



AN OVERVIEW OF THE MIDDLE PLEISTOCENE IN THE NORTH MEDITERRANEAN REGION.

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ABSTRACT: The Middle Pleistocene was a crucial stage for the evolution of European mammals, a time when the majority of the modern taxa appeared in the continent for the first time. It is also in this interval that periodicity and intensity of glacial-interglacial cycles changed, an event that strongly impacted on Mediterranean marine and terrestrial ecosystems, and on vertebrate communities. This area can thus be considered an important laboratory to investigate how major climatic events influenced mammals' communities (among which also hominin populations) and the habitats they occupied. The state of art of the Middle Pleistocene palaeontological, archaeological and palaeoanthropological record of north Mediterranean region, and of the Italian Peninsula in particular, is here discussed.

Keywords: Chibanian, European ecosystems, Early-Middle Pleistocene Transition, Biochronology, Mammals, Human evolution.

1. INTRODUCTION

The definition of the Early-Middle Pleistocene boundary triggered an intense debate among Quaternary geologists, stratigraphers, and palaeontologists (Cita et al., 2006; Gibbard & Head, 2010; Head & Gibbard, 2015). A large consensus was reached during the XII INQUA Congress, and the beginning of the Middle Pleistocene was placed at the Matuyama/Brunhes palaeomagnetic reversal (~0.78 Ma), within the Marine Isotope Stage (MIS) 19. No doubts instead for the end of the Middle Pleistocene, placed at 129 ka, which corresponds to the beginning of the Last Interglacial (MIS 5), that therefore marks the start of the Late Pleistocene. After a long-lasting debate, the Middle Pleistocene has been referred to the chronostratigraphic Chibanian stage, from a sequence located in Chiba Prefecture (Japan) and ratified by IUGS in January 2020 (Suganuma et al., 2021). The Middle Pleistocene subepoch represents a crucial phase for the Earth System as it witnessed the change in the frequency of glacial-interglacial cycles from 41 kyr to 100 kyr occurred during the 1.2- 0.4 Ma (with some authors placing its onset as far back as 1.4 Ma, see: Head & Gibbard, 2015) interval, an event known as the Middle Pleistocene Revolution (MPR) or Early-Middle Pleistocene Transition (EMPT) (Clark et al., 2006; Head & Gibbard, 2015; Maslin & Brierly, 2015). The consolidation of the EMPT is conventionally placed around the MIS 12 - 11 passage during the Mid-Brunhes Event (MBE) after which an increase of the amplitude of the glacial and interglacial periods is recorded (Head & Gibbard, 2015). During

the last two decades, a large number of studies on the European Middle Pleistocene provided novel knowledge on palaeoenvironments, palaeoclimates and vertebrate communities, and a valuable amount of data on the Mediterranean Europe, and Italian Peninsula in particular.

Many issues are still unclear among the specialists, mainly due to the fragmentary framework of the discoveries. The state of art of the palaeontological, palaeoanthropological and archaeological research is thus crucial for a comprehensive understanding of European palaeoenvironmental dynamics and mammal palaeocommunities. Here, we briefly discuss these aspects, offering an overview of key aspects on the study of the Middle Pleistocene in the Mediterranean region.

2. OLD ISSUES AND NEW PERSPECTIVES

During the last two decades, the knowledge on Middle Pleistocene ecosystems has been enriched by a number of papers (e.g., Rivals, 2012; Strani et al., 2018; Bellucci et al., 2021). Of special interest are those focused on new methods, which allowed to investigate different aspects of archaeological and palaeontological deposits, or to correlate different palaeoenvironmental proxies and palaeoclimate records (Rivals et al., 2009; Strani et al., 2018). Also, the application of isotopic analysis on sediments, speleothems and vertebrate remains has become more diffused (Kuitens et al., 2015; Pushkina et al., 2020). The results of these researches potentially provide crucial information on palaeoenvironments and climate.

Another aspect which needs to be stressed concerns the radiometric method used for reliable chronological constrains of Quaternary sedimentary successions. During the 1960s, these methodologies were already available for the specialists, but in the last decade the technological progress allows to refine the obtained chronological data with both radiometric (radiocarbon, Ar-Ar, U-series) and electron spin resonance (ESR) dating. A number of studies focused on the definition of more accurate chronological framework have been published during the last decade, providing a new age for some key Pleistocene deposits. An example is the new age of the Fontana Ranuccio deposit dated at 408 ± 10 ka (Pereira et al., 2018), whereas historically its age was of 458 ± 6 Ka (Biddittu et al., 1979; Segre & Ascenzi, 1984) shifting the age of the deposits from full glacial conditions of MIS12 to interglacial MIS11. However, despite the increased use of the radiometric and ESR methods, still nowadays only a limited number of European deposits possess reliable chronological constrains. This explains why the reconstruction of the human and vertebrate evolution and of Quaternary ecosystems dynamics is based only on few localities (e.g., Gliozzi et al., 1997). In addition to this, it is necessary to consider that many works were historically published on local journals, often in the authors native language (Italian, Spanish, French, etc.), or just discussed in master/doctoral theses. These researches are hardly available for international scientists, being a strong impediment in the understanding of palaeocommunity changes across the Middle Pleistocene.

In summary, despite the recent improvement, palaeontological, palaeoanthropological and archaeological data for some Middle Pleistocene European localities, especially those of north-central Mediterranean region, are either quite scarce or not well disseminated, and this represents an important limiting factor for the reconstruction of the mammal fauna evolution and their response to the environmental changes that occurred during this pivotal phase of the Quaternary. A review of the state of art of Middle Pleistocene research and new data on historical key sites can therefore offer crucial data for the understanding of Mediterranean palaeoenvironmental dynamics and mammal palaeocommunities.

3. THE MIDDLE PLEISTOCENE TERRESTRIAL ECOSYSTEMS IN NORTH-CENTRAL MEDITERRANEAN REGION

3.1. Paleobotanical framework

In northern Mediterranean Europe, a drop in temperature and a change in the dominant cyclicality strongly influenced the terrestrial ecosystems during the Early-Middle Pleistocene transition until the end of Pleistocene (Bertini, 2010; Russo Ermolli et al., 2010a; Kahlke et al., 2011; Combourieu-Nebout et al., 2015; Head & Gibbard, 2015; Strani, 2020). The European vegetational landscapes generally changed following global climate patterns. As Bertini (2010) pointed out, "a close correspondence between the climate fluctuations recorded by marine oxygen isotope records and long pollen records during the Pleistocene indicates that there were also considerable regional differences in the vegetation

structure, composition and responses to climate, depending on geographic and historical factors". In the Mediterranean area, and in the Italian Peninsula in particular, such a condition is evident. Alternation of *Artemisia* steppe and thermophilous forest marks the overall glacial-interglacial vegetation change. "Taxodiaceae", *Cathaya* (plus *P. haploxylon* type), *Tsuga*, *Cedrus*, *Carya*, *Pterocarya*, along with other taxa, progressively disappeared throughout the Pleistocene, with the last subtropical elements being extirpated during the Middle Pleistocene due to the increased severity of the glacial periods (Bertini, 2010; Manzi et al., 2011; Combourieu-Nebout et al., 2015).

The effect of climatic changes can be clearly observed in central and southern Italy, especially during glacial stages where the expansion of steppe and grasslands occurred (Manzi et al., 2011). Even if the record is quite fragmentary, a marked shift can be detected between 0.7-0.6 Ma, probably due to the extreme climate conditions recognized during the MIS 16. The following interglacial stage (MIS 15) included modern taxa, as *Carpinus* and *Ulmus*, testifying therefore a clear vegetation turnover (Manzi et al., 2011). Another vegetational shifts occurred in correspondence of MIS 12, with major effects in southern Italy (Russo Ermolli et al., 2010b). The latter coincides with the Mid-Brunhes Event (MBE), which marks the MIS 12 - 11 transition, after which an increase of the amplitude of the glacial and interglacial periods is recorded. Generally speaking, deciduous *Quercus* or *Fagus* dominated forests, and typical Mediterranean taxa (e.g. *Quercus ilex*) become the most common vegetation during Middle Pleistocene interglacials, whereas conifers, steppe and grasslands expanded during glacial periods (Russo Ermolli et al., 2010a,b; Bertini, 2010; Manzi et al., 2011; Magri & Palombo, 2013; Combourieu-Nebout et al., 2015).

3.2. Mammal faunas and biochronology

The mammal biochronological scale is based on the evolutionary degree of the faunal elements of the assemblages and on their dispersal, and therefore their first and last occurrences mark pivotal bioevents (Gliozzi et al., 1997). The Villafranchian/Galerian transition (corresponding to the 1.2-0.9 Ma interval) can be considered one of the most controversial issues in the European biochronological framework. The marked faunal turnover recorded within the Jaramillo Subchron occurred following the shift to glacial-interglacial cycles dominated by a 100 kyr frequency. The use of the term Epivillafranchian, suggested by Kahlke (2009) for the Villafranchian/Galerian transitional faunas, has been formally defined (Bellucci et al., 2015). Taking into account the data recorded from the European localities, during the Epivillafranchian biochron, the first occurrence of *Praemegaceros verticornis*, *Bison menneri*, *Megaloceros savini*, *Cervus elaphus* and *Sus scrofa* are recognized (Bellucci et al., 2015). In the revised framework proposed by Bellucci et al. (2015), the *Crocota crocuta* bioevent (Sardella & Palombo, 2007; Sardella & Petrucci, 2012) marks the beginning of Galerian, and therefore the end of Epivillafranchian.

One of the most important sites for the study of the Middle Pleistocene is the area of Ponte Galeria (Rome,

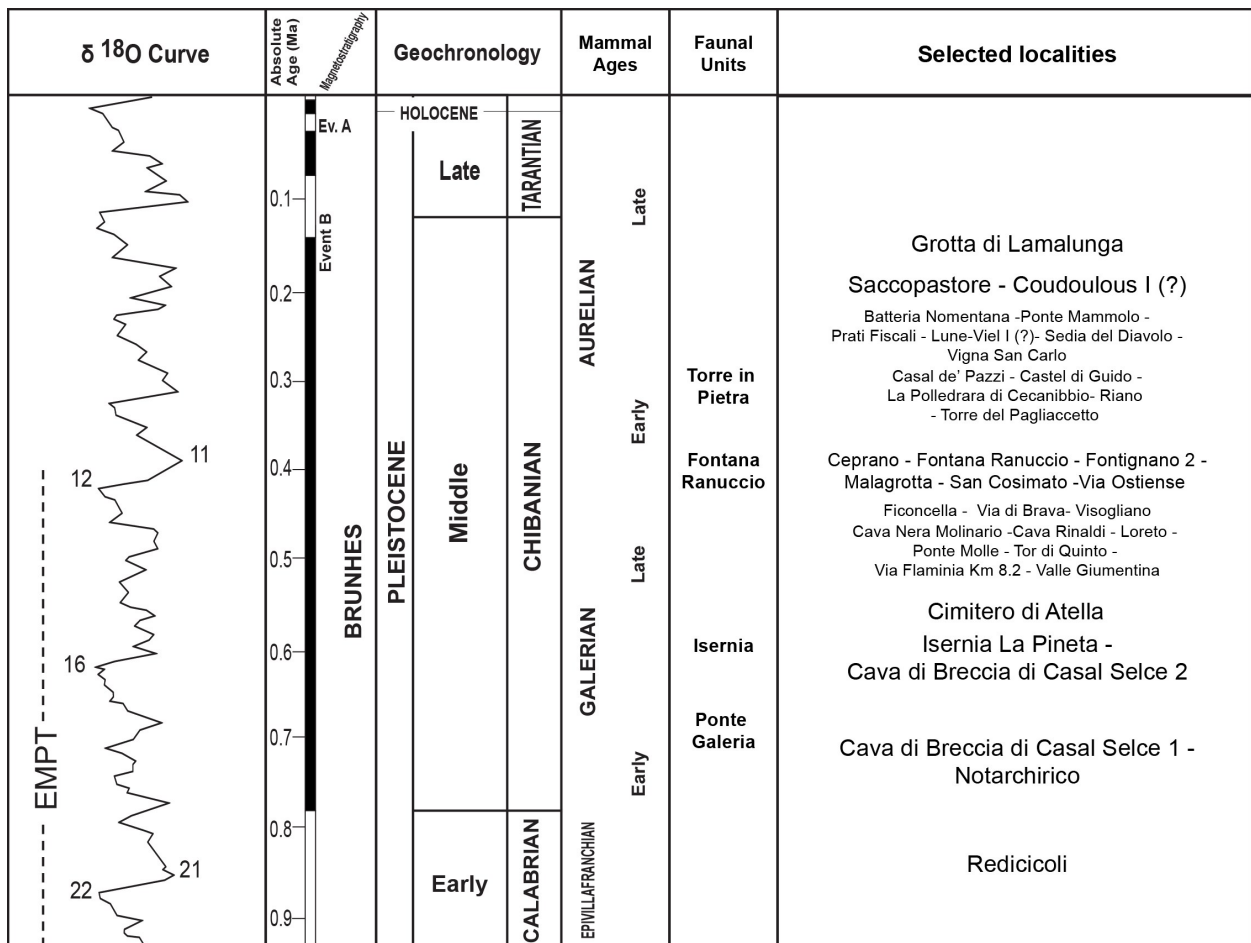


Fig. 1 - Integrated chronological scheme of the Middle Pleistocene and selected localities considered in this work (modified from Gliozzi et al., 1997).

central Italy), where sedimentary sequences exposed in quarries have been studied by geologists and palaeontologists for decades. These deposits provided a rich fossil vertebrate collection, which allows the development of an important part of Quaternary biochronology. The terms Galerian and Aurelian (Mammal Ages) themselves have their origin from Ponte Galeria sites and from many palaeontological sites located along the Aurelia State Highway, respectively (e.g., Gliozzi et al., 1997; Di Stefano et al., 1998; Petronio & Sardella, 1999; Milli et al., 2004; Romano et al., 2021). After Bellucci et al. (2015) revision the Galerian Mammal Age includes three Faunal units: Ponte Galeria, Isernia and Fontana Ranuccio (Gliozzi et al., 1997; Petronio & Sardella, 1999; fig. 1). Since the end of the XX century a more detailed biochronological framework has been set up (Milli et al., 2004; Sardella, 2007; Palombo et al., 2008, 2009; Petronio et al., 2011; Marra et al., 2014; Bellucci et al., 2015; Sardella et al., 2015). Therefore, most of the more significative fossil mammal assemblages from which the Middle Pleistocene biochronology has been defined, come from the Campagna Romana area. For instance, at Casal Selce the large mammal fauna renewal of ungulates and carnivorans during the Early-

Middle Pleistocene transition is documented with the presence of *Mammuthus trogontherii*, *Hemibos galerianus*, *Praemegaceros verticornis* and *Megaloceros savini* (Petronio & Sardella, 1998; Palombo & Sardella, 2007; Sardella & Petrucci, 2012). As aforementioned, the fossil record of Casal Selce also documents the earliest occurrence of *Crocota crocuta* (*C. crocuta* event), that replaced the Villafranchian giant hyaena *Pachycrocuta brevirostris* (Sardella & Petrucci, 2012).

Among the bovids, important elements of the Galerian faunas are *Bison schoetensacki*, *Praeovibos* and *Ovibos*. As highlighted by Iannucci et al. (2021), the aurochs *Bos primigenius* spread around 0.5 Ma in Italy, becoming soon a common element of the Galerian-Aurelian faunal assemblages of Europe. In addition to these taxa, the rare water buffalo *Bubalus murrensis* also occurs and spread into northern Europe during temperate climatic stages (Sardella, 2007 and references therein), whereas the *Hemibos galerianus* is quite scarce (Petronio & Sardella, 1998; Martinez-Navarro & Palombo, 2007). Among cervids, in the early Middle Pleistocene European faunas *Praemegaceros verticornis*, *Megaloceros savini* and *Dama roberti* are recorded (e.g., Sardella et al., 2006; Sardella, 2007; Breda & Lis-

ter, 2013; Bellucci et al., 2021; Stefanelli et al., 2021), which were replaced later by *Praemegaceros solilhacus* and *Dama clactoniana* (e.g., Sardella et al., 2006; Breda & Lister, 2013; Breda et al., 2015). The red deer appears in Europe during the Epivillafranchian (Bermúdez de Castro et al., 1997; Iannucci et al., 2021 and reference therein), but its evolutionary history is still unclear. General consensus was reached in recognizing the simpler antler morphology of earlier forms, but different opinions on the validity and relationships of subspecies persist. For instance, based on the fossil record from the area of Rome, four different chronosubspecies were instituted: *Cervus elephus acoronatus*, *Cervus elephus eostephanoceros*, *Cervus elephus rianensis* and *Cervus elephus elaphus* (Leonardi & Petronio, 1974; Di Stefano & Petronio, 1992, 1993; Di Stefano et al., 1998; Di Stefano & Petronio, 2002).

One of the most abundant group of the Middle Pleistocene ecosystem is hippopotamuses, but there are conflicting opinions on their systematics and evolutionary history (e.g., Caloi et al., 1980; Mazza, 1991, 1995; Mazza & Bertini, 2013; van der Made et al., 2017). However, hippopotamuses together with proboscideans and rhinoceroses were among the largest terrestrial mammals in Galerian and Aurelian assemblages.

The proboscideans are well diffused across Europe during the Middle Pleistocene. The earliest record of the straight tusked-elephant *Palaeoloxodon antiquus*, attributed to Epivillafranchian, was attested at Vallparadis Estació, but this attribution was recently questioned (Bellucci et al., 2015 and reference therein). However, the straight tusked-elephant is a very common element of Galerian and Aurelian assemblage (e.g., Moncel et al., 2020a; Abruzzese et al., 2016; Rocca et al., 2018; Rocca & Aureli, 2020; Stefanelli et al., 2021), until its disappearance, probably occurred during the early Late Pleistocene (Mecozzi et al., 2021b and reference therein). Another important biochronological marker for the Galerian is the earliest dispersal of *Mammuthus trogontherii* recognized at Ponte Galeria FU, which replaced the Villafranchian species, *Mammuthus meridionalis* (Bellucci et al., 2015).

Rhinoceroses are represented by three taxa: *Stephanorhinus hundsheimensis*, *Stephanorhinus hemitoechus* and *Stephanorhinus kirchbergensis*. The latter is quite sporadic in mammal communities, with a few specimens recorded at the Middle Pleistocene sites of Visogliano (MIS 13-10; Pandolfi, 2013), Ponte Molle (MIS 13; Mecozzi et al., 2021) and Tor di Quinto (MIS 13; Pandolfi & Marra, 2015). The earliest occurrence of *S. hundsheimensis* is attested during the Late Villafranchian (Ballatore & Breda, 2013 and reference therein), but its last occurrence needs to be clarified. Pandolfi et al. (2018) attributed a few postcranial elements from Grotta Romanelli (Lecce, southern Italy) to hundsheim rhinoceros, hypothesizing a Middle Pleistocene age (~0.6 Ma) for the levels K-I of this deposit. Nevertheless, the lowermost levels of Grotta Romanelli have been historically referred to early Late Pleistocene because it directly overlies a Tyrrhenian beach deposit (level K, MIS 5e). With the aim to define a more accurate chronological scheme for the sequence of this key site, a new

project initiated during the 2015, whose preliminary results suggest that a possible late Middle Pleistocene age for the lower complex cannot be ruled out (Sardella et al., 2018, 2019; Mecozzi et al., 2021a). The narrow-nosed rhinoceros, *S. hemitoechus* is instead an important marker, as its earliest occurrence in Europe is dated approximately at 0.5 Ma (Caune de l'Arago, from levels chronologically referred to MIS 14; Moigne et al., 2006).

Among the equids, two Villafranchian taxa persisted during the early Middle Pleistocene, *Equus altidens* and *Equus sussenbornensis* (Boulbes & Asperen, 2019). The modern caballoid diffused in Europe approximately at 0.6 Ma, but there are different interpretations of the variability of the Middle Pleistocene equids: as ecomorphological adaptations (*Equus ferus* spp.) or as two distinct forms (*Equus mosbachensis* and *Equus ferus*) (Boulbes & Asperen, 2019 and reference therein). The first true horse remains have been generally attributed to *E. mosbachensis*, a taxon that appears present in Europe from the early to the late Middle Pleistocene, until the first dispersal of *Equus ferus* (e.g., Boulbes & Asperen, 2019; Strani et al., 2019; Mecozzi & Strani, 2021; Saarinen et al., 2021; Strani et al., 2021). During the Middle Pleistocene *Equus hydruntinus* is also recorded for the first time, but its dispersal is not a synchronous event. In Spain, the earliest presence of this taxon is probably attested at about 0.6 Ma, whereas in Italy its dispersal is considered as chronological marker of the Aurelian biochron (MIS 10-9) (Boulbes & Asperen, 2019 and reference therein; fig. 1). In France, the earliest record of this equid is documented from late Middle Pleistocene localities of Lunel-Viel (MIS 9-7) and Orgnac (MIS 9-8) (Boulbes & Asperen, 2019; Brugal et al., 2021 this volume).

Another important event of the Middle Pleistocene is the earliest occurrence of the brown bear *Ursus arctos*, historically placed within the Fontana Ranuccio Faunal Unit (Fig. 1), based on findings unearthed in the homonymous local fauna of Fontana Ranuccio (0.4 Ma, MIS 11), where this species was found in association with *Ursus deningeri* (Azzaroli, 1983). The ursid record from this locality has been revised by Conti et al. (2021), who cannot confirm with certainty the occurrence of *U. arctos*. In the Fontana Ranuccio locality are however recorded other modern taxa both within the large (e.g. *Cervus*, *Dama*, *Bos*) and small mammal assemblage (e.g. *Lepus*, *Erinaceus*, *Eliomys*) (Strani et al., 2018; Bona & Strani, this volume).

European primates and carnivoran records are quite scarce, and the majority of the medium- and large-sized taxa became extinct during the Middle Pleistocene, like the large felid *Panthera gombaszoegensis* (Sardella, 2007). The Barbary Macaque, *Macaca sylvanus*, is recorded in a few Italian Middle Pleistocene localities (Mecozzi et al., 2021c). Its presence offers important data for the reconstruction of the Mediterranean palaeoenvironments, and the findings associated with lithic artifacts require particular attention to the potential *Homo-Macaca* interactions during the Pleistocene (Strani et al., 2018; Mecozzi et al., 2021c). In addition to iconic predators like *Crocota crocuta* and *Panthera sensu lato*, other carnivorans characterized the Middle

Pleistocene ecosystems as *Hyaena prisca*, *Canis mosbachensis*, *Cuon alpinus*, *Meles meles* and *Lynx pardinus* (Caloi & Palombo, 1983; Palombo & Sardella, 2007; Palombo et al., 2008, 2009; Mecozzi et al., 2017, 2020a, b, 2021d; Mecozzi, 2021).

Another important faunal renewal took place ~0.3 Ma (MIS 9), marking the beginning of the Aurelian Mammal Age, where the last Villafranchian representatives and few Galerian taxa disappeared, replaced by new modern-like species such as the wolf *Canis lupus*, the bears *Ursus arctos* and *Ursus spelaeus*, *Megaloceros giganteus*, as well as the brown hare *Lepus europaeus* (Gliozzi et al., 1997; Di Stefano et al., 1998; Palombo et al., 2002). The most famous Italian local fauna of the Torre in Pietra FU is that of the iconic site of La Polledrara di Cecanibbio (Marano et al., 2021).

In France, early Aurelian assemblages can be related to the biochron MNQ24, characterized by the first occurrence of *Saiga tatarica* (never recorded in Italy), *Ursus spelaeus*, *Capra ibex* and *Coelodonta antiquitatis* (Sardella, 2007 and references therein). Important early Aurelian French assemblages are recorded at Lunel Viel and Coudoulous I (Brugal et al. 2021; Fernandez et al. 2021). Interestingly, bioclimatic models indicate that the palaeoecological requirements of species were very similar between the different faunal associations of the French locality of Coudoulous I, and that -while significant climatic changes occurred- they prevented a complete species turn-over. This is in accordance with what observed in central Italy, where similar herbivorous mammals adopted similar palaeoecological adaptations during MIS 15 and during MIS 11 (Strani et al., 2021).

The climatic deterioration occurred during the last 0.3 Ma provided the ecological basis for the appearance of the cold-stage fauna generally known as *Mammuthus-Coelodonta* faunal complex, which characterized the late Middle and Late Pleistocene of the northern Hemisphere (Kahlke, 1999). In the Italian Peninsula, this cold adapted faunal complex was recorded only during the Late Pleistocene, but the record of *Mammuthus primigenius* and *Coelodonta antiquitatis* is quite poor. In French, these taxa appeared during the late Middle Pleistocene, where probably favorable climatic condition established earlier (Palombo & Valli, 2004).

In sum, the northern Mediterranean area, allows for the in-depth study of how the climatic shift of the Middle Pleistocene influenced the palaeocommunities both in terms of evolution and composition of mammal taxa.

3.3. Middle Pleistocene human populations

The Middle Pleistocene witnessed some important events in the history of human evolution. The Italian human presence is documented by a rich fossil record and archaeological evidences found in a number of deposits (e.g., Belli et al., 1991; Piperno, 1999; Manzi et al., 2001; Scott & Gibert, 2009; Manzi et al., 2011; Aureli et al., 2012; Gallotti & Peretto, 2015; Peretto et al., 2015; Moncel et al., 2019, 2020a,b).

The Italian Peninsula has an important role in the study of the European Middle Pleistocene human populations, especially for the emergence of the Mode 2 technology and the dispersal of *Homo heidelbergensis* and *Homo neanderthalensis*. Buzi et al. (2021) confirms

the importance of the Italian territory and provides a revision of the pre-modern human fossil record from this region, updating the information previously reported in the "Catalogue of Italian Fossil Human Remains from the Palaeolithic to the Mesolithic" (Alciati et al., 2005).

By the beginning of the Middle Pleistocene, the earliest Acheulean *Homo heidelbergensis* groups spread through Europe. A site of particular interest is Notarchirico (southern Italy), where the earliest evidence of Acheulean settlement in Italy has been studied and placed even further back in time (Moncel et al., 2020a). At Notarchirico, four occupation levels have been unearthed, including one with bifaces dated through $^{40}\text{Ar}/^{39}\text{Ar}$ on tephra and ESR on bleached quartz, that enable to place the occupation between 695 and 670 ka (MIS 17), almost coeval with the Moulin-Quignon and la Noira sites (France)(Moncel et al., 2020a). As Moncel et al. (2020a) pointed out, during the early Middle Pleistocene *Homo heidelbergensis* groups arrived in Europe, where they were exposed to "challenging environmental conditions, which may have stimulated new cultural responses". The diversity of tools and activities observed at Notarchirico, Moulin-Quignon and la Noira sites shows that the north Mediterranean was populated by adaptable hominins during this time. In particular, at the MIS 17/MIS 16 transition (670 and 650 ka), a very rapid expansion of shared traditions over western Europe has been documented (Muttillio et al., 2021). It must be stressed that the lithic samples over this period have been studied with different theoretical/methodological approaches preventing a comprehensive discussion. For instance, different approaches have been used even for the study of artefacts collected in distinct stratigraphical units of the same site (Muttillio et al., 2021 and reference therein). However, as stated by Muttillio et al. (2021), the technical behaviors documented during the early Middle Pleistocene (between MIS 17/16 and MIS 12) in the Italian peninsula are extremely diversified. Finally, the authors highlighted how a homogeneous and comprehensive study of all Italian lithic samples of this period is required as a starting point to perform a large comparison of the various industries of the Italian peninsula and also to evaluate them in a broadest European context.

Middle Pleistocene lithic assemblages of Europe also show a great variability in technological and typological characteristics (Wiśniewski, 2014; Malinsky-Buller, 2016; Villa et al., 2016; Picin, 2017). No general consensus was reached on how to interpret of this variability, especially in relation with the Lower-Middle Paleolithic transition (LMPT) occurred during the Middle Pleistocene (MIS 9-8) (Malinsky-Buller, 2016). The LMPT is marked by the passage from biface production to Levallois technology (Malinsky-Buller, 2016). A recent large revision carried out by Moncel et al. (2020b), suggests that the emergence of the Middle Paleolithic is older than generally supposed, and it can be referred to MIS 12. In addition, the authors highlight that during the early Middle Paleolithic other technologies were also used. An important question rises about why the Levallois technology became the dominant technological strategy of the Middle Paleolithic from the MIS 9, which needs to be investigated (Moncel et al., 2020b).

The early human presence in the Italian Peninsula,

in addition to the fragmentary femur collected from the upper levels of Notarchirico (Moncel et al., 2020a and reference therein), is documented at Isernia La Pineta (MIS 15, Isernia, southern Italy) by an isolated deciduous incisor (Peretto et al., 2015). Fontana Ranuccio (Frosinone, central Italy) can be considered one of the most important sites, with 4 isolated human teeth, many vertebrate taxa and tools (Biddittu et al., 1979; Segre & Ascenzi, 1984; Rubini et al., 2014; Zanolli et al., 2018; Grimaldi et al., 2020). Palaeoecological data from the Fontana Ranuccio site provide new information on the environments occupied by Middle Pleistocene *Homo* in the Italian Peninsula. Dietary adaptations of the ungulate community and of small mammal taxa suggest that *Homo* populations occupied a region characterised by widespread wooded environments, and with grasslands inhabited mostly by groups of large ungulates, as attested by the diverse types of dietary behaviours observed in this group, with a relative dominance of cervids displaying a browsing or mixed diet (Strani et al., 2018), and by enamel isotopic data (Strani et al., 2019). Harsher climatic conditions during adverse seasons may have played a key role, driving ungulates that needed a large amount of food intake, such as the large-sized aurochs (*Bos primigenius*), to feed also on sub-optimal resources (Strani et al., 2018). Another important locality for human evolution is Ceprano (MIS 11, Frosinone, central Italy), where a partial cranium was historically discovered (Manzi et al., 2001; Manzi, 2016; Di Vincenzo et al., 2017). This specimen, recently revised, is ascribed to *Homo heidelbergensis* by Manzi (2016). Finally, of considerable interest are the fossils recovered from the end of the Middle Pleistocene from Altamura (Bari, southern Italy) and Saccopastore (Rome, central Italy). The first site includes a probably complete skeleton with a cranium embedded in calcite concretions attributed to *Homo neanderthalensis* (Lari et al., 2015; Di Vincenzo et al., 2019). The latter yielded two nearly complete crania of *H. neanderthalensis*, Saccopastore 1 and Saccopastore 2 (Sergi, 1944, 1948, 1962; Bruner & Manzi, 2006, 2008). The age of the deposit was historically attested to the Last Interglacial, but a recent reassessment of the aggradational succession in the area of Rome suggested an oldest chronology (MIS 7, Marra et al., 2015).

4. CONCLUSION

The roots of “modern” terrestrial ecosystems in the Mediterranean region can be placed in the Middle Pleistocene, when global climate patterns strongly conditioned the European vegetational landscape changes and those in the large ungulates and carnivoran guilds. However, the gap of knowledge or not up-to-date information from some historical Middle Pleistocene key-localities of the Mediterranean region is a major concern for Quaternary research. In Italy for instance, many works were published during the XX century on not-easily accessible local journals, and some materials were never formally described, limiting the available information on Middle Pleistocene Quaternary ecosystems. The literature revision of historical palaeontological and archaeological works can help to obtain a more

comprehensive framework of human and other mammals’ evolution. Furthermore, historical museum collections such as those partially studied during the XX century, represent a palaeontological and archaeological heritage with significant scientific and socio-cultural value (DeMiguel et al., 2021). These collections are of great importance to describe unpublished material or re-evaluate the information of the published ones, as for instance the fossils from the Middle Pleistocene localities of Fontana Ranuccio (Conti et al., 2021), Fontignano (Iannucci et al., 2021), Lunel-Viel (Brugal et al., 2021) and Ponte Molle (Mecozzi et al., 2021).

Overall, the archaeo-geo-palaeontological evidence from Italy and France presented in this volume is of particular interest to depict an accurate reconstruction of the modern terrestrial communities’ changes toward the contemporary world of the Holocene.

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