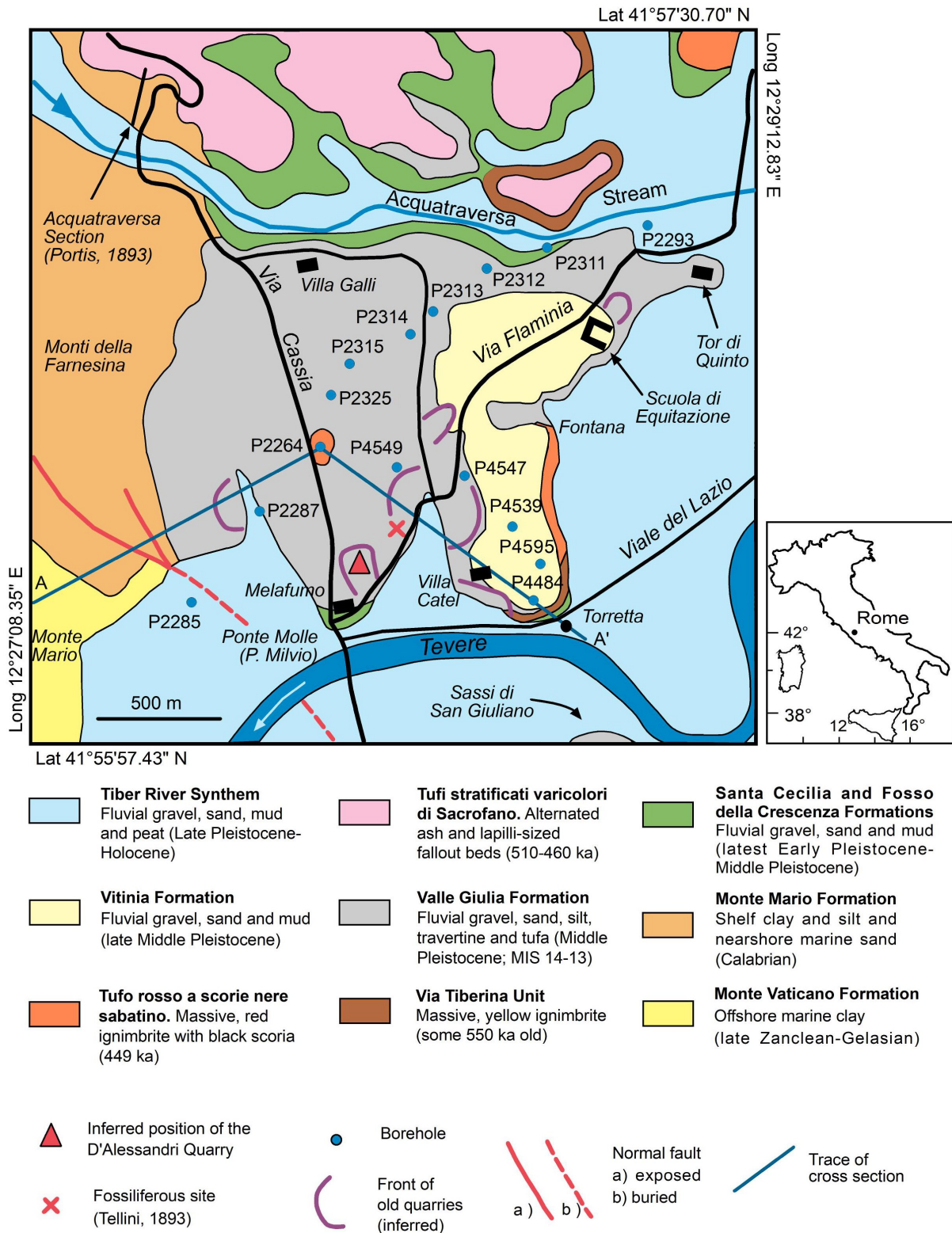
Fig. 1 - Geological sketch map of the Ponte Molle-Tor di Quinto area (from Funiciello & Giordano, 2008a; modified), with trace of the geological cross section (Fig. 2), the location of the Cava D'Alessandri and boreholes used for stratigraphic analysis (Figs 4, 5). Toponyms refer to the historical geological maps by Tellini (1893) and Verri (1915); see also figure 3.

during the World War II (Fabiani & Maxia, 1953; Mecozzi et al., 2020). These episodes caused the loss and damage of many fossil specimens or of their associated labels. Nonetheless, the fossil remains recovered from the urban area of Rome and its surroundings, also known as Campagna Romana (Roman Campaign), represent the most abundant Middle Pleistocene fossil samples founded in Italy, and thus the area assumes a key-role in the study of vertebrate assemblage evolutionary trends and palaeoenvironmental reconstructions. The importance of this territory is reflected in the Large Land Mammal Biochronological Scale, where two Roman localities are chosen as Faunal Units: Ponte Galeria and Torre in Pietra (Gliozzi et al., 1997).

In this work, we analyze the fossil sample from Ponte Molle (also known as Ponte Milvio) (PM), a historical locality of the urban area of Rome described by Portis (1893). The revision of the stratigraphical succession of the deposit allows us to reconstruct the provenance of the fossil material and to provide chronological constrains trough the correlation with the lithostatigraphic and synthemic units of the national geological cartography (CARG Project; Funiciello & Giordano, 2008a, b) and the geochronologically-constrained aggradational units of the Paleo-Tiber reported in literature (Marra et al., 2014).

2. PONTE MOLLE AND ITS TROUBLED HISTORY

The presence of the fossil remains in the Tiber alluvial deposit in the Tor di Quinto area was already reported in the second half of the 19th century, when Ponzi (1867) recognized the occurrence of several species from the quarries opened at PM, from the same gravels quarried for building material (Tab. 1). The stratigraphical succession exposed in the quarry called Cava D'Alessandri was firstly described by Portis (1893). In this work, he illustrated several sedimentary deposits occurred in the city of Rome, with a special focus on the northern-western area, where in addition to Cava D'Alessandri, the successions exposed at Tor di Quinto (=Torretta di Quinto) and Acquatraversa (all located in the Tor di Quinto district) were also described (Fig. 1). The author pointed out the presence of fossil remains referable to the "classical" fauna of PM (implying that findings of similar assemblages were already common) only from the lowermost level of the stratigraphic succession (Tab. 1). This level, consisting of tuffaceous gravels and sands (i.e. with tuffaceous clasts and minerals of volcanic origin), and including a diversified faunal assemblage, was the first properly described outcrop of the "cosiddette ghiaie diluviali di Ponte Molle" [so-called diluvial gravel of Ponte Molle]. Later, Portis (1902) described an isolated upper molar belonging to a juvenile specimen classified as *Elephas antiquus* (=*Palaeoloxodon antiquus*) (Tab. 1). Portis (1907) analyzed the sample of Bovidae from several deposits of the urban area of Rome and its surroundings, attributing several cranial remains from PM to *Bos primigenius* (Tab. 1). Portis (1909) studied the canid fossil remains from the urban area of Rome, among which two fragments of hemimandible and one isolated lower carnassial from the "cosiddette ghiaie di Ponte Molle presso

Cava D'Alessandri" were referred to a small-sized form of *Canis lupus* (Tab. 1). In addition, he noticed that in the fossil collection of Ponzi two replica, a fragment of maxillary and a fragment of hemimandible, respectively, were present, but the original remains were missing. These two fossils were also referred to *C. lupus*. Portis (1909) also attributed a complete femur to *Meles meles* (=*Meles taxus*) and an upper canine to the genus *Lynx*, both collected from the basal level of Cava D'Alessandri (Tab. 1). Later, Portis (1920) listed the Cervidae taxa identified in the city of Rome and its surroundings, reporting the presence of *Cervus* (*Praealces*) *latifrons* from PM (Tab. 1). However, due to the intense urbanization of the area, the quarries and the other aforementioned outcrops were destroyed or buried below anthropogenic deposits. Following this, subsequent studies were conducted exclusively on the historical fossil collections recovered during the end of 1800s and the first decades of 1900. During the 1960s, Ambrosetti & Bonadonna (1967) resumed the paleontological research on this locality and correlated the PM fauna with the Ponte Galeria formation (*sensu* Conato et al., 1980) exclusively on the basis of the occurrence of some Galerian taxa, even if no description of the materials was performed. After decades, Caloi & Palombo (1986) carried out the revision of the fossiliferous localities of the area of Rome and listed the following species from the lower level of Ponte Milvio (=Ponte Molle): *Cervus* (*Cervus*) *acoronatus, Cervus* (*Dama*) sp. (=*Cervus* [*Dama*] *quirinus*), *Megaceros* cf. *solilhacus* (=*Cervus* [*Praealces*] *latifrons*) and *Hippopotamus incognitus* (Tab. 1). Even in this case, neither descriptions nor figures of the fossil sample were included. Di Stefano & Petronio (1992) firstly described the mammal assemblage from PM, identifying two distinct faunal assemblages, as they regarded some mammals as Galerian forms (e.g. *C. elaphus acoronatus*) and others as more typical elements of late Middle to Late Pleistocene assemblages (e.g. *Dama clactoniana*) (Tab. 1). Capasso Barbato et al. (1998) realized a preliminary revision of the deposit, recognizing at least three different assemblages of Middle Pleistocene age and also referring a few specimens to the Holocene (Tab. 1). Shortly after, Di Stefano et al. (1998) further detailed the "two-assemblages" hypothesis, attributing the first to Isernia Faunal Unit (early Middle Pleistocene) and the second to Vitinia Faunal Unit (late Middle Pleistocene), mainly on the ground of the presence of different fallow deer subspecies, respectively *Dama clactoniana* and *Dama dama tiberina*.

More recently, an isolated horn-core stored at the Monastery of Santa Scolastica in Subiaco (Rome), previously referred to *Bubalus murrensis* by Cassoli & Segre (2004), was ascribed to *Hemibos galerianus* by Martínez-Navarro & Palombo (2007) (Tab. 1). Palombo (2004) figured a partial cranium with nearly complete antler classified as *C. elaphus acoronatus* and a partial cranium and complete antler ascribed to *D. dama tiberina* (=*Dama quirinus*).

Billia & Petronio (2009) revised the Rhinocerotidae sample, recognizing only the presence of *Stephanorhinus kirchbergensis*, whereas Pandolfi (2013) and Pandolfi & Marra (2015) identified three different taxa: *S.*

Taxa	Ponzi (1867)	Portis (1893)	Portis (1902)	Portis (1907)	Portis (1909)	Portis (1920)	Caloi & Palombo (1986)	Di Stefano & Petronio (1992)	Capasso Barbato et al. (1998)	Cassoli & Segre (2004)	Martínez-Navarro & Palombo (2007)	Billia & Petronio (2009)	Pandolfi & Marra (2015)
Elephantidae		X											
Palaeoloxodon (Elephas) antiquus (=Palaeoloxodon antiquus)			X					X	X				
Hippopotamidae	X	X							X				
Hippopotamus cf. antiquus									X				
Hippopotamus incognitus							X						
Hippopotamus cf. amphibius								X	X				
Hippopotamus sp.	X	X						X	X				
Rhinocerotidae	X	X											
Stephanorhinus hundsheimensis													X
Stephanorhinus kirchbergensis									X			X	X
Stephanorhinus hemitoechus									X				X
Dicerorhinus sp. (=Stephanorhinus sp.)	X	X						X					X
Bovidae	X	X											
Bos primigenius				X				X	X				
Bubalus murrensis										X			
Hemibos galerianus											X		
Sus scrofa	X	X						X	X				
Cervidae	X												
Cervus (Praealces) latifrons						X							
Megaceros cf. solilhacus (=Cervus [Praealces] latifrons)							X						
Cervus (Cervus) acoronatus (Cervus elephus acoronatus)							X	X	X				
Cervus elephus elaphus								X	X				
Cervus (Dama) dama ssp. (=Cervus [Dama] quinus)							X						
Dama dama clactoniana								X	X				
Dama dama								X	X				
Euraxis eurygonos									X				
Capreolus capreolus								X	X				
Equus caballus (=Equus ferus)								X	X				
Equus (Asinus) hydruntinus (=Equus hydruntinus)								X	X				
Ursus sp.								X	X				
Canis cf. mosbachensis									X				
Canis lupus					X				X				
Crocuta crocuta									X				
Lynx sp.	X				X				X				
Meles meles	X				X				X				
Carnivora	X												

Tab. 1 - Mammal taxa from Ponte Molle reported in previous works.
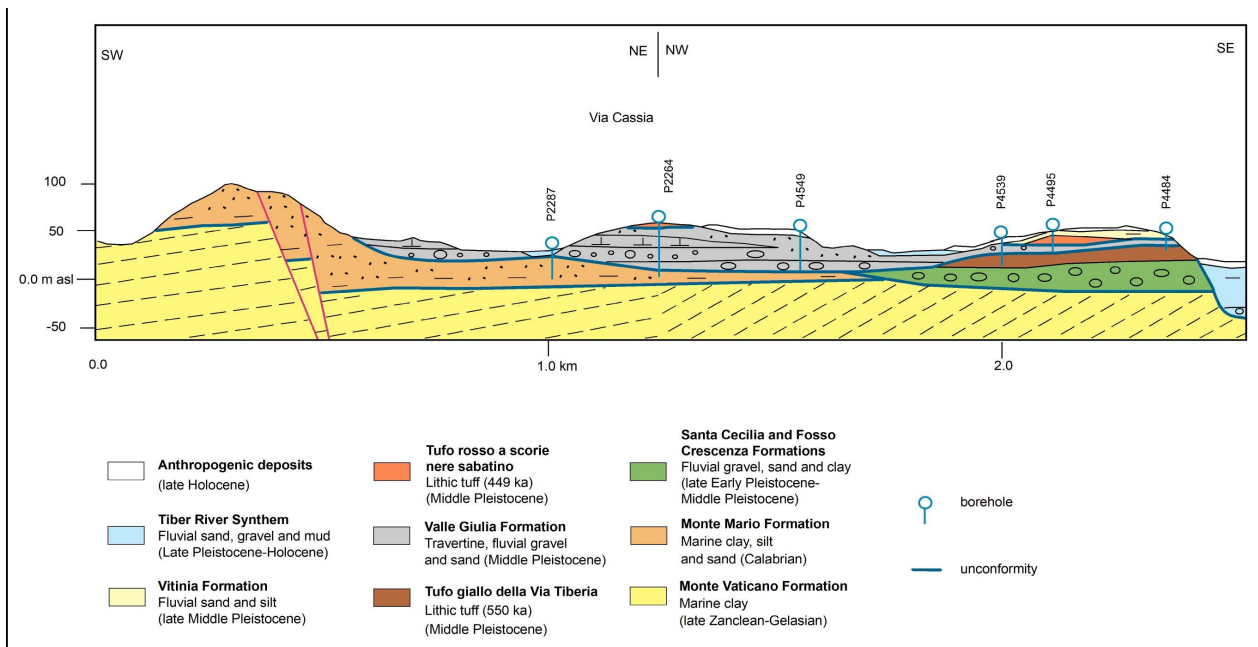
Fig. 2 - Geological cross section of the Ponte Molle area. The trace of the section is represented on figure 1.

kirchbergensis, Stephanorhinus hemitoechus and *Stephanorhinus hundsheimensis*, as well as several remains undeterminable at specific level (*Stephanorhinus* sp.) (Tab. 1). Pandolfi & Marra (2015) also proposed a reinterpretation of the age of the deposit. They noticed that part of the specimens labels report that fossils were collected from "gravels and sands" and others from "tuffaceous conglomerates", and supposed this as indicative of the presence of two levels of different age: the lower one, a gravel and sand level where *S. hundsheimensis* occurred; and the upper one, a tuffaceous conglomerate level which included *S. kirchbergensis* and *S. hemitoechus.* This upper level was correlated with a tephra detected at 1.5 km along Via Flaminia Nuova, dated at 465±7 ka, whereas the lower level was correlated to the base of the Paleo-Tiber 2 cycle at 810-790 ka (Pandolfi & Marra, 2015). However, from an historical perspective, this label-based repartition of the assemblage is not supported. In fact, even not accepting early researchers' interpretations, they explicitly regarded the fauna of PM as coming from a single level (Ponzi, 1867; Portis, 1893). Consequently, they would not have reported on the labels a separation that they had not observed in the field. Moreover, even though some labels do report "gravels and sands" and others "tuffaceous conglomerates", others again indicate "gravels, sands, and tuffaceous conglomerates", or even "so-called gravels of Ponte Molle" or variable combinations of these forms, which clearly were all different ways to refer to the same thing: a fluvial formation with gravel and sand, rich in fossils and volcanic material.

The so-called fauna of PM was the typical assemblage recovered from the gravel quarries and other sporadic findings occurred during construction works in the district of Tor di Quinto, in the northern-western area of Rome (Ponzi, 1867). Several specimens were recovered from Cava D'Alessandri, which was also the first properly described outcrop (Portis, 1893). Despite several specimens from this site have been object of study (e.g., Capasso Barbato et al., 1998; Di Stefano et al., 1998), an in-depth analysis is still needed to redefine the faunal assemblage.

3. GEOLOGICAL SETTING

The study area of PM and Tor di Quinto is located on the right bank of the Tiber River and corresponds to a well preserved fluvial terrace, with 50-60 m a.s.l. mean elevation, laying eastward of the N-S directed Monte Mario-Monti della Farnesina ridge, up to 140 m high (Fig. 1). The terrace is bounded to the east and south by the alluvial plain of the meandering Tiber River, at 16 m a.s.l., and to the north by the narrow valley of Fosso dell'Acquatraversa.

The original terrace relief, as deduced by the observation of historical geological and topographic maps (Tellini, 1893; Verri, 1915; IGM, 1936), was characterized by a gentle undulating topography interrupted, internally, by small N-S oriented valleys and at the northern and eastern edges by steep scarps, where natural outcrops were exposed and examined by the authors (Portis, 1893; De Stefani, 1904). Nowadays the natural landform is strongly modified after a re-shaping from the intense urban transformations of the last 120 years, and almost no exposures are preserved.

On the local stratigraphy, the bedrock corresponds to the marine clay, silt and sands of the Monte Vaticano and Monte Mario Formations, attributed respectively to the Zanclean-Gelasian and to the late Santernian (Calabrian) (Funiciello & Giordano, 2008a, 2008b). The bedrock crops out along the Monte Mario-Monti della Farnesina ridge, is found in the subsoil of the fluvial terrace (Fig. 2), and is crossed by NW-SE trending normal faults down-throwing the north-eastern blocks

(Funiciello & Giordano, 2008a; Cosentino et al., 2009).

The terrace is composed of an approximately 50 m thick succession of fluvial deposits with interbedded pyroclastic units, which covers with angular unconformity the bedrock; it is interpreted as an alluvial fill terrace (Merrits, 2007; Pazzaglia, 2013). At the base are present alternated gravel, sand and silt of the Fosso della Crescenza and Santa Cecilia Formations of the latest Early Pleistocene-early Middle Pleistocene. They record the oldest fluvial sedimentation in the area, up to the MIS 16-15, and are covered by the Via Tiberina Unit (Tufo Giallo della Via Tiberina Auct) an approximately 550 ka old and few meters thick ignimbrite (Karner et al., 2001), sourced by the Sabatini Mts District and cropping out close to the Torretta site.

Most of the fill terrace is represented by the fluvial Valle Giulia Formation (MIS 14-13), up to 30 m thick and composed of basal channel gravels grading upward into cross bedded sands, travertine, tufas and floodplain muds. This formation has a relatively high-relief basal unconformity carved into the bedrock and older fluvial deposits and defines an approximately N-S directed paleo-valley infill (Giordano et al., 2003; Funiciello & Giordano, 2008a; Marra & Florindo, 2014; Giustini et al., 2018). The formation is rich in volcanoclastic material, re-sedimented in the fluvial environment, and crystals of volcanic origin found in the sandy matrix of the gravels. North of the Acquatraversa Stream the "Tufi stratificati varicolori di Sacrofano" crop out, composed of alternated ash and lapilli sized fallout beds (510-460 ka old) that, along with the Valle Giulia Formation, define the Villa Glori Synthem.

On the top of the terrace there are locally present the "Tufo rosso a scorie nere sabatino", a red massive ignimbrite with back scoria (about 449 ka old; Karner et al., 2001) and the overlaying Vitinia Formation (late Middle Pleistocene, approximately 285-270 ka old; Karner et al., 2001; Giordano et al., 2003) composed of few meters thick pebbly sand and mud, rich in volcanic minerals. The Vitinia Formation corresponds in this area to the "Formazione fluvio-lacustre" by Ventriglia (1971, 2002). Finally, the Tiber River plain and Acquatraversa valley are composed of basal gravels and overlaying channel sands and floodplain mud with interbedded peat layers of the Tiber River Synthem (or Tiber Depositional Sequence *sensu* Milli et al., 2016), which records the last cycle of fluvial incision and sedimentation of Late Pleistocene-Holocene (MIS 5d-1). Anthropogenic deposits, up to 15 m thick, cover the natural substratum in most of the study area.

4. MATERIALS AND METHODS

The osteological analyses of the large mammal fauna from the Middle Pleistocene site of PM were carried out, considering remains collected from the end of 1800 to early decades of 1900. The fossil remains are stored at MUST. Taxonomic and skeletal element identifications made in this study are based on the reference collection of the PaleoFactory Laboratory, Department of Earth Sciences, Sapienza, University of Rome (PF). In order to evaluate species abundance, the count of the number of remains (NISP) (Grayson, 1984) and the

estimate of the minimum number of individuals (MNI) (Bökönyi, 1970) have been performed (Tab. 2). In addition, the age at death was also determined.

We carried out biometric comparisons for a selection of taxa relevant for their biochronological and paleoenvironmental significance: *Bos primigenius*, medium-sized deer (*Dama* spp. and *Dama*-like), *Sus scrofa*, and *Hippopotamus*. For *B. primigenius* and medium-sized deer, we measured the maximum meso-distal length above the root-crown junction of the lower third molar (M_3L). For *S. scrofa*, measurements of the lower third molar were taken following von den Driesch (1976). For *Hippopotamus* ssp. measurements of the lower third molar were taken following Mazza (1995): OL: outer length; AB: anterior breadth. Measurements were taken with a digital caliper to the nearest 0.1 mm.

For *Bos primigenius* we considered specimens stored in the following institutions: Contrada Cozze, Casa Minniti (National Archeological Museum of Melfi); as well as literature data: Punta Lucero (Gomez-Oliveira et al., 2015); Malagrotta (Caloi & Palombo, 1979); Igue des Rameaux- amont, Lunel-Viel, Pech de l'Azé II (Uzunidis-Boutillier, 2017); Fara Sabina (Angelelli, 1981); Ilford (Wright, 2013). Subfossil samples of *Bos taurus* from Elvas-Kreuzwiese (Boschin, 2018) and Silves-lix (Davis et al., 2008) were also included. We selected the M_3 since it is the best documented tooth in the studied sample. In addition, this tooth is easily distinguishable from the other lower molars, which makes more reliable the literature data used for comparison.

Morphometric data of medium-sized deer from Pirro Nord and extant Italian specimens of *Dama dama dama* stored at PF have been considered. Literature data of several medium-sized deer taxa have been included: *Pseudodama* group: Kalamotó (*Dama* sp., Tsoukala & Chatzopoulou, 2005); Saint-Prest (*Dama* sp., Guérin et al., 2003), Erpfinger Höhle (*Dama nestii*, Lehmann, 1957), Le Vallonnet (*Dama vallonnetensis*, de Lumley et al., 1988), Cueva Victoria (*Pseudodama vallonnetensis*, van der Made, 2012), Atapuerca TD8 (*Dama vallonnetensis*, van der Made et al., 2017a); *Dama roberti*: Pakefield, Westbury, West Runton (Breda & Lister, 2013), Contrada Monticelli (*Dama* cf. *roberti*; Stefanelli et al., 2021), Valdemino (Breda, 2015); *Dama clactoniana*: Fontana Ranuccio, Grays Thurrock, Jarwick, Visogliano (Di Stefano, 1994), Notarchirico (Cassoli et al., 1999), Atapuerca TD11 (Azanza & Sanchez, 1990), Caune de l'Arago (*Dama* cf. *clactoniana*, Magniez et al., 2013). We selected the lower third molar (M_3) since it is the best documented tooth in our *Dama* sample. In addition, this tooth can be easily recognized from the other lower molars, and therefore a misleading interpretation can be excluded from the data taken from the paleontological literature.

For *Sus scrofa* we considered specimens studied in the following institutions: Bristie 1 (Civic Museum of Natural History, Trieste), Melpignano (PF), and literature data for West Runton, Trimingham, Grays Thurrock, Oreston, Hutton (Lister et al., 2010); Petralona (Tsoukala & Guérin, 2016); Kyparíssia (Atanassiou et al., 2018); Gajtan, Lunel-Viel (Fistani, 1996); Cerè (Fabiani, 1919); Torre del Pagliaccetto (Caloi & Palombo, 1978), and extant Italian wild boar (Iannucci et

al., 2020b); considering that a relationship between size shifts in *S. scrofa* and environmental fluctuations has been recently recognized in late Middle Pleistocene-Early Holocene Apulia (southern Italy), we also included several Late Pleistocene Apulian localities in the comparison, grouped in "Glacial" (MIS 4 and 2) and "Interglacial" (MIS 5 and 3) samples (Iannucci et al., 2020b). We selected M_3 as it is widely available in our sample and in the literature, as well as being easily identifiable and common focus of studies on wild boar morphometry.

We also considered morphometric literature data of genus *Hippopotamus* from Plio-Pleistocene sites of Europe as well as extant *Hippopotamus amphibius* (Mazza, 1995). We selected M_3 because it is the most numerous tooth in our sample.

For investigating chronological and/or geographical biometric variability and possible size variations in the selected taxa we used boxplots of M_3 length, for *B. primigenius*, medium-sized deer, and *S. scrofa*; and plot of length vs breadth of M_3 for *Hippopotamus*.

4.1. Cartography and stratigraphic analysis

Historical and modern geological and topographic maps have been analyzed and compared among each other (Tellini, 1893; Verri, 1915; IGM, 1936; Ventriglia, 1971, 2002; Funiciello & Giordano, 2008a), coupled with a bibliographic review of scientific articles and historical chronicles (Ponzi, 1867; Portis, 1893; De Stefani, 1904; Ranzato, 2019), in order: 1) to locate as precisely as possible the Cava D'Alessandri, other old toponyms and fossil sites of PM, and the described stratigraphic sections no longer observable; 2) to infer the position and areal extension of other old quarries active between the last decades of the 19th and first half of the 20th century (Fig. 1).

In particular, the synoptic observation of old maps, from the oldest to the youngest, has allowed to individualize changes in the shape of topographic contour lines (i.e. from a convex to a concave one) resulting in half-circular morphologies in plain view, here interpreted as ancient quarry fronts and floors (see also Ciotoli et al., 2015, for the method). *In situ* observations and 3D views from the software Google Earth Image©2019TerraMetrics has permitted, in some cases, to recognize steep scarps and differences in heights within the urbanized area, strengthening the hypothesis of old quarry fronts.

Fig. 3 - Sketches of the historical geological maps by Tellini (1893) on the left, and Verri (1915) on the right, showing the area of Ponte Molle and its transformations between the late XIX and the early XX century. In the Tellini's (1893) map there are featured a small N-S oriented topographic depression, just north-east of the Osteria (di Melafumo) toponym, in the same area described by Portis (1893), and a fossil site (red asterisk; see also figure 1). In the Verri's (1915) map it is reported the C. d'Alessandri toponym just north of the Osteria, and the topographic depression (the former quarry) is replaced by a newly built area (V. Trezza toponym).

The stratigraphic section of Cava D'Alessandri has been drawn basing on the description by Portis (1893), who reported the precise position of the unique vertebrate-bearing level of the quarry.

To reconstruct the stratigraphic architecture of the PM-Tor di Quinto infill terrace, two correlation panels among the Cava D'Alessandri section and 15 borehole logs have been realized. The latter deriving from literature and unpublished data (Ventriglia, 2002) and stored in the CNR IGAG database of subsoil data of Rome (Cavarretta et al., 2005). Correlation was based on the application of standard methods of physical stratigraphy on core data (Bridge, 2003; Collinson et al., 2006) with particular emphasis on the identification of key bounding surfaces and architectural elements: main unconformities, channel bodies, floodplain deposits. This has allowed to put the vertebrate-bearing level of Cava D'Alessandri into the correct physical and chrono-stratigraphic frame.

5. RESULTS

5.1. Geography and stratigraphy

From the compared analysis of cartographic and literature data (Portis, 1893; Tellini, 1893; De Stefani, 1904; Verri, 1915) it appears that Cava D'Alessandri was likely sited on the northern flank of via Flaminia about 150 m north of the Osteria di Melafumo (Tavern), with this tavern located just after PM (Fig. 1). Figure 1 shows the localities mentioned by the authors and ancient toponyms, in some cases no longer in use, plotted on a sketch of the modern geological map of Rome (Funiciello & Giordano, 2008a).

On the Tellini's (1893) geological map a small N-S trending topographic depression can be noticed, which cuts transversally the southern slope of the PM-Tor di

Quinto terraced relief. This place roughly corresponds to the C. d'Alessandri toponym, as reported on the later Verri's (1915) geological map (Fig. 3). The topographic depression of the Tellini's (1893) map is interpreted as the ancient Cava D'Alessandri (Fig. 1), being it substituted by a re-covered area with small buildings above it in the Verri's (1915) map. This testifies the very rapid changes of the growing city in the PM area. Another fossiliferous site was shown by Tellini (1893) further north along the Via Flaminia, and is reported on figure 1, as other old quarries and the outcrops described by Portis (1893): Torretta and Acquatraversa.

The stratigraphy of Cava D'Alessandri described by Portis (1893) is represented on figure 4. The vertebrate-bearing level was located in the lower cross bedded fluvial gravels, 8.5 m thick, that are replaced above by calcareous sand and silt (1.5 m thick) and by a fining-upward succession (16 m thick) of sandy pebbles, grey sand and silt with concretions, plant fragments and freshwater and terrestrial mollusks (*Corbicula fluminalis*, Helicidae). From the modern geological map, Cava D'Alessandri belongs to the Valle Giulia Formation (Fig. 1), ascribed to the intermediate portion of Middle Pleistocene and correlated with MIS 14-13 (Funiciello & Giordano, 2008b).

The stratigraphic-sedimentological log of Cava D'Alessandri is correlated with nearby borehole logs (see also figures 1 and 2 for their location), which allows to define the stratigraphic architecture of the PM-Tor di Quinto infill terrace. The two produced correlation panels are presented on figure 5. The first panel (Fig. 5a), in which the Cava D'Alessandri log is plotted, is NW-SE oriented with an across-valley direction; the other (Fig. 5b) is almost perpendicular in the along-valley direction (NE-SW).

The panels detail the stratigraphic setting already shown in the cross section of figure 2, with the marine bedrock of the Monte Vaticano and Monte Mario Formations, the overlaying Middle Pleistocene formations composing the aggradational terrace (Fosso della Crescenza and Santa Cecilia Formations, Via Tiberina Unit, Valle Giulia Formation, "Tufo rosso a scorie nere sabatino", Vitinia Formation), the late Pleistocene-Holocene Tiber River Synthem in the plain, the anthropogenic deposits. The main unconformity separating the bedrock from the overlaying infill terrace of PM-Tor di Quinto results from the enveloping of the singular basal unconformities of the fluvial Fosso della Crescenza, Santa Cecilia and Valle Giulia Formations, all incised by the ancient Tiber into the bedrock in response of recurrent sea level falls and lowstands. The infill terrace is thus the result of the complex vertical and lateral stack of several Middle Pleistocene units, with a discontinuous stratigraphic-sedimentologic record occurred throughout the approximate 0.80-0.27 Ma time interval.

The oldest fluvial and pyroclastic units (Fosso della Crescenza, Santa Cecilia Formations and Via Tiberina Unit) are rarely crossed by the well cores in the eastern portion of the terrace. The fluvial sediments are represented by prevailing beige sand and silt, with intercalated pebbles and with a reddish-brown paleosol on the top (P2313 borehole; Fig 5b).

Conversely, the panels show for the Valle Giulia

Formation the classical pattern of infill of the Quaternary fluvial incised valleys in the Rome area, i.e. that related both to the Tiber River and tributaries (Milli, 1997; Milli et al., 2008, 2016; Mancini et al., 2018), with a high relief unconformity, basal gravels and overlaying alternated sand and fine deposits.

The basal unconformity of Valle Giulia Formation is well incised into the marine bedrock and the older Fosso della Crescenza-Santa Cecilia Formations and Via Tiberina Unit (550 ka old); it records the sea level fall occurred between the MIS 15 and MIS 14, and the MIS 14 lowstand of sea level (glacial phase).

Stratigraphic section of the D'Alessandri Quarry (Portis, 1893)

39 m a.s.l.

Planar and lenticular bedded grey sand and clayey-marly sand, with calcareous concretions, plant remains and freshwater and terrestrial mollusks: *Corbicula fluminalis* (Muller), Helicidae (thickness: 10.0 m)

Laminated sand with interbedded granules (2.0-4.0 m)

Pebbles with sand (2.0 m)

Poorly cemented, white calcareous sand and silt, with carbonate concretions (1.5 m)

quarry floor (22 m a.s.l.)

Cross bedded gravel with sandy matrix, rich in volcanic minerals (1.5 m)

Fossil-bearing (vertebrates), cross bedded gravel with sandy matrix, rich in volcanic minerals (thickness: 7.0 m)
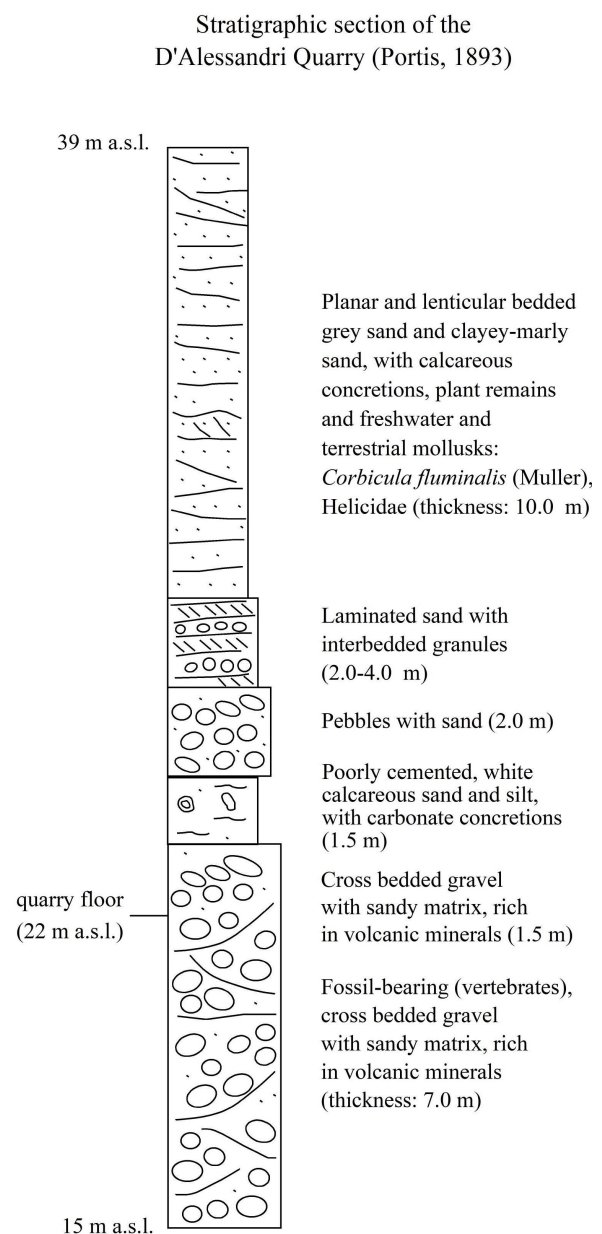
15 m a.s.l.

Fig. 4 - Stratigraphic-sedimentologic log of the Cava D'Alessandri; see figure 1 for the location of the log (red triangle).
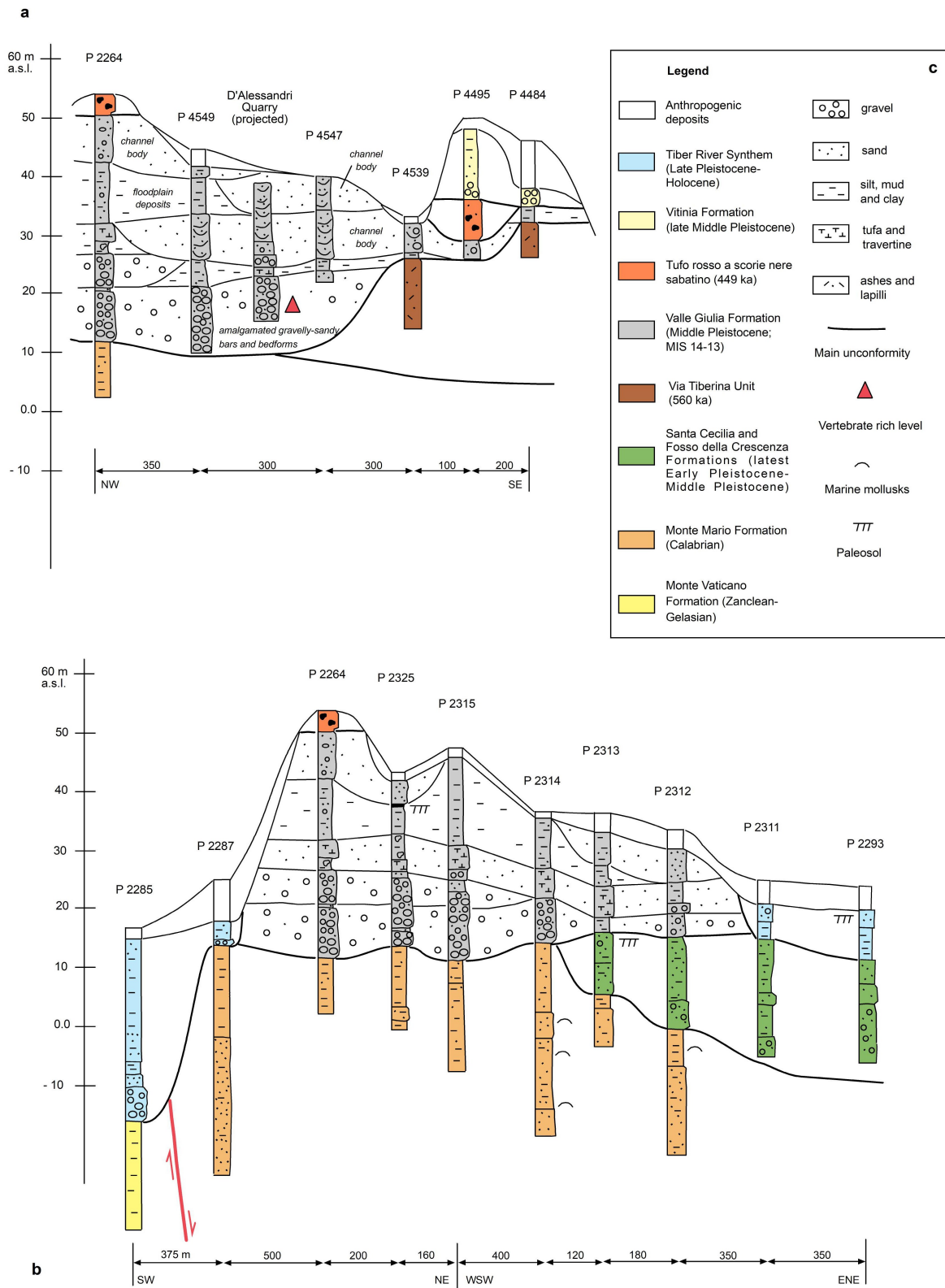
Fig. 5 - Correlation panels among borehole logs and the Cava D'Alessandri log detailing the stratigraphic architecture of the Ponte Molle-Tor di Quinto terrace: a) across-valley panel; b) down valley panel; c) legend. The location of boreholes is on figure 1.

Anatomical portion	Palaeoloxodon antiquus NISP	MNI	Hippopotamus ex gr. antiquus NISP	MNI	Stephanorhinus kirchbergensis NISP	MNI	Stephanorhinus hemitoechus NISP	MNI	Stephanorhinus sp. NISP	MNI	Bos primigenius NISP	MNI	Sus scrofa NISP	MNI	Cervus elaphus acoronatus NISP	MNI	Cervus elaphus eostephanoceros NISP	MNI
Horn core/Antler/Tusk	2	1									1						2	1
Cranium											2	1			1	1	3	3
Maxillary	1	1															1	1
Hemimandible	4	2	2	1							11	9					8	6
Upper teeth	9	1	9	3	6	2	4	1	23	1	142	17	3	1			7	2
Lower teeth	9	1	29	4	3	1			16	1	145	23	4	1			38	11
Teeth	10		1						4									
Scapula	1	1									1	1						
Humerus											2	2						
Radius											1	1						
Ulna																		
Metacarpal			1	1							3	3						
Carpal																		
Vertebra	11		2								42							
Rib	3		3															
Pelvi											1							
Femur									1	1	3	2						
Tibia			1	1							3	3						
Fibula																		
Astragalus	1	1	1	1							10	5					1	1
Calcaneus											1	1						
Tarsal																		
Metatarsal	1	1	1	1							1	1					1	1
Metapodial																		
I Phalange											3							
II Phalange											2							
III Phalange																		
Total	52	2	50	4	9	2	4	1	44	1	374	23	7	1	1	1	61	11

Anatomical portion	Dama clactoniana NISP	MNI	Capreolus capreolus NISP	MNI	Equus mosbachensis NISP	MNI	Equus hydruntinus NISP	MNI	Lepus sp. NISP	MNI	Castor fiber NISP	MNI	Canis cf. mosbachensis NISP	MNI	Crocuta crocuta NISP	MNI	Lynx sp. NISP	MNI	Meles meles NISP	MNI
Horn core/Antler/Tusk	13	2																		
Cranium																				
Maxillary													1	1						
Hemimandible	7	5	1	1							1	1	1	1						
Upper teeth	6	2			28	3	6	1												
Lower teeth	11	3			27	3	5	1							1	1				
Teeth																				
Scapula																				
Humerus									1	1							1	1	1	1
Radius																	1	1		
Ulna																	2	1		
Metacarpal																				
Carpal																				
Vertebra	7								1								1			
Rib									1											
Pelvi																	2	1		
Femur																	2	1		
Tibia					1	1											2	1		
Fibula																	2	1		
Astragalus					1	1														
Calcaneus																	1	1		
Tarsal																				
Metatarsal																				
Metapodial																				
I Phalange	1				1															
II Phalange																				
III Phalange					2															
Total	45	5	1	1	60	3	11	1	3	1	1	1	2	1	1	1	14	1	1	1

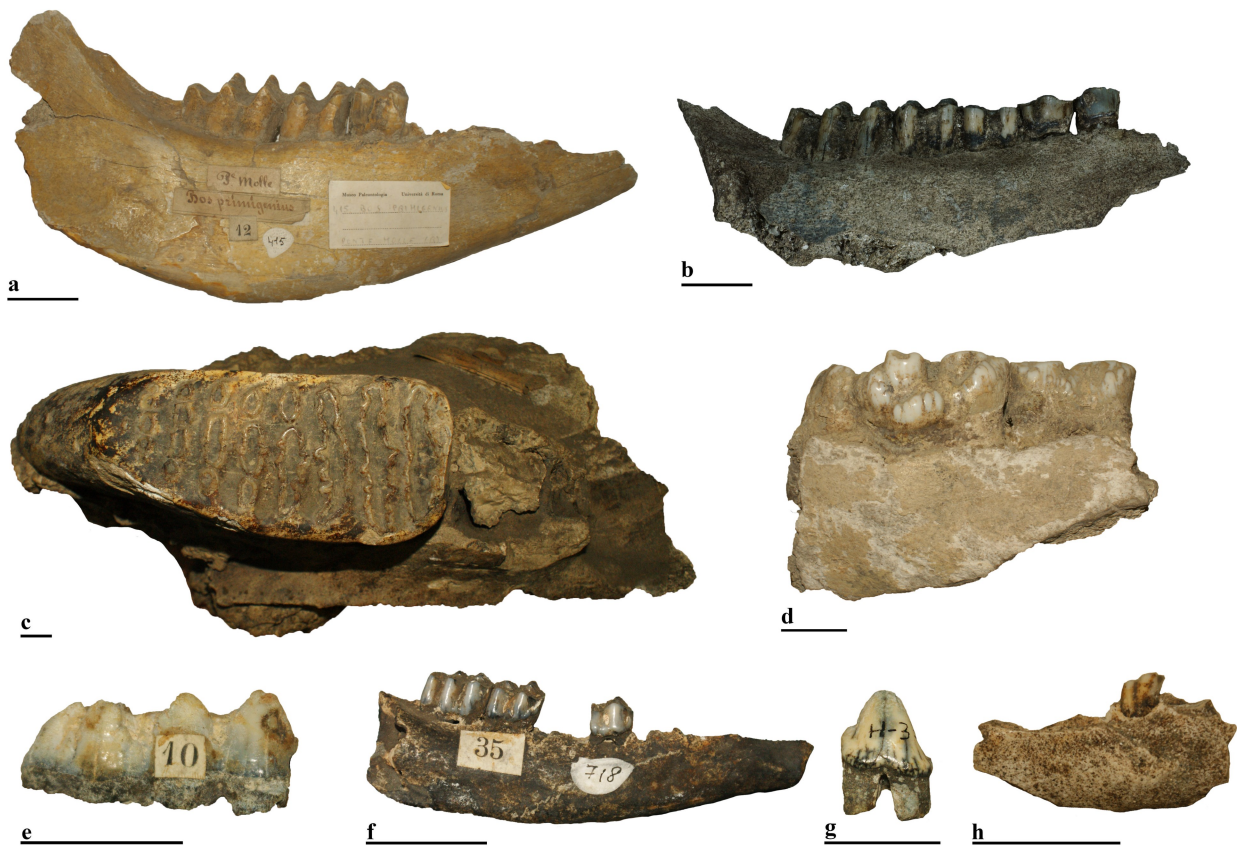Tab. 2 - Mammal fossil remains from Ponte Molle stored at MUST.

Fig. 6 - Mammal fossils from Ponte Molle: a - 415, right hemimandible of *Bos primigenius* in labial view; b - 426, right hemimandible of *Bos primigenius* in labial view; c -1857, right maxillary of *Palaeoloxodon antiquus* in occlusal view; d - 46, left hemimandible of *Hippopotamus* ex gr. *antiquus* in lingual view; e - 166, left lower third molar of *Sus scrofa* in lingual view; f - 718, right hemimandible of *Capreolus capreolus* in labial view; g - 1175, right lower third premolar of *Crocuta crocuta* in labial view; h - 128, right hemimandible of *Castor fiber* in lingual view. Scale bar 3 cm.

The lower portion of the incised-valley fill corresponds to amalgamated sandy gravels, 10-15 m thick, with cross bedded bars and bedforms of the braided river environment. The fossiliferous gravels correspond to the "cosiddette ghiaie diluviali di Ponte Molle" by Portis (1893) and form a laterally and downstream continuous body with tabular shape. They are related to the onset of the sea level rise occurred between MIS 14 and MIS 13 (latest lowstand and early transgressive phases of filling), at the end of the glacial phase.

Above the gravels, fluvial pebbly-silty sands alternate with floodplain fine deposits and with travertines and freshwater tufas. All these deposits recorded the fluvial sedimentation in response to the late rise and highstand of sea level during the MIS 13 (transgressive and highstand phases) and under interglacial climate conditions.

The sands define at least three vertically stacked channel bodies (*sensu* Gibling, 2006), each 10 m thick, lens shaped and with fining upward arrangement of facies, from pebbly to silty sand (Fig. 5a). The channel sands, likely attributed to a meandering-style fluvial system (as compared to other analogues in the Rome area; Milli et al., 2016), are laterally confined by planar bedded floodplain silt and muds, and by travertines and

tufas of fluvial and spring environments. Travertines and tufas, cropping out at Tor di Quinto, define a downstream almost continuous tabular body in the intermediate portion of the incised valley fill, at 20-30 m a.s.l. elevations (Fig. 5b). These continental carbonates record a well-known phase of increasing $CaCO_3$ deposition by spring waters, related to a renewal of the local tectonic activity during the MIS 13 (Funiciello & Giordano, 2008b).

On the top, the Valle Giulia Formation is constrained by the 449 ka old "Tufo rosso a scorie nero sabatino", which deposited on a morphologically very articulated surface recording the main fluvial incision at the MIS 13-12 transition. A following phase of fluvial sedimentation is represented by the Via Tiberina Unit, that deposited at the end of MIS 9 and MIS 8.5 (Giordano et al., 2003).

5.2. Faunal assemblage from Ponte Molle

The fossil sample from PM includes 741 taxonomically identified elements recovered from the lower part of the deposit, chronologically referred to the Middle Pleistocene (Tab. 2) (Fig. 6). The faunal assemblage is largely dominated by *Bos primigenius* (50.5%), which is mainly represented by isolated upper and lower teeth (Tab.

skeleton. The fossils are in a good state of preservation, although often enwrapped by a thin crust of sand with abundant volcanic material that range from reddish to greyish. A few specimens, especially the remains referable to large herbivores, are partially embedded in pebbles whose dimension vary from a few millimeters to more than ten centimetres. In the fossil material there is no sign of bite marks or rodent gnaw marks, or human butchering and exploiting activity. Therefore, it is possible to suggest that carnivorans or humans did not play any key role in the accumulation of the fossil remains. Unfortunately, the stratigraphic information written on specimen's labels is quite limited, preventing further taphonomic analyses.

Finally, likely deriving from the upper part of the deposit, clearly chronologically referable to the Holocene due to their preservation, several species were identified: *B. primigenius* (11 specimens), *Bubalus* sp. (1 specimen), *C. elaphus* (1 specimen), *Equus ferus* (6 specimens), *E. hydruntinus* (5 specimens) and *M. meles* (14 specimens; Mecozzi, 2021).

5.3. Taxonomic revision

The fossil sample from PM was never systematically studied, with only a preliminary faunal list reported by Di Stefano & Petronio (1992) and Capasso Barbato et al. (1998) (Tab. 1).

Here, we revised the fossil material stored at MUST.

The cervid sample is referred to four taxa: *C. elaphus acoronatus*, *C. elaphus eostephanoceros*, *D. clactoniana* and *C. capreolus*. The subspecies *C. elaphus acoronatus* is represented by a partial cranium and a nearly complete antler (Fig. 7), whereas the rest of the red deer sample is classified as *C. elaphus eostephanoceros* (Fig. 7). These two red deer subspecies differ in the terminal part of the antler: a simple bifurcation in *C. elaphus acoronatus* and a real crown with at least 5 tines in *C. elaphus eostephanoceros*. These two taxa were reported by Di Stefano & Petronio (1992, 1993) and their presence in the faunal assemblage from PM is confirmed.

Considering the medium-sized deer, no remain can be attributed to *Euraxis eurygonos* (=*Axis eurygonos*). The only fallow deer recognized from PM is *D. clactoniana* (Fig. 8). Di Stefano & Petronio (1997) proposed a new fallow deer subspecies based on the sample of PM, *D. dama tiberina*. The main diagnostic features of this taxon are related to the morphology of the antlers, which should be different from *D. clactoniana* in: a posterior direction of the spellers on the palm; a more basally located brow tine; brow tine and the trez tine less developed; flatter palm and terminal tines. Nevertheless, the morphology of the antler from PM is extremely close to that of *D. clactoniana* from Fontana Ranuccio, Riano and Swanscombe (Fig. 8). Considering that the taxonomy of the Plio-Pleistocene cervid is mainly based on antler (e.g., Di Stefano & Petronio, 1993; Breda & Lister, 2013), the morphological affinity of the antler from PM to that of *D. clactoniana* suggests it belongs to the same species, thus invalidating the validity of the subspecies *D. dama tiberina*. The differences proposed by Di Stefano & Petronio (1997) are not enough to separate *D.*

Fig. 7 - Antlers of *Cervus elaphus* from Ponte Molle: a, CE 4 *Cervus elaphus acoronatus* in frontal (1) and medial (2) views; b, SN151/FS, *Cervus elaphus eostephanoceros* in lateral (1) and medial (2) views. Scale bar 3 cm.

2). The cervids (*Cervus elaphus eostephanoceros* and *Dama clactoniana*) (14.5%), a large equid (*Equus mosbachensis*) (8.1%), the straight tusked elephant (*Palaeoloxodon antiquus*) (7%), rhinos (*Stephanorhinus hemitoechus, Stephanorhinus kirchbergensis, Stephanorhinus* sp.) (7.6%) and *Hippopotamus* ex gr. *antiquus* (=*Hippopotamus tiberinus*) (6.7%) are well represented, whereas *Sus scrofa*, *Equus hydruntinus* and *Capreolus capreolus* are quite scarce (Tab. 2). A single antler testifies the presence of *Cervus elaphus acoronatus* (Fig. 7). The middle- to small-sized mammals are represented by a lower number of fossils (2.7%), Among these, there are 14 remains ascribed to a single *Lynx* individual.

A restricted part of the sample is referred to juvenile individuals (9.8%), nearly exclusively represented by isolated teeth: *H.* ex gr. *antiquus* (2 specimens), *S. hemitoechus* (2 specimens), *Stephanorhinus* sp. (3 specimens), *B. primigenius* (37 specimens), *C. elaphus eostephanoceros* (1 specimen), *E. mosbachensis* (13 specimens) and *E. hydruntinus* (1 specimen). An exception is represented by the remains of *Lynx sp.,* where 14 juvenile postcranial specimens belonging to the same
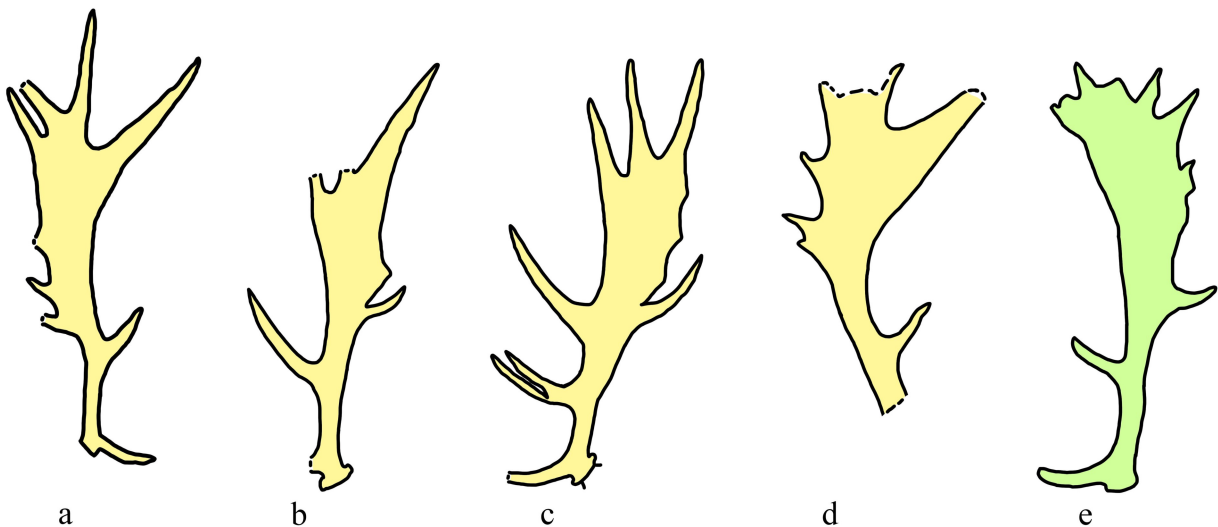
Fig. 8 - Antlers of fallow deer: a, MPUR 605 from Ponte Molle; b, Riano 6 from Riano (Leonardi & Petronio, 1976); c, 16349 from Swanscombe (Leonardi & Petronio, 1976); d, FR56539 from Fontana Ranuccio (Cassoli & Segre Naldini, 1993); e, no catalogue number of extant Italian specimen of *D. dama dama* (Di Stefano & Petronio, 1993). Colours: yellow -*Dama* clactoniana; green - extant *Dama dama dama*. The images are not in scale.

clactoniana and *D. dama tiberina*, but rather fall within the intraspecific morphological variability of the former. By contrast, the overall antler morphology of *D. clactoniana* largely differs from that of *D. dama* (see Leonardi & Petronio, 1976 for discussion).

A small-sized deer is also documented at PM, attested by a nearly complete hemimandible. Its morphology cannot be distinct from that of the extant specimens of *Capreolus capreolus*. Another cervid taxon was reported at PM, classified as *Megaceros* cf. *solilhacus* (=*Cervus* [*Praealces*] *latifrons*) (Tab. 1). Despite this, no remains of the MUST collection can be referred to a megacerine deer, but we cannot exclude that specimens of this taxon are stored in other repositories, as in the case of the horn core of *Hemibos galerianus*.

The taxonomical identification of Middle Pleistocene bovids faced considerable difficulties, especially for isolated and/or fragment fossils. Nevertheless, the sample from PM includes 374 remains, including diagnostic elements (Tab. 2). Portis (1907) also described several cranial fragments. We were able to recognize only a few of these specimens in MUST. There are, however, a few crania and cranial fragments in the old collection of MUST without information on their provenance and in need of restoration, some of which could have been recovered from PM. Several features can be detected in the PM sample: horn cores inserted in the cranium in a more latero-posterior position, with an outward and backward direction in the proximal part, and upward and slightly forward in the terminal part (e.g., Portis, 1907, Plate XIII, Fig. 3); well-developed entostyle and a more columnar and hypsodont appearance (swelling absent) of the upper molars; V-shaped enamel around the central cavity of both the upper and lower molars; the two main lobes more mesiodistally developed in the lower molars; presence of a small accessory stylid between hypoconid and hypoconulid in the lower

third molar (see Sala, 1986 for discussion). In postcranial elements, clear diagnostic features are less numerous but however significative, as the distally divergence of the medial and lateral intercondylar crests in metapodials (see Sala, 1986, for the description of other diagnostic features). The overall morphology of the sample from PM is close to that of *B. primigenius*.

Equids are the other well represented group in the faunal assemblage from PM, with two forms well-different in size. The taxonomic status of the Middle Pleistocene *Equus* is still a controversial topic, and no consensus is reached (van Asperen, 2012; Boulbes & van Asperen, 2019). The open issues concern how to interpret the biometric variations, if related to intraspecific variability or ecomorphotypes (e.g., van Asperen, 2012; Boulbes & van Asperen, 2019). As such, several authors referred the Middle Pleistocene fossils to *E. mosbachensis,* taxon only characterized for its large size and a few features of the postcranial elements (e.g., presence of the tendon insertion of the anterior brachialis muscle on the inner edge of the diaphysis of the radius, strong supra-articular tuberosities on metapodials) (e.g., Uzunidis-Boutillier, 2017; Boulbes & van Asperen, 2019). Conversely, van Asperen (2013) considered the European Middle Pleistocene sample as a single species, *E. ferus* ssp. The dental remains from PM are large-sized, whereas the postcranial elements provided no element for a taxonomical allocation. Considering the dimensions, the specimens are referred to the European Middle Pleistocene *E. mosbachensis.*

A few teeth of equid from PM can be instead referred to a small-sized form. Dental diagnostic features of *E. hydruntinus* have been summarized by Boulbes (2009): angular parastyle, rounded and narrow normally mesostyle, a deep postprotoconal valley, pli caballin simplified and short protocone in the upper teeth; metastylid longer than metaconid, with a less deep lin-

gual groove, a deep ectoflexid (on molars) and a few marked or absent pli caballin in the lower teeth. These features have been observed in the sample from PM, and therefore the presence of *E. hydruntinus* can be confirmed.

The hippo remains are very common in the European Plio-Pleistocene record, but even in this case there are conflicting opinions on their systematics and evolution (see van der Made et al., 2017b for discussion). Three forms are generally recognized: *Hippopotamus antiquus*, *Hippopotamus* ex gr. *antiquus* (= *H. tiberinus*) and *Hippopotamus amphibius*. Whereas the last shows clearly diagnostic morphological characters, well different than the other two taxa, *H. antiquus* and *H.* ex gr. *antiquus* differ mainly for their size (Mazza, 1995; Mazza & Bertini, 2013). Following the taxonomical diagnosis proposed by Mazza (1995), the morphology of the specimens from PM falls in the variability of *H. antiquus*. Based on the medium size of the remains, the sample from PM is ascribed to *H.* ex gr. *antiquus*.

The elephant sample from PM includes fragmentary tusks, partial maxillaries and hemimandibles, isolated upper and lower teeth and several postcranial elements (Tab. 2). Tusks are incomplete and no useful taxonomical characters can be observed. Dental remains are hypsodont and generally possess a high number of laminae, a high lamellar frequency, reduced enamel thickness and less developed cementum. These features are considered typical of *P. antiquus* (Palombo, 1986, 1995; Palombo et al., 2003).

One of the groups better investigated from PM is the Rhinocerotidae. The sample was taxonomically identified for the first time by Capasso Barbato et al. (1998), who

Catalogue number	Bilia & Petronio (2009)		Pandolfi (2013)	
	Anatomical identification	Specific attribution	Anatomical identification	Specific attribution
MPUR 1412/8	M_1 or M_2	*S. kirchbergensis*	M_1	*S. hundsheimensis*
MPUR 1417/115	M^2	*S. kirchbergensis*	M^2	*S. kirchbergensis*
MPUR 1421/107	P^4	*S. kirchbergensis*	P^4	*S. kirchbergensis*
MPUR 1445/27	M^1	*S. kirchbergensis*	DP^4	*S.* aff. *S. hundsheimensis*
MPUR 1454/117	M^3	*S. kirchbergensis*	M^3	*S. hundsheimensis*
MPUR 1454/118	M^3	*S. kirchbergensis*	M^3	*S. hundsheimensis*
MPUR 1420/97			P^4	*S. hundsheimensis*
MPUR 1438/18			DP^4	*S. hemitoechus*
MPUR 1439-134			P^3	*S. hemitoechus*
MPUR 1451/26			M^1	*S. hemitoechus*
MPUR 1448/51			DP_4	*S. hemitoechus*
MPUR 1456/126			P^4	*S. kirchbergensis*
MPUR 1446/49			M_1	*S. kirchbergensis*
MPUR1415/63			M_3	*S. kirchbergensis*
MPUR 1523/2			Femur	*S.* aff. *S. hundsheimensis*
MPUR 1465-114			DP^1	*Stephanorhinus* sp.
MPUR 1444-95			upper tooth	*Stephanorhinus* sp.
MPUR 1452-112			upper tooth	*Stephanorhinus* sp.
MPUR 1452-113			upper tooth	*Stephanorhinus* sp.
MPUR 1492			P^4	*Stephanorhinus* sp.
MPUR 1414-94			M^2	*Stephanorhinus* sp.
MPUR 1419-39			lower molar	*Stephanorhinus* sp.
MPUR 1416-43			M_2	*Stephanorhinus* sp.
MPUR 1416-42			M_3	*Stephanorhinus* sp.
MPUR 1456-127			upper tooth	*Stephanorhinus* sp.
MPUR 1440-119			upper molar	*Stephanorhinus* sp.
MPUR 1418-23			M^1	*Stephanorhinus* sp.
MPUR 1460-55			P_4	*Stephanorhinus* sp.
MPUR 1442-65			M_3	*Stephanorhinus* sp.
MPUR 1441-70			M_1 or M_2	*Stephanorhinus* sp.
MPUR 1450-64			M_2 or M_3	*Stephanorhinus* sp.

Tab. 3 - *Stephanorhinus* remains identified in previous works

recognized the presence of *S. kirchbergensis* and *S. hemitoechus*. Six isolated teeth of *S. kirchbergensis* were carefully described by Billia & Petronio (2009) (Tab. 3). Pandolfi (2013) revised these specimens and studied other rhino remains from PM (Tab. 3). The author classified as *S. hundsheimensis* four teeth previously attributed by Billia & Petronio (2009) to *S. kirchbergensis*, and referred other three teeth to *S. kirchbergensis* and four to *S. hemitoechus*. We need to take into account that Pandolfi (2013) recognized two distinct faunal assemblages, referred to Ponte Galeria and

Vitinia FUs respectively. Following this chronological repartition, the author attributed a few fossils from this hypothetical "lower level" to *S. hundsheimensis*. The revision of the material from PM supports the classification of Billia & Petronio (2009) for MPUR 1412/8, MPUR 1417/115, MPUR 1421/107, MPUR 1445/27, MPUR 1454/117 and MPUR 1454/118 as *S. kirchbergensis*. The revision of MPUR 1420/97 led doubt on the presence of *S. hundsheimensis*. In fact, its morphology differs from the P^4 of *S. hundsheimensis* from Isernia La Pineta (Ballatore & Breda, 2013) in the profile of the
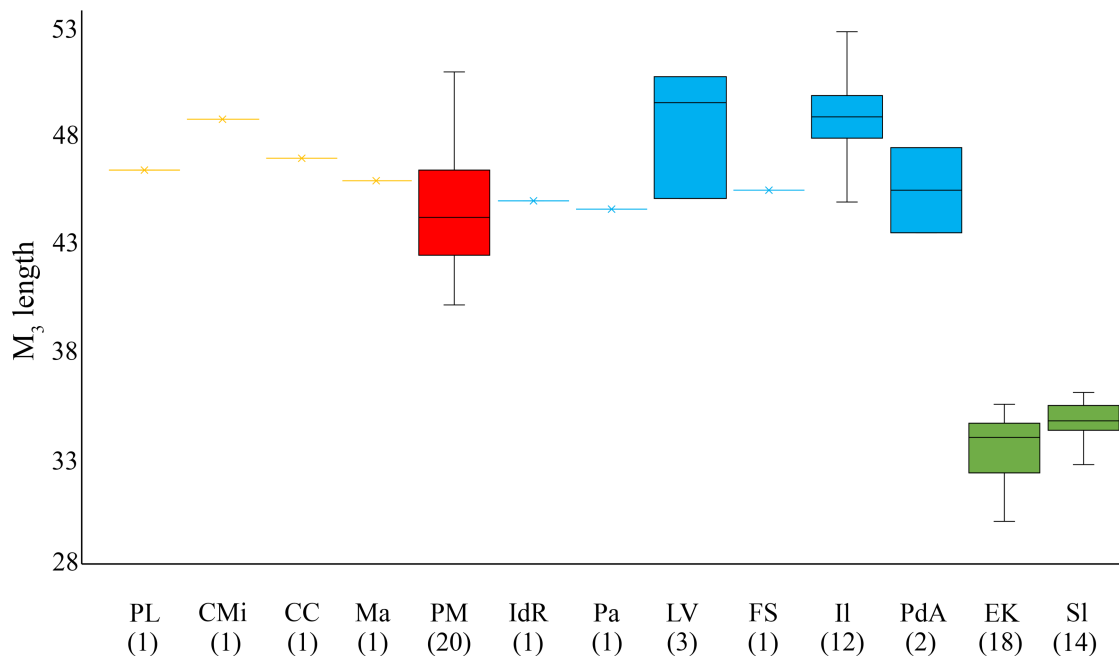
Fig. 9 - M_3 length (mm) of *Bos primigenius* from Middle Pleistocene sites of Europe and subfossil specimens of *Bos taurus*. Colors: Orange - early Middle Pleistocene: PL, Punta Lucero; CMi, Casa Minniti; CC, Contrada Cozze; Ma, Malagrotta; Red - PM, Ponte Molle; Light blue - late Middle Pleistocene: IdR, Igue des Rameaux-amont; Pa, Payre; LV, Lunel-Viel; FS, Fara Sabina; Il, Ilford; PdA, Pech de l'Azé II; Green - subfossil specimens of *Bos taurus;* EK, Elvas-Kreuzwiese; Sl, Silves-lix. Number of specimens indicated in the brackets.

postfossette and the medisinus. In this scenario, we confirm the presence of *S. kirchbergensis* and *S. hemitoechus*, whereas that of *S. hundsheimensis* cannot be supported.

Sus scrofa is the only suid species documented in the European Middle Pleistocene, it differs from the Early Pleistocene *Sus strozzii* in several anatomical features, the most notable on wild boar remains from PM are the presence of a "scrofic" cross-section of male lower canines and the proportionally narrower teeth (Iannucci et al., 2020a). The chronosubspecific repartition in a large-sized *Sus scrofa priscus* eventually giving rise to a small-sized *S. scrofa scrofa* (e.g., Fistani, 1996) seems a too simple interpretation of a more complex pattern, with several dimensional shifts occurred during the Pleistocene (Lister et al., 2010; Iannucci et al., 2020b).

Two taxa are here identified for the first time: *Castor fiber* and *Lepus* sp. The European beaver is documented only by a partial hemimandible, which possesses features falling in the variability of the extant specimens of *C. fiber* (Komosa et al., 2007; Nowicki et al., 2019). In addition, the specimen is similar to those reported from Cuenca-Bescos et al. (2017) from several Spain Pleistocene deposits, with a lower first molar squared in shape in occlusal view, both mesial and posterior sides planar, less brachyodont chewing teeth and lacking fossettids (isolated enamel islands on the occlusal surface). Few fragmentary postcranial elements can be attributed to hare. Lack of clear diagnostic features prevents a specific attribution.

Carnivorans at PM are quite scarce. Portis (1909)

reported the presence of *Lynx*, *Canis lupus* and *Meles meles* (Tab. 1). According to the author, the lynx sample included a partial hemimandible, currently lost. Other fossils belong to the same skeleton probably found in anatomic connection. A recent study focuses on evolutionary history of European fossil lynxes, which reveals as *L. pardinus* (=*Lynx spelaeus/Lynx pardinus spelaeus*) is the only lynx recognized during the Middle Pleistocene (Mecozzi et al., 2021a). In the PM sample, only skeleton remains are documented, which have small dimensions. Nevertheless, postcranial diagnostic characters in fossil lynxes are quite unmapped. Considering this, we attributed these specimens to *Lynx* sp., avoiding the taxonomical attribution based on chronological grounds.

Canid sample consists of a lower canine and two replica of left maxillary and right hemimandible respectively. Portis (1909) noted the lacking of the original specimens, writing (Pag. 220):"*Dove si trovano conservati gli originali di questi due modelli?*" (Where are the original specimens of these two replica stored?). In addition, three specimens, two partial hemimandibles and a lower first molar described by Portis (1909), are not present in the MUST sample. The available material shows a reduced size and the protocone of the upper fourth premolar is aligned with the mesial margin of the teeth. A small-sized *Canis,* currently lost, was also reported by Portis (1909). Thus, we suggest a possible attribution to *Canis* cf. *mosbachensis*.

Portis (1909) also described the right complete humerus of the European badger. The revision of this fossil confirms its attribution to *M. meles.*
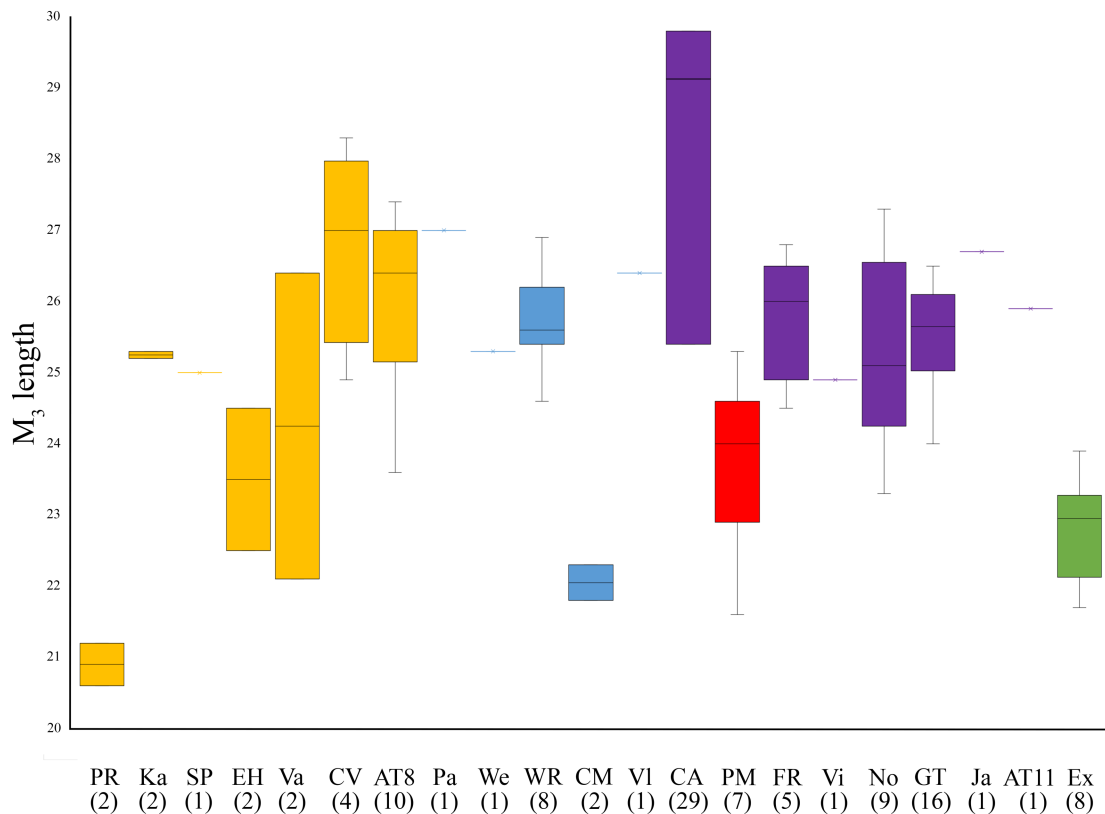
Fig. 10 - M$_3$ length (mm) of medium-sized deer from late Early Pleistocene to late Middle Pleistocene sites of Europe and extant specimens. Colors: Orange - *Pseudodama* group: PR, Pirro Nord; Ka, Kalamotó; SP, Saint-Prest; EH, Erpfinger Höhle; Va, Le Vallonnet; CV, Cueva Victoria; AT8, Atapuerca TD8; Light blue - *Dama roberti*: Pa, Pakefield; We, Westbury; WR, West Runton; CM, Contrada Monticelli (*Dama* cf. *roberti*); Vl, Valdemino; red - PM, Ponte Molle; Purple: *Dama clactoniana*; CA, Caune de l'Arago (*Dama* cf. *clactoniana*); FR, Fontana Ranuccio; Vi, Visogliano; No, Notarchirico; GT, Grays Thurrock; Ja, Jarwick; AT11, Atapuerca TD11; Green - Ex, extant specimens of *Dama dama dama*. Number of specimens indicated in the brackets.

The last carnivoran species, reported only by Capasso Barbato et al. (1998) (Tab. 1), is *Crocuta crocuta*. An upper third premolar and a replica of coprolite can be assigned to the spotted hyaena. The P^3 is squared in shape in occlusal view, its labial margin is quite straight and the lingual cingulum is absent; distal accessory cusp is connected to the paracone with a weak crest. These features resemble those of *C. crocuta,* and differ from those of *Hyaena prisca* (=*Pliocrocuta perrieri*).

Two additional carnivorans, an ursid and a large felid, were reported by previous works (Tab. 1). Nevertheless, no fossils of the MUST sample can be attributed to these taxa, thus their presence at PM cannot be confirmed. Similarly, to large-sized deer, we cannot exclude that additional fossils could be stored in other repository, as the Scientific Cabinet of high schools of Rome or the Monastery of Santa Scolastica in Subiaco (Rome). Finally, considering the misadventures suffered by the paleontological collection of MUST during the 1900 century, we cannot exclude that part of the sample from PM has been destroyed.

5.4. Biometry of selected taxa

The biometric comparison of the M$_3$ of *B. primige-*

nius from Middle Pleistocene European sites highlights no chronological or geographical trend (Fig. 9). In particular, the rich sample from PM (21 specimens) shows a large variability, which encompasses that of the fossil specimens from Middle Pleistocene sites of Europe. Subfossil samples of *B. taurus* include specimens with shorter M$_3$.

The length of M$_3$ of the fossil samples belonging to the fallow deer lineage shows a large variability (Fig. 10). The sample from Pirro Nord displays the smallest size among the considered samples, well different from the other contemporaneous materials (late Early Pleistocene). No great difference can be detected among the fossil taxa, which generally possess a longer M$_3$ than the extant Italian specimens of *D. dama dama*. It is noteworthy that the two smallest samples in figure 10 are from Pirro Nord and Contrada Monticelli sites, both geographically located in the Apulian Peninsula (southern Italy), which represent the southern margin of their geographical range.

The biometric comparison of *S. scrofa* M$_3$ length also shows a large variability, with no clear chronological or geographical trend identifiable (Fig. 11). Middle Pleistocene specimens are on average larger than the extant
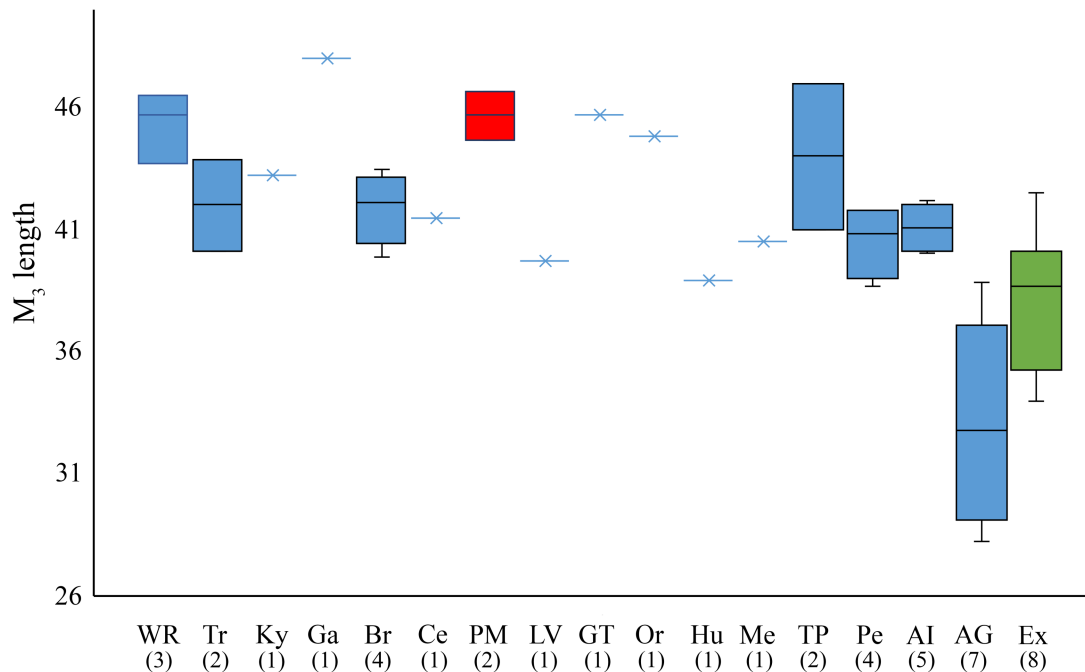
Fig. 11 - M$_3$ length (mm) of *Sus scrofa* from Middle Pleistocene sites of Europe and extant specimens.
Colors: Light blue - *Sus scrofa*: WR, West Runton; Tr, Trimingham; Ky, Kyparissia; Ga, Gajtan; Br, Bristie 1; Ce, Cerè; LV, Lunel-Viel; GT, Grays Thurrock; Or, Oreston; Hu, Hutton; Me, Melpignano; TP, Torre del Pagliaccetto; Pe, Petralona; AI, Apulia Interglacial (MIS 5 and MIS 3 Apulian sites); AG, Apulia Glacial (MIS 4 and MIS 2 Apulian sites); Red - PM, Ponte Molle; Green - Ex, extant specimens of *Sus scrofa*. Number of specimens indicated in brackets.

Italian populations, and the sample of Late Pleistocene MIS 4 and MIS 2 Apulian sites is the only one markedly smaller. Remains from PM are among the largest of the European Middle Pleistocene.

The plot of the M$_3$ of fossil and extant hippos reveals differences between the groups: *H. antiquus* which generally has longer teeth. *H.* ex gr. *antiquus*, fossil and extant *H. amphibius* are characterized by reduced dimensions (Fig. 12).

6. DISCUSSION

6.1. The age of the deposit

From the stratigraphic analysis, the fauna from Cava D'Alessandri can be attributed to the lower gravelly level of the Valle Giulia Formation. This formation is chronologically constrained by two radiometrically well dated ignimbrites, i.e. at the base by the 550 ka old Via Tiberina Unit and on the top by the 449 ka "Tufo rosso a scorie nere sabatino". On the basis of the detailed sedimentological reconstruction of the internal architecture of the PM-Tor di Quinto fill terrace (sensu Pazzaglia, 2013), it is excluded that the basal gravels of PM ("cosiddette ghiaie diluviali di Ponte Molle") could be attributed to other fluvial formations older than the Valle Giulia Formation. In fact, the Fosso della Crescenza and Santa Cecilia Formations in the study area are very different from the basal gravels, being represented by prevailing sand and silt.

This suggests, for this restricted area, the occurrence of different facies for the different formations (or portions of them) to be correlated to diverse depositional environments: gravelly-dominated braided river environment for the basal Valle Giulia Formation; sand-dominated meandering-style river environment for the Fosso della Crescenza-Santa Cecilia Formations (Fig. 5).

6.2. Biochronological implications

The revision of the geological and stratigraphic data indicates a time deposition between 540 and 460 ka for the mammal faunal assemblage from PM, which confirms a Middle Pleistocene age for the deposit. Among mammals identified in the MUST sample, several species provide further biochronological insights.

The first group considered is Rhinocerotidae, with two species recorded: *Stephanorhinus kirchbergensis* and *S. hemitoechus*. *Stephanorhinus kirchbergensis* is poorly documented in Italy, but in addition to PM this species was recorded from the Middle Pleistocene sites of Visogliano (MIS 13-10) (Pandolfi, 2013) and Tor di Quinto (MIS 13) (Pandolfi & Marra, 2015). *Stephanorhinus hemitoechus* can be considered an important marker as its earliest occurrence in Europe is from an undefined site of Campagna Romana, approximately dated at about 0.5 Ma (age estimated from the correlation of the encrusted pumice after texture and the geochemical analyses; Pandolfi et al., 2013), and from the Caune de

l'Arago, from levels chronologically referred to MIS 14 (Moigne et al., 2006).

The second group with strong chronological implications is Cervidae. The presence of *D. clactoniana* and *C. elaphus eostephanoceros* clearly indicates a Middle Pleistocene age. The Clacton fallow deer (*D. clactoniana*) appears in several European localities during MIS 11 (Breda et al., 2013) but it is possible that its dispersal predates this age. Indeed, in central Italy an earlier occurrence may be that from the levels alfa and a of Notarchirico (Cassoli et al., 1999), whose interbedded reworked volcanic minerals have been recently dated between 658±9 Ka and 612±5 Ka (Moncel et al., 2020; Mecozzi et al., 2021b). The other cervid group, the red deer, is represented by two different subspecies: *C. elaphus acoronatus* and *C. elaphus eostephanoceros*. The first subspecies is represented by an isolated partial cranium and complete antler (Fig. 7). In Italy, the crownless red deer (*C. elaphus acoronatus*) is recorded from Slivia to Isernia FUs (ca 850-550 ka) (e.g., Palombo et al., 2001; Petronio et al., 2011). Its presence at PM is quite surprising, since it is the only taxon that would suggest an early Middle Pleistocene age. Despite this, we need to consider that these fossils were collected during the end of 1800s and early decades of 1900s, during quarrying activity. Moreover, this is one of those remains that are not accompanied by a historical label, and the possibility that it may have been recovered from an older deposit outcropping in the surrounding area should be taken into account. The other red deer, most common in the studied sample, is the eostephanoceros red deer (*C. elaphus eostephanoceros*) (Fig. 7). This taxon was instituted by Di Stefano & Petronio (1993) mainly considering the antler discovered at Cava Nera Molinario (Rome, central Italy) and Fontana Ranuccio, localities chronologically ranging between about 500 - 400 Ka (Marra et al., 2018; Strani et al., 2018). However, considering the chronostratigraphic revision carried out by Marra et al. (2014, 2018), it seems that both subspecies are documented from deposits of the area of

Rome referred to MIS 13, namely *C. elaphus acoronatus* from Via Flaminia Km 8.2, and *C. elaphus eostephanoceros* from Cava Nera Molinario) (see Iannucci et al., 2021 for discussion).

Among the equids, of considerable interest is the presence of *E. hydruntinus*, whose evolutionary history was recently redefined by Boulbes & van Asperen (2019). The authors suggested a clear presence of this taxon in the European record since the late Middle Pleistocene (MIS 11), with a possible first dispersal during MIS 15. In Italy, this taxon was considered as a marker of the Aurelian large mammal faunal assemblage (late Middle Pleistocene, Gliozzi et al., 1997). However, new findings from Vallparadís Section (level 11, EVT3, dated later than 600 ka) (Aurell-Garrido et al., 2010; Martínez et al., 2014) and quarry Carpentier d'Abbeville (dated and correlated with MIS 15) (Antoine et al., 2016) suggest an earlier dispersal of the Regalìa Ass (*E. hydruntinus*) in Europe.

The wild boar, *S. scrofa*, is scarcely represented during early Middle Pleistocene glacial stages, and the relatively large size of the remains recovered from PM is close to that of other findings referred to MIS 13, MIS 11 or MIS 9 interglacials (Fig. 11; Iannucci et al., 2020b).

Other mammal taxa identified in the PM faunal assemblage indicate a Middle Pleistocene age, but with no clear chronological definition, among which *H.* ex gr. *antiquus, E. mosbachensis*, and *C.* cf. *mosbachensis*. Finally, several species from PM provide no constraints, since they are characterized by a long chronological distribution (Middle to Late Pleistocene or Holocene), as *P. antiquus, B. primigenius, S. scrofa, C. capreolus, C. fiber, C. crocuta, Lynx* sp. and *M. meles*. In this scenario, the faunal assemblage of PM could be referred to MIS 13.

6.3. Paleoenvironmental implications

Redefining the PM faunal assemblage provides important paleoenvironmental and paleoecological clues. Indeed, the species represented constitute a fau-
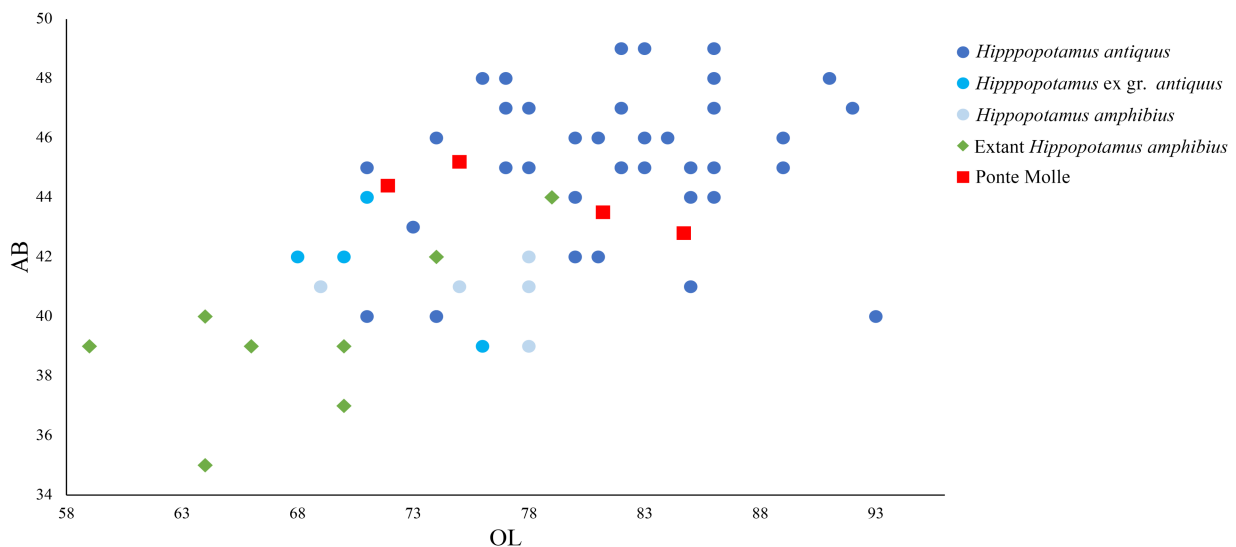

Fig. 12 - Plot of outer length (OL) vs. anterior breadth (AB) of M₃ of fossil and extant hippos.

nal assemblage typical of Middle Pleistocene interglacials of Italy (Strani et al., 2018). The presence and relative abundance of *P. antiquus, H.* ex gr. *antiquus, C. elaphus eostephanoceros, D. clactoniana, S. scrofa* and *B. primigenius* indicate warm and humid climatic conditions. This could be also true for *Hemibos galerianus,* ancestral to the *Bubalus* lineage (Petronio & Sardella, 1998; Martinez Navarro et al., 2011), considering the occurrences and plausible ecological preferences of the extinct buffalo (Koenigswald et al., 2019). Nonetheless, the mix of taxa adapted to different environments suggests the presence of a mosaic of open spaces (e.g. rhinos and equids) and woodlands (e.g. cervids and *S. scrofa*).

Other ecological and paleoenvironmental information can be inferred from the biometric comparisons of *S. scrofa* and *D. clactoniana*. In fact, even though these species are greatly chronologically and geographically variable (Lister et al., 2010; van der Made et al., 2014; Di Stefano et al., 2015; Iannucci et al., 2020a; Stefanelli & Mecozzi, 2020), shifts in size can be influenced by ecological factors (Geist, 1971, 1987; Lindstedt & Boyce, 1985; Weinstock, 1997).

Focusing on a temporal and chronologically well-constrained sample, Iannucci et al. (2020b) recognized several size shifts experienced by *S. scrofa* during the late Middle Pleistocene to Early Holocene of Apulia in southern Italy, with smaller population occurring during glacial stages. They suggest an indirect triggering role of climate, in reducing the availability of trophic resources. Even though more data are needed to substantiate this hypothesis and elucidate its geographical constraints, *S. scrofa* remains from the Middle Pleistocene of the area of Rome are scanty but usually large-sized (Fig. 11), and thus fit well with what expected for interglacial stages in the Mediterranean area.

The very small size of the fallow deer of PM is also interesting though puzzling to interpret. Indeed, according to Weinstock (1997) the more severe winters of glacial stages should cause a strong decrease of the food supply and lead to a higher mortality rate. This leads to a decrease of the intraspecific competition during the following growth season (Guthrie, 1984), which implies a higher quality and quantity of food resources (Weinstock, 1997). Therefore, glacial and interglacial size fluctuations in cervids should be observed. Nevertheless, the dimensions of the late Early to Middle Pleistocene European samples do not support this separation (Fig. 10). It is possible that this reflects a different ecological adaptation in the species, which would be worth to be investigated in future research.

7. CONCLUSIONS

The large mammal faunal assemblage from Ponte Molle is dominated by *Bos primigenius*, with *Palaeoloxodon antiquus*, *Hippopotamus* ex gr. *antiquus, Cervus elaphus eostephanoceros* and *Equus mosbachensis* well represented (Tab. 1). The carnivorans are documented by a few taxa, all represented by a limited sample.

Aside from a few spurious Holocene specimens, most of the faunal elements are consistent with an attribution to a single assemblage, which best fits within the Fontana Ranuccio FU. The historical background and geological constraints also support the view that the recovery of fossil remains from the area of PM was concentrated in the Valle Giulia Formation, which is dated between 540 ka and 460 ka. Even though we cannot exclude that a few specimens may have been misreported or mixed from different layers, an age older than 550 Ky seems highly unlikely, as no formation of such an old age is documented in the area.

Moreover, the presence or relative abundance of species usually widespread during warm periods, such as *B. primigenius, P. antiquus, H.* ex gr. *antiquus, C. elaphus eostephanoceros* and *D. clactoniana,* is also suggestive of an interglacial environment.

The reassessment of the classical fauna from PM, and the re-description of the sections of Cava D'Alessandri, Torretta di Quinto, and Acquatraversa will serve as a basis for reinterpreting other historical and recent collections of the area of Rome, as well as providing new data for our understanding of Middle Pleistocene mammal assemblages of Europe.

REFERENCES

Ambrosetti P., Bonadonna F.P. (1967) - Revisione dei dati sul Plio-Pleistocene di Roma. Atti Accademia Gioenia di Scienze Naturali in Catania, 18, 33-70.

Angellelli F. (1981) - Cenni preliminari sulla fauna Quaternaria di Fara Sabina (Rieti) conservata nel Museo del Servizio Geologico D'Italia. Bollettino del Servizio geologico d'Italia, 102, 3-12.

Antoine P., Moncel M.H., Limondin-Lozouet N., Locht J.L., Bahain J.J., Moreno D., Voinchet P., Auguste P., Stoetzel E., Dabrowski J., Bello S.M., Parfitt S.A., Trombret O., Hardy B. (2016) - Palaeoenvironment and dating of the early acheulean localities from the Somme river basin (Northern

France): new discoveries from the high terrace at Abbeville-carriere Carpentier. Quaternary Science Reviews, 149, 338-371.
Doi: 10.1016/j.quascirev.2016.07.035

Athanassiou A., Michailidis D., Vlachos E., Tourloukis V., Thompson N., Harvati K. (2018) - Pleistocene vertebrates from the Kyparíssia lignite mine, Megalopolis Basin, S. Greece: Testudines, Aves, Suiformes. Quaternary International, 497, 178-197.

Aurell-Garrido J., Madurell-Malapeira J., Alba D.M., Moyà-Solà S. (2010) - The stenonian and caballoid equids from the Pleistocene section of Vallparadís (Terrassa, Catalonia, Spain). Cidaris, 30, 61-66.

Azanza B., Sanchez B. (1990) - Les cervidés du Pléistocene moyen d'Atapuerca (Burgos, Espagne). Quaternaire, 1(3-4), 197-212.

Ballatore M., Breda M. (2013) - *Stephanorhinus hundsheimensis* (Rhinocerontidae, Mammalia) teeth from the early Middle Pleistocene of Isernia La Pineta (Molise, Italy) and comparison with coeval British material. Quaternary International, 302, 169-183.

Billia E.M., Petronio C. (2009) - Selected records of *Stephanorhinus kirchbergensis* (Jäger, 1839) (Mammalia, Rhinocerotidae) in Italy. Bollettino della Società Paleontologica Italiana, 48(1), 21-32.

Bökönyi S. (1970) - A new method for determination of the number of individuals in animal bone material. American Journal of Archaeology, 74, 291-292.

Boschin F. (2018) - Animal remains from the multilayered site of Elvas-Kreuzwiese pf 574 (South Tyrol, Italy). Annalen des Naturhistorischen Museums in Wien. Serie A für Mineralogie und Petrographie, Geologie und Paläontologie, Anthropologie und Prähistorie, 120, 195-210.

Boulbes N., van Asperen E.N. (2019) - Biostratigraphy and Palaeoecology of European *Equus*. Front. Ecol. Evol., 7, 301.
Doi: 10.3389/fevo.2019.00301

Breda M. (2015) - The early Middle Pleistocene fallow deer *Dama roberti* new insight on species. Geological Journal, 50, 257-270.

Breda M., Lister A. (2013) - *Dama roberti*, a new species of deer from the early Middle Pleistocene of Europe, and the origins of modern. Quaternary Science Reviews, 69, 155-167.

Bridge J.S. (2003) - Rivers and Floodplains. Forms, Processes, and Sedimentary Record. Blackwell Publishing, Oxford, pp. 491.

Caloi L., Palombo M.R. (1978) - Anfibi, rettili e mammiferi di Torre del Pagliaccetto (Torre in Pietra, Roma). Quaternaria, 20, 315-428.

Caloi L., Palombo M.R. (1979) - Resti di mammiferi del Pleistocene Medio di Malagrotta (Roma). Bollettino del Servizio Geologico Italiano, 100, 141-188.

Caloi L., Palombo M.R. (1986) - Le Mammalofaune Plio-Pleistocene dell'area Laziale: problemi biostratigrafici ed implicazioni paleoclimatiche. Memorie del Servizio Geologico Italiano, 35, 99-126.

Capasso Barbato L., Di Stefano G., Petronio C.,Sardella R. (1998) - Pleistocene mammal faunas from Ponte Molle (Rome). Quaternary International, 47/48, 73-75.

Cassoli P.F., Segre A.G. (2004) - *Bubalus murrensis* Berk. Nel Pleistocene Romano. Quaternaria Nova, 7, 129-138.

Cassoli F., Di Stefano G., Tagliacozzo A. (1999) - I Vertebrati dei livelli superiori (Alfa ed A) della serie stratigrafica di Notarchirico. In: Notarchirico: Un sito del Pleistocene medio iniziale nel bacino di Venosa (Ed. by Piperno M.). Edizioni Osanna, Venosa, Italia, 361-438.

Cavarretta G., Cavinato G.P., Mancini M., Moscatelli M., Patera A., Raspa G., Stigliano F., Vallone R., Folle D., Garbin F., Milli S., Storoni Ridolfi S. (2005) - I terreni di Roma sotto l'aspetto della geologia tecnica. In: La IV dimensione. Lo spazio sotterraneo di Roma. (Ed. by Gisotti G., Pazzagli G., Garbin F.). Geologia dell'Ambiente, suppl. 4/2005, 33-46.

Ciotoli G., Stigliano F., Mancini M., Marconi F., Moscatelli M., Cavinato G.P. (2015) - Geostatistical interpolators for the estimation of the geometry of anthropogenic deposits in Rome (Italy) and related physical-mechanical characterization with implications on geohazard assessment. Environmental Earth Sciences, 74, 2635-2658.

Collinson J., Mountney N., Thompson D. (2006) - Sedimentary Structures. Third Edition. Terra Publishing, Edinburgh, pp. 292.

Conato V., Esu D., Malatesta A., Zarlenga F. (1980) - New data on the Pleistocene of Rome. Quaternaria, 22, 131-176.

Cosentino D., Cipollari P., Di Bella L., Esposito A., Faranda C., Giordano G., Gliozzi E., Mattei M., Mazzini I., Porreca M., Funiciello R. (2009) - Tectonics, sea-level changes and palaeoenvironments in the early Pleistocene of Rome (Italy). Quaternary Research, 72(1), 143-155.

Davis S. J., Gonçalves M.J., Gabriel S. (2008) - Animal remains from a Moslem period (12th/13th century AD) lixeira (garbage dump) in Silves, Algarve, Portugal. Revista portuguesa de Arqueologia, 11(1), 183-258.

de Lumley H., Kahlke H.-D., Moigne A.M., Moulle P.E. (1988) - Les faunes des Grands Mammiferes de la grotte du Vallonnet, Roquebrune-cap-Martin, Alpes-Maritimes. L'Anthropologie, 92(2), 465-496.

De Rita D., Funiciello R., Corda L., Sposato A., Rossi U. (1993) - Volcanic units. In: Sabatini Volcanic Complex (Ed. by Di Filippo M.), Consiglio Nazionale Delle Ricerche, Progetto Finalizzato "Geodinamica" Monografie Finali, 11, 33-79.

De Stefani C. (1904) - Gli strati subterrestri della cava Mazzanti al Ponte Molle. Atti della Reale Accademia dei Lincei, Rendiconti classe di scienze fisiche, matematiche e naturali - Geologia, 13, 319-325.

Di Stefano G. (1994) - Il daino pleistocenico dell'Eurasia. PhD Thesis, Sapienza, University of Rome, pp. 270.

Di Stefano G., Petronio C. (1992) - Nuove osservazioni su *Cervus elaphus acoronatus* Beninde del Pleistocene europeo. Bollettino della Società Paleontologica Italiana, 31(3), 295-315.

Di Stefano G., Petronio C. (1997) - Origin and evolution

of the European fallow deer (*Dama*, Pleistocene). Neues Jahrbuch für Geologie und Paläontologie, 203, 57-75.

Di Stefano G., Petronio C., Sardella R. (1998) - Biochronology of Pleistocene mammal faunas from Rome urban area. Il Quaternario, 11, 191-199.

Di Stefano G., Pandolfi L., Petronio C., Salari L. (2015) - Considerations on the morphometry and the occurrence of *Cervus elaphus* (Mammalia, Cervidae) from the Late Pleistocene of the Italian Peninsula. Rivista Italiana di Paleontologia e Stratigrafia, 121, 1-18.

Driesch von den A. (1976) - A guide to the measurement of animal bones from archaeological sites. Peabody Museum Bulletin 1, 1-136.

Fabiani R. (1919) - I mammiferi quaternari della regione Veneta. Memorie dell'Istituto Geologico Universitario di Padova, 5, 1-174.

Fabiani R., Maxia E.C. (1953) - L'Istituto e i Musei di Geologia e Palentologia. Pubblicazione Istituto di Geologia e Paleontologia di Roma, 9, 1-31.

Fistani A.B. (1996) - *Sus scrofa priscus* (Goldfuss, de Serres)(Mammalia, Artiodactyla, Suidae) from the Middle Pleistocene layers of Gajtan 1 site, southeast of Shkodër (north Albania). Annales de Paléontologie, 82, 177-229.

Funiciello R., Giordano G. (2008a) - Carta Geologica d'Italia alla scala 1:50.000, Foglio 374 Roma. APAT, Dipartimento Difesa del Suolo, Servizio Geologico d'Italia.

Funiciello R., Giordano G. (2008b) - Note illustrative della Carta Geologica d'Italia alla scala 1:50.000, Foglio 374 Roma. APAT, Dipartimento Difesa del Suolo, Servizio Geologico d'Italia, pp. 158.

Funiciello R., Giordano G. (2010) - The Colli Albani Volcano. IAVCEI Special Publication, n. 3, pp. 400.

Funiciello R., Rosa C. (1995) - L'area romana e lo sviluppo delle ricerche geologiche. In: Funiciello R. (ed.) La Geologia di Roma. Il Centro Storico. Memorie Descrittive della Carta Geologica d'Italia, 50, 23-29.

Geist V. (1971) - Mountain Sheep: A Study in Behavior and Evolution. University of Chicago Press, Chicago, pp. 383.

Geist V. (1987) - Bergmann's rule is invalid. Canadian Journal of Zoology, 65, 1035-1038.

Gibling M.R. (2006) - Width and thickness of fluvial channel bodies and valley fills in the geological record: a literature compilation and classification. Journal of Sedimentary Research, 76, 731-770.

Giordano G., Esposito A., De Rita D., Fabbri M., Mazzini I., Trigari A., Rosa C., Funiciello R. (2003) - The sedimentation along the Roman coast between Middle and Upper Pleistocene: the interplay of eustatism, tectonics and volcanism. New data and review. Il Quaternario, 16(1bis), 121-129.

Giustini F., Brilli M., Mancini M. (2018) - Geochemical study of travertines along middle-lower Tiber valley (central Italy): genesis, palaeo-environmental and tectonic implications. International Journal of Earth Sciences, 107, 1321-1342.

Gliozzi E., Abbazzi L., Argenti A., Azzaroli A., Caloi L., Capasso Barbato L., Di Stefano G., Esu D., Ficcarelli G., Girotti O., Kotsakis T., Masini F., Mazza P., Mezzabotta C., Palombo M.R., Petronio C., Rook L., Sala B., Sardella R., Zanalda E., Torre D. (1997) - Biochronology of selected Mammals. Molluscs and Ostracodes from the Middle Pliocene to the Late Pleistocene in Italy. The state of the art. Rivista Italiana di Paleontologia e Stratigrafia, 103 (3), 369-388.

Gómez-Olivencia A., Sala N., Arceredillo D., García N., Martínez-Pillado V., Rios-Garaizar J., Garate D., Solar G., Libano, I. (2015) - The Punta Lucero Quarry site (Zierbena, Bizkaia): a window into the Middle Pleistocene in the Northern Iberian Peninsula. Quaternary Science Reviews, 121, 52-74.

Grayson D.K. (1984) - Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas. Academic Press, Orlando, pp. 202.

Guérin C. (1980) - Les rhinocéros (Mammalia, Perissodactyla) du Miocène terminal au Pléistocène supérieur en Europe occidentale. Comparaison avec les espèces actuelles. Documents du Laboratoire de Géologie de Lyon, 79, 1-1185.

Guérin C., Dewolf Y., Lautridou J.P. (2003) - Révision d'un site paléontologique célèbre: Saint-Prest (Chartres, France). Geobios, 36(1), 55-82.

Guthrie R.D. (1984) - Mosaics, allelochemics, and nutrients: an ecological theory of late Pleistocene megafaunal extinctions. In Quaternary Extinctions, a Prehistoric Revolution (Ed. by Martin P.S., Klein R.G.). 259-298.

Iannucci A., Gasparik M., Sardella R. (2020b) - First report of *Sus strozzii* (Suidae, Mammalia) from the Early Pleistocene of Hungary (Dunaalmás) and species distinction based on deciduous teeth. The Science of Nature, 107, 5.

Iannucci A., Sardella R., Strani F., Mecozzi B. (2020a) - Size shifts in late Middle Pleistocene to Early Holocene *Sus scrofa* (Suidae, Mammalia) from Apulia (southern Italy): ecomorphological adaptations? Hystrix, the Italian Journal of Mammalogy, 31(1), 10-20.

Iannucci A., Mecozzi B., Sardella R. (2021) - Large mammals from the Middle Pleistocene (MIS 11) site of Fontignano 2 (Rome, central Italy), with an overview of "San Cosimato" assemblages. Alpine and Mediterranean Quaternary, 34(1), 155-164.

IGM (1936) - Castel Giubbileo, F° 150 della Carta d'Italia a scala 1:25000, Tavoletta IV NO. Istituto Geografico Militare, Firenze.

Karner D.B., Marra F., Renne P.R. (2001) - The history of the Monti Sabatini and Alban Hills volcanoes: groundwork for assessing volcani-tectonic hazards for Rome. Journal of Volcanology and Geothermal Research, 107, 185-219

Koenigswald W.V., Schwermann A.H., Keiter M., Menger F. (2019) - First evidence of Pleistocene *Bubalus murrensis* in France and the stratigraphic occurrences of *Bubalus* in Europe. Quaternary International, 522, 85-93.

Komosa M., Frąckowiak H., Godynicki S. (2007) - Skulls of neolithic Eurasian beavers (*Castor fiber* L.) in comparison with skulls of contemporary beavers from natural biotopes of Wielkopolska Region

(Polska). Pol J Environ Stud, 16(5), 697-705.

Lehmann U. (1957) - Weitere Fossilfunde aus dem ältesten Pleistozän der Erpfinger Höhle (Schwäbische Alb). Mitteilungen aus dem Geologischen Staatsinstitut in Hamburg, 26, 60-99.

Leonardi G., Petronio C. (1976) - The Fallow deer of European Pleistocene. Geologica Romana, 15, 1-67.

Lindstedt S.L., Boyce M.S. (1985) - Seasonality, fasting endurance, and body size in mammals. American Nature, 125, 873-878.

Lister A.M., Parfitt S.A., Owen F.J., Collinge S.E., Breda M. (2010) - Metric analysis of ungulate mammals from the early Middle Pleistocene of Britain, in relation to taxonomy and biostratigraphy. II: Cervidae, Equidae and Suidae. Quaternary International, 228, 157-179.

Mancini M., Marini M., Moscatelli M., Stigliano F., Cavinato G.P., Di Salvo C., Simionato M. (2018) - Stratigraphy of the Palatine hill (Rome, Italy): a record of repeated Middle Pleistocene-Holocene paleovalley incision and infill. Alpine and Mediterranean Quaternary, 31(2), 171-194.

Manzi G., Magri D., Palombo M.R. (2011) - Early-Middle Pleistocene environmental changes and human evolution in the Italian peninsula. Quaternary Science Reviews, 30(11-12), 1420-1438.

Marra F., Florindo F. (2014) - The subsurface geology of Rome: sedimentary processes, sea-level changes and astronomical forcing. Earth-Sciences Reviews, 136, 1-20.

Marra F., Karner D.B., Freda C., Gaeta M., Renne P.R. (2009) - Large mafic eruptions at the Alban Hills Volcanic District (Central Italy): chronostratigraphy, petrography and eruptive behaviour. Journal of Volcanology and Geothermal Research, 179, 217-232.
DOI: 10.1016/j.jvolgeores.2008.11.009.

Marra F., Sottili G., Gaeta M., Giaccio B., Jicha B., Masotta M., Palladino D.M., Deocampo D. (2014) - Major explosive activity in the Sabatini Volcanic District (central Italy) over the 800-390 ka interval: geochronological-geochemical overview and tephrostratigraphic implications. Quaternary Science Reviews, 94, 74-101.
Doi: 10.1016/j.quascirev.2014.04.010.

Marra F., Nomade S., Pereira A., Petronio C., Salari L., Sottili G., Bahain J.J., Boschian G., Di Stefano G., Falguerès C., Florindo F., Gaeta M., Giaccio B., Masotta M. (2018) - A review of the geologic sections and the faunal assemblages of Aurelian Mammal Age of Latium (Italy) in the light of a new chronostratigraphic framework. Quaternary Science Reviews, 181, 173-199.
Doi: 10.1016/j.quascirev.2017.12.007.

Martínez K., Garcia J., Burjachs F., Yll R., Carbonell E. (2014) - Early human occupation of Iberia: the chronological and palaeoclimatic inferences from Vallparadís (Barcelona, Spain). Quaternary Science Reviews, 85, 136-146.
Doi: 10.1016/j.quascirev.2013.12.002

Martínez-Navarro B., Palombo M.R. (2007) - The horn-core of *Hemibos galerianus* from Ponte Silvio, Rome (Italy). Rivista Italiana di Paleontologia e Stratigrafia, 113, 531-534.

Martínez-Navarro B., Ros-Montoya S., Espigares M.P., Palmqvist P. (2011) - Presence of the Asian origin Bovini, *Hemibos* sp. aff. *Hemibos gracilis* and *Bison* sp., at the early Pleistocene site of Venta Micena (Orce, Spain). Quaternary International, 243 (1), 54-60.

Mazza P. (1995) - New evidence on the Pleistocene hippopotamuses of western Europe. Geologica Romana, 31, 61-241.

Mazza P., Bertini A. (2013) - Were Pleistocene hippopotamuses exposed to climate-driven body size changes? Boreas, 42, 194-209.

Mecozzi B. (2021) - *Meles meles* from Middle Pleistocene to Early Holocene of the Italian Peninsula within the evolution of European badgers in the Quaternary of Eurasia. Palaeontographica, Abt. A.: Palaeozoology - Stratigraphy.
Doi: 10.1127/pala/2021/0100

Mecozzi B., Iurino D.A., Profico A., Rosa C., Sardella R. (2020) - The wolf from the Middle Pleistocene site of Ostiense (Rome): the last occurrence of *Canis mosbachensis* (Canidae, Mammalia) in Italy, Historical Biology.
Doi: 10.1080/08912963.2020.1769090

Mecozzi B., Sardella R., Boscaini A., Cherin M., Costeur L., Madurell-Malapeira J., Pavia M., Profico A., Iurino D.A. (2021a) - The tale of a short-tailed cat: New outstanding Late Pleistocene fossils of *Lynx pardinus* from southern Italy. Quaternary Science Reviews, 106840.
Doi: 10.1016/j.quascirev.2021.106840

Mecozzi B., Iannucci A., Sardella R., Curci A., Daujeard C., Moncel M.-H. (2021b) - *Macaca* ulna from new excavations at the Notarchirico Acheulean site (Middle Pleistocene, Venosa, southern Italy). Journal of Human Evolution, 153.
Doi: 10.1016/j.jhevol.2020.102946

Merrits D.J. (2007) - Terrace sequences. In: Encyclopedia of Quaternary Sciences (Vol. I) (Ed. by Elias S.A.). Elsevier, Netherlands, 694-704.

Milli S. (1997) - Depositional setting and high-frequency sequence stratigraphy of the middle-upper Pleistocene to Holocene deposits of the Roman basin. Geologica Romana, 33, 99-136.

Milli S., Palombo M.R., Petronio C., Sardella R. (2004) - The Middle Pleistocene deposits of the Roman Basin (Latium, Italy): an integrated approach of mammal biochrology and sequence stratigraphy. Rivista Italiana di Paleontologia e Stratigrafia, 110, 557-567.

Milli S., Moscatelli M., Palombo M.R., Parlagreco L., Paciucci M. (2008) - Incised-valleys, their filling and mammal fossil record: a case study from Middle-Upper Pleistocene deposits of the Roman Basin (Latium, Italy). GeoActa, Special Publication, 1, 67-88.

Milli S., Mancini M., Moscatelli M., Stigliano F., Marini M., Cavinato G.P. (2016) - From fluvial to shelf, anatomy of a high-frequency depositional sequence: the Late Pleistocene-Holocene Tiber Depositional Sequence. Sedimentology, 63, 1886-

1928.

Moigne A.M., Palombo M.R., Belda V., Heriech-Briki D., Kacimi S., Lacombat F., de Lumley M.A., Moutoussamy J., Rivals F., Quilès J., Testu A. (2006) - Les faunes de grands mammifères de la Caune de l'Arago (Tautavel) dans le cadre bio-chronologique des faunes du Pléistocène moyen italien. L'anthropologie, 110(5), 788-831.

Moncel M.H., Santagata C., Pereira A., Nomade S., Voinchet P., Bahain J.J., Daujeard C., Curci A., Lemorini C., Hardy B., Eramo G., Berto C., Raynal J.P., Arzarello M., Mecozzi B., Iannucci A., Sardella R., Allegretta I., Delluniversità E., Terzano R., Dugas P., Jouanic G., Queffelec A., d'Andrea A., Valentini R., Minucci E., Carpentiero L., Piperno M. (2020) - The origin of early Acheulean expansion in Europe 700 ka ago: new findings at Notarchirico (Italy). Scientific reports, 10(1), 1-16.

Nowicki W., Brudnicki W., Kirkiłło-Stacewicz K., Skoczylas B., Wach J. (2019) - Craniometric features of the population of European beaver (*Castor fiber* L., 1758). Slovenian Veterinary Research, 56(2), 43-52.

Palombo M.R. (1986) - Observations sur *Elephas antiquus* Falconer et Cautley du Pleistocène moyen d'Italie: essai d'évaluation des caractères dentaires. Geologica Romana, 23 (1984), 99-110

Palombo M.R. (1995) - Gli elefanti del Pliocene superiore e del Pleistocene dell'Italia centrale peninsulare; alcune considerazioni. Studi Geologici Camerti, vol. spec. 1994 (B), 447-458

Palombo M.R. (2004) - Le mammalofaune della campagna romana: biocronologia, paleoambienti. II Congresso GeoSed, Escursione precongresso, Roma, 1-29.

Palombo M.R., Azanza B., Alberdi M.T. (2001) - Italian Mammal Bichronology from the latest Miocene to the Middle Pleistocene: a multivariate approach. Geologica Romana, 36, 355-368.

Palombo M.R., Anzidei A.P, Arnoldus-Huyzendveld A. (2003) - La Polledrara di Cecanibbio: one of the richest *Elephas* (*Palaeoloxodon*) *antiquus* sites of the late Middle Pleistocene in Italy. In: Advances in Mammoth Research (Proceedings of the Second International Mammoth Conference, Rotterdam, May 16-20 1999) (Ed. by Reumer J.W.F., De Vos J., Mol D.). DEINSEA, 9, 317-330.

Pandolfi L. (2013) - Rhinocerotidae (Mammalia, Perissodactyla) from the Middle Pleistocene site of Ponte Milvio, Central Italy. Bollettino della Società Paleontologica Italiana, 52(3), 219-229.

Pandolfi L., Marra F. (2015) - Rhinocerotidae (Mammalia, Perissodactyla) from the chrono-stratigraphically constrained Pleistocene deposits of the urban area of Rome (Central Italy). Geobios, 48(2), 147-167.

Pandolfi L., Gaeta M., Petronio C. (2013) - The skull of *Stephanorhinus hemitoechus* (Mammalia, Rhinocerotidae) from the Middle Pleistocene of Campagna Romana (Rome, central Italy): biochronological and paleobiogeographic implications. Bulletin of Geosciences, 88(1), 51-62.

Pazzaglia F.J. (2013) - Fluvial terraces. In: Treatise on Geomorphology 9 (Ed. by Wohl E.). Academic Press, San Diego, California, 379-412.

Pereira A., Nomade S., Moncel M., Voinchet P., Bahain J., Bidditu I., Falguères C., Giaccio B., Manzi G., Parenti F., Scardia G., Scao V., Sottil G., Vietti A. (2018) - Integrated geochronology of Acheulean sites from the southern Latium (central Italy): Insights on human-environment interaction and the technological innovations during the MIS 11-MIS 10 period. Quaternary Science Reviews, 187, 112-129.
Doi: 10.1016/j.quascirev.2018.03.021

Petronio C., Sardella R. (1998) - *Bos galerianus* n. sp. (Bovidae, Mammalia) from Ponte Galeria Formation (Rome, Italy). Neues Jahrbuch für Geologie und Paläontologie, 5, 289-300.

Petronio C., Sardella R. (1999) - Biochronology of the Pleistocene mammal fauna from Ponte Galeria (Rome) and remarks on the Middle Galerian faunas. Rivista Italiana di Paleontologia e Stratigrafia Stratigrafia, 105(1), 155-164.

Petronio C., Bellucci L., Martiinetto E., Pandolfi L., Salari L. (2011) - Biochronology and palaeoenvironmental changes from the Middle Pliocene to the Late Pleistocene in Central Italy. Geodiversitas, 33(3), 485-517.

Ponzi G. (1867) - Storia fisica del bacino di Roma. Atti Accademia Pontificia Nuovi lincei, 20, 1-20.

Portis A. (1893) - Contributi alla storia fisica del bacino di Roma e studii sopra l'estensione da darsi al Pliocene Superiore. Volume 1. Roux e C., Torino/Roma, pp. 294.

Portis A. (1896) - Contributi alla storia fisica del bacino di Roma e studii sopra l'estensione da darsi al Pliocene Superiore. Volume 2. Roux e C., Torino/Roma, pp. 514.

Portis A. (1900) - Di una formazione stagnale presso la Basilica di Ostiense di Roma e degli avanzi di fossili vertebrati in essa rinvenuti. Bollettino della Società Geologica Italiana, 19, 179-240.

Portis A. (1902) - Di un dente anomalo di Elefante fossile e della presenza dell'*Elephas primigenius* in Italia. Bollettino della Società Geologica Italiana, 21, 93-114.

Portis A. (1907) - Di alcuni avanzi fossili di grandi ruminanti principalmente della provincia di Roma. Palaeontolographia italica, 13, 141-198.

Portis A. (1909) - Avanzi di canidi fossili dai terreni sedimento-tufacei di Roma. Bollettino della Società Geologica Italiana, 28, 203-247.

Portis A. (1920) - Elenco delle specie Cervicorni fossili in Roma e attorno a Roma. Bollettino della Società Geologica Italiana, 36, 130-139.

Ranzato G. (2019) - La liberazione di Roma. Alleati e Resistenza. Editori Laterza, Bari, pp. 651.

Romano M., Mecozzi B., Sardella R. (2021) - The Middle Pleistocene paleontological research in the Campagna Romana (central Italy) at the 19th-20th century transition: an historical overview. Alpine and Mediterranean Quaternary, 34(1), 109-129.

Stefanelli D., Mecozzi B. (2020) - Body-mass estimation from Middle Pleistocene fallow deer of Europe.

Fossilia, Volume 2020, 47-51.
Doi: 10.32774/FosRepPal.2020.0613

Stefanelli D., Mecozzi B., Francescangeli R., Girone A., Marino M., Montenegro V., Sardella R., Breda M. (2021) - The Fallow deer from Contrada Monticelli (Bari, Southern Italy): the southernmost occurrence of a large *Dama* of the early Middle Pleistocene. Bollettino Società Paleontologica Italiana, 60,1.
Doi: 10.4435/BSPI.2021.02

Strani F., Demiguel D., Bona F., Sardella R., Biddittu I., Bruni L., De Castro A., Guadagnoli F., Bellucci L. (2018) - Ungulate dietary adaptations and palaeoecology of the Middle Pleistocene site of Fontana Ranuccio (Anagni, Central Italy). Palaeogeography, Palaeoclimatology, Palaeoecology, 496, 238-247.

Tellini A. (1893) - Carta Geologica dei dintorni di Roma. Regione alla destra del Tevere. Cromolit. Danesi, Roma (scale 1:50.000).

Tsoukala E., Chatzopoulou K. (2005) - A new Early Pleistocene (Latest Villafranchian) site with mammals in Kalamotó (Mygdonia Basin, Macedonia, Greece). Preliminary Report. Mitt. Komm. Quartärforsch. Österr. Akad. Wiss., 14, 213-233.

Tsoukala E., Guérin C. (2016) - The Rhinocerotidae and Suidae of the Middle Pleistocene from Petralona cave (Macedonia, Greece). Acta Zoologica Bulgarica, 68, 243-264.

Uzunidis-Boutillier A. (2017) - Grands herbivores de la fin du Pléistocène moyen au début du Pléistocène supérieur dans le sud de la France. Implications anthropologiques pour la lignée néandertalienne. PhD thesis, Aix-Marseille University, pp. 797.

van Asperen E.N. (2012) - Late Middle Pleistocene horse fossils from northwestern Europe as biostratigraphic indicators. Journal of Archaeological Science, 39, 1974-1983

van Asperen E.N. (2013) - Implications of age variation and sexual dimorphism in modern equids for Middle Pleistocene equid taxonomy. Int. J. Osteoarchaeol., 23, 1-12.
Doi: 10.1002/oa.1231

van der Made J., Stefaniak K., Marciszak A. (2014) - The Polish fossil record of the wolf *Canis* and the deer *Alces, Capreolus, Megaloceros*, *Dama* and *Cervus* in an evolutionary perspective. Quaternary international, 326, 406-430.

van der Made J., Rosell J., Blasco R. (2017a) - Faunas from Atapuerca at the Early-Middle Pleistocene limit: The ungulates from level TD8 in the context of climatic change. Quaternary International, 433, 296-346.

van der Made J., Sahnouni M., Boulaghraief K. (2017b) - *Hippopotamus gorgops* from El Kherba (Algeria) and the context of its biogeography. In: Proceedings of the II Meeting of African Prehistory: Burgos 15-16 April 2015, 135-169.

Ventriglia U. (1971) - La geologia della città di Roma. Amministrazione Provinciale di Roma, Roma.

Ventriglia U. (2002) - Geologia del territorio del Comune di Roma. Amministrazione Provinciale di Roma, Roma.

Verri A. (1915) - Carta Geologica di Roma. Regio Ufficio Geologico (scale 1:15.000).

Weinstock J. (1997) - The relationship between body size and environment the case of Late Pleistocene reindeer (*Rangifer tarandus*). Archeofauna, 6, 123-135.

Wright E. (2013) - The history of the European aurochs (*Bos primigenius*) from the Middle Pleistocene to its extinction: an archaeological investigation of its evolution, morphological variability and response to human exploitation. PhD thesis, University of Sheffield, pp. 324.