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FEDERICO FAMIANI ⁽¹⁾, PIETRO ATZORI ⁽²⁾, CARMELO PETRONIO ⁽²⁾, LEONARDO SALARI ⁽³⁾

PRELIMINARY REPORT ON THE EARLY PLEISTOCENE DEPOSIT FROM BASTARDO (UMBRIA, ITALY): GEOLOGIC, BIOCHRONOLOGIC AND PALAEOGEOGRAPHIC CONSIDERATIONS

Abstract - F. FAMIANI, P. ATZORI, C. PETRONIO, L. SALARI, *Preliminary report on the Early Pleistocene deposit from Bastardo (Umbria, Italy): Geologic, biochronologic and palaeogeographic considerations.*

The mammal fossil remains collected from the Molino creek site, near Bastardo (Giano dell'Umbria, Perugia, central Italy), in the south-eastern branch of the Tiberino Basin, were described. Villafranchian mammal assemblages in this part of the basin are extremely rare. Teeth and bone remains were found in a horizon of fine light brown gray clayey sands with orange veins included in fluvio-alluvial deposits, attributed to the Bevagna Unit (Early Pleistocene). The mammal remains were not in good preservation conditions. However, several taxa such as *Macaca sylvanus florentinus*, *Canis* sp., *EQUUS stenonis*, *Sus* cf. *S. strozzii*, *Eucladoceros ctenoides vel dicranios* and *Axis nestii* were identified. The occurrences of *A. nestii* and *E. ctenoides vel dicranios* would allow to attribute this late Villafranchian deposit to a time interval included in the Olivola and Tasso Faunal Units. The biochronology of the mammal assemblage from Bastardo indicates the temporal correlation with several local faunas from the south-western branch of the Tiberino Basin. This result agrees with the chronologic correlation, hypothesized on the basis of continental gastropods, between Bevagna Unit, in the south-eastern branch of the Tiberino Basin, and Santa Maria di Ciciliano Subsynthem, in the south-western branch of the same basin. Therefore, the fossil remains from Bastardo offer the opportunity to get to know the south-eastern branch of the Tiberino Basin a little better.

Key words - mammal assemblages, Faunal Units, Villafranchian, Tiberino Basin, Central Italy

Riassunto - F. FAMIANI, P. ATZORI, C. PETRONIO, L. SALARI, *Nota preliminare sul deposito del Pleistocene Inferiore di Bastardo (Umbria, Italia): considerazioni geologiche, biocronologiche e paleogeografiche.*

Sono descritti i resti fossili di mammiferi raccolti presso il torrente Molino, in località Bastardo (Giano dell'Umbria, Perugia, Italia centrale), nel ramo sud-orientale del Bacino Tiberino. Le associazioni di mammiferi villafranchiani in questa parte del bacino sono estremamente rare. In un orizzonte di sabbie argillose di colore grigio avana con venature arancioni comprese in depositi fluvio-alluvionali attribuiti all'Unità di Bevagna (Pleistocene inferiore) sono stati rinvenuti resti di denti e di ossa. I resti dei mammiferi non erano in buone condizioni di conservazione. Tuttavia sono stati identificati diversi taxa come *Macaca sylvanus florentinus*, *Canis* sp., *EQUUS stenonis*, *Sus* cf. *S. strozzii*, *Eucladoceros ctenoides vel dicranios* e *Axis nestii*. La presenza di *A. nestii* ed *E. ctenoides vel dicranios* consentirebbe di attribuire questo deposito tardo-villafranchiano ad un intervallo di tempo compreso nelle Unità Faunistiche di Olivola e Tasso. La biocronologia dell'associazione a mammiferi di Bastardo indica una correlazione temporale con diverse faune locali del ramo sud-occidentale del Bacino Tiberino.

Questo risultato concorda con la correlazione cronologica, ipotizzata sulla base dei gasteropodi continentali, tra l'Unità di Bevagna, nel ramo sud-orientale del Bacino Tiberino, e il Sottosistema di Santa Maria di Ciciliano, nel ramo sud-occidentale dello stesso bacino. I resti fossili da Bastardo offrono quindi l'occasione per conoscere un po' meglio il ramo sud-orientale del Bacino Tiberino.

Parole chiave - associazioni a mammiferi, Unità Faunistiche, Villafranchiano, Bacino Tiberino, Italia Centrale

INTRODUCTION

Plio-Pleistocene continental deposits are found in the Tiberino Basin, a depositional basin located in Umbria (central Italy), north of Rome. The Tiberino Basin is an extensional basin situated at the western margin of the Apennines Chain and it is the major intermontane continental basin along the Italian Peninsula. It extends for about 125 km in the north-northwest direction, with a width of up to 20 km. After a straight stretch that begins north Città di Castello, it was divided in a south-western and a south-eastern branch south Perugia, outlining an upside-down Y shape (Basilici, 1997, 2000). Initially interpreted as a large lake, the Tiberino Lake (Lotti, 1917), the Tiberino Basin is a complex depositional system of various lacustrine, palustrine and fluvial environments, often coalescing and alternating in time and space (Conti & Girotti, 1977; Ambrosetti *et al.*, 1987, 1995; Basilici, 1997, 2000; Bizzarri *et al.*, 2018). Most of the fossiliferous deposits, sometimes rich in vertebrate remains, were found in the south-western branch, while they are rarer in the south-eastern branch (Ambrosetti *et al.*, 1995; Petronio *et al.*, 2002; Argenti, 2004; Petronio & Salari, 2021, and references therein). The deposit from Bastardo (Fig. 1A), in the south-eastern branch, offers the opportunity to know this part of the Tiberino Basin. In spring 2009, following the excavation work for the construction of a Park along the Molino creek, in Bastardo (Giano dell'Umbria, Perugia, central Italy), in Casa Romana Street, numerous fragments of fossil

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bones were found. In this case, the type of the clayey-sandy sediments has not favored the preservation of these remains, which were intensely degraded. These outcropping remains were recovered by geologists, including one of the authors (F.F., among others), who, as required by the Code of Cultural Heritage (D.Lgs 22/2004), promptly reported their presence to the Soprintendenza Archeologia Belle Arti e Paesaggio dell'Umbria (SABAPU). In the months of June and July 2009, geological investigations were carried out to evaluate the possible areal extension of the fossiliferous deposit and to estimate the wealth of finds. The potential of the deposit was unexpectedly high to the point that until now, through the recovery work carried out by SABAPU, many remains belonging to macromammals have been brought to light.

The aim of this work on the new deposit from Bastardo, authorized by the SABAPU, is to describe briefly the mammal remains and discuss their biochronologic, stratigraphic, palaeoenvironmental and palaeogeographic implications in this branch of the Tiberine Basin where the Villafranchian faunal assemblages are rare.

GEOLOGICAL SETTING

The Neogene and Quaternary geological evolution of the vast area between western Umbria, south-eastern Tuscany and north-eastern Latium is well known in literature (Basilici, 1992; Ambrosetti *et al.*, 1995; Abbazzi *et al.*, 1997; Argenti, 1999, 2004; Petronio *et al.*, 2002; Girotti *et al.*, 2003; Cherin *et al.*, 2013a, 2013b, 2014, 2016). From Villafranchian, this area is characterized by continental deposits, which evolved in a shallow basin. In this context, the Bastardo basin is part of the great Tiberino Basin. The genesis and geological evolution of this depression has been studied in detail by Gregori (1988) and Cattuto *et al.* (1988), who have highlighted interesting morpho-tectonic situations due to recent Quaternary tectonics activity. The surface of this continental basin is about 80 km² and the same has been considered by various Authors (e.g., Cattuto *et al.*, 1988; Gregori, 1988; Ambrosetti *et al.*, 1995) as a "gulf" of the south-eastern branch of the great Tiberino Basin which, as is well known, is the largest fluvio-lacustrine area of the Pliocene - lower Pleistocene in Central Italy.

The paleogeographic evolution of this area was strongly influenced, as previously mentioned, by the tectonic events that have affected the Umbria-Marchean area during the last two million years (Famiani *et al.*, 2020). The Bastardo basin has undergone a partially independent geological and structural evolution, which can be schematized by the succession of events illustrated again by Cattuto *et al.* (1988). The extensional tectonics

also affected the most ancient fluvial-lacustrine deposits (Pliocene - lower Pleistocene) (GE.MI.NA., 1963; Coltorti & Pieruccini, 1997; 2006). The graben of the Tiberino Basin formed in the Pliocene is affected by other normal faults that cause it to overturn towards to south-west, generating a distortion of the surface runoff and of the eroded areas with consequent formation of the Bastardo basin (lower Pleistocene). The watercourses that had a prevalent outflow towards the NE are thus blocked by the formation of the Montefalco horst (Cattuto *et al.*, 1988; Gregori, 1988; Bucci *et al.*, 2016; Famiani *et al.*, 2020), a phase that will become more important in the middle Pleistocene by increasing the height differences. Currently, the Bastardo basin is drained by two streams: the Puglia stream that flows west and collects the drainage of the Martani Mountains, including Molino creek, and the Attone stream that drains the southern area of the Montefalco horst (Cattuto *et al.*, 1988; Mirabella *et al.*, 2018). The stratigraphic succession of the basin has been the subject of study since the early 1900s (Lotti, 1926), given the presence of numerous deposits of lignite in the outcrop that were extracted until the early 1990s (Bizzarri *et al.*, 2011, 2018). The stratigraphic sequence, in particular, is characterized by mainly fine fluvial and lacustrine deposits, in which powerful levels and lenses of lignitiferous clays are interbedded in the basal and central portion of the basin. Laterally, towards the edges, it increases the thickness of the sands and silts with gravel lenses that are more frequent at the top of the stratigraphic succession (Cattuto *et al.*, 1988; Gregori, 1988; Coltorti & Pieruccini, 1997; Mirabella *et al.*, 2018). Not connected with the sequence of Bastardo basin, but partially etheropic in the border of the basin, in the south-western area there are present sub-horizontal travertine deposits (Torri - Barattano - San Terenziano), which do not form a continuous plateau and are related to the upwelling of waters rich in calcium carbonate along the edge faults of the same basin, and which put the Umbria-Marchean carbonatic stratigraphic series in contact with the continental deposits (Cattuto *et al.*, 1988; Gregori, 1988; Mirabella *et al.*, 2018). The general orographic structure is a ridge that, observed in plan, has a width (about 16 km) less than half the length (about 36 km) and an orientation in the Apennine sense or in the NW-SE direction in the central sector and North and NS in the southern one (Bucci *et al.*, 2016; Famiani *et al.*, 2020).

In detail (Fig. 1B), according to CARG project, the stratigraphy of area is:

- Bevagna Unit consist in yellowish clay and sandy clays, gradually passing upwards to sand and yellow or ocra, in the western sector there are frequent gravel deposits relating to the environment defined in the previous literature as Pianacce Unit and Colle del Marchese Unit.

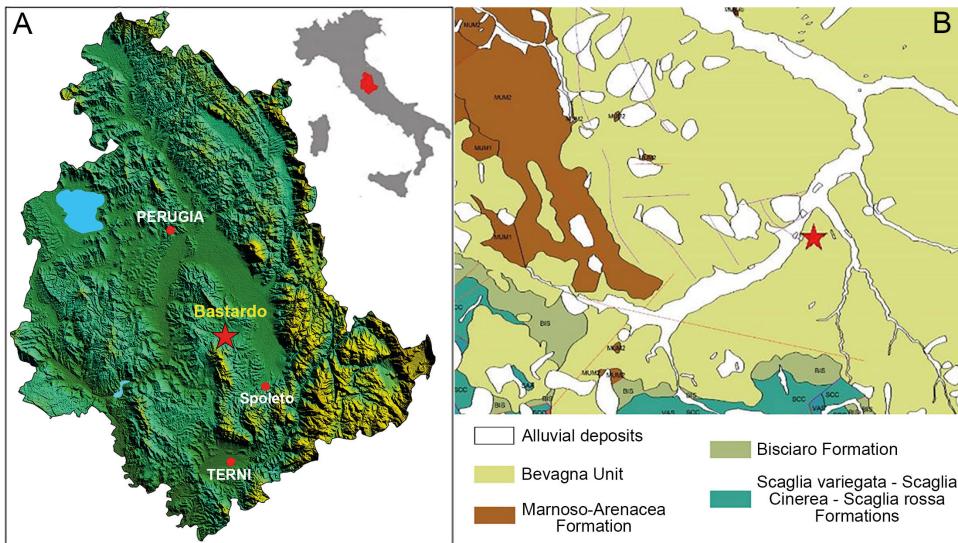


Figure 1. Bastardo site (Umbria, central Italy): A) geographical localization (red star) (modified after Petronio *et al.*, 2020); B) excerpt of the geological map of Umbria 1:10000, Sez. 323110 (modified from Regione Umbria, 2014); red star: location of the site.

- Montefalco Unit: Conglomerates and gravels consisting of sub-angular pebbles and rarely flat round pebbles up to 30 cm in length in a matrix of sand or silt. They emerge in a widespread manner along the waterways around the town of Montefalco. The clasts are Mesozoic-Cenozoic carbonates from the Umbria-Marche sequence, and to a lesser extent sandstone from the Marnoso - Arenacea Formation.

SITE STRATIGRAPHY

In particular (Fig. 2), from bottom to top, the succession consists of:

1. Deposit about one meter thick, mainly of yellowish-gray sandy clays, gradually passing upwards to yellow sands.
2. Cross-lamination fine sands of brown-brownish color with rounded inclusions of gravel size between 4.00 m and 2.5 m from the ground level; this level gradually becomes a brown silty clay sand. Inside this deposit there is a horizon of fine clayey sands of a light brown gray color with orange veins (iron/manganese mineralization?) containing the various remains of mammal faunas described in this work. The remains have a preferential orientation N310° and this suggests that the deposition was in a driven current system.
3. Deposits of conglomerates in clear disagreement with the previous sediments, with an erosive contact surface compared to the underlying deposits. The conglomerates are about 30% of the material and are mostly rounded and immersed in a black or brown clayey matrix. There are also gravelly lenses with little rounding. This material can be traced back to the latter part of the Pleistocene and the Holocene.

4. The last 50 cm are anthropic reworked deposits. The lithological characteristics and the deposit containing the fossil material allow it to be referred to the Bevagna Unit (Lower Pleistocene), to the Valle Umbra Subsynthem and to the Tiberine Synthem. This Unit is present in the Bevagna area and around the Bastardo Power Plant, fed by lignite beds from the same sandy-clayey sediments. Based on the continental gastropods (Esu & Girotti, 1974), Bevagna Unit was tentatively correlated with the Santa Maria di Ciciliano Formation of the south-western branch of the Tiberino Basin (Petronio *et al.*, 2002). Santa Maria di Ciciliano Formation, such as Fosso Bianco and Acquasparta Units, is currently classified as subsynthem of the Todi Synthem (Regione Umbria, 2014). The results presented herein are derived from data collected through time, often following excavations, also analyzing drilling for private constructions and the former sedimentologic description, achieved directly in the field is unpublished. Even the tectonics played an important role in modeling the present morphology of Bastardo basin since Middle-Late Pleistocene, even until last interglacial stage (Gregori & Cattuto, 1986). Two major fault systems were acting: one, in the Western side uplifting the Monte Martano ridge along the border fault, while its piedmont accumulated in fan deposits; the other one, the antithetic west dipping fault system was uplifting the conglomerates of the second sedimentary phase (presumably), originally laying at the plain level, up to the present Montefalco hill, nearly 180 meters above the Umbra valley. Immediately before this phase of uplift, small ponds were isolated, with local carbonate-siliceous deposition (Bizzarri *et al.*, 2011, 2018). Geological survey of area with a lot of drilling that get under the sand sequences reveal a 30-meter thick of gray and blue clay with lignite levels.

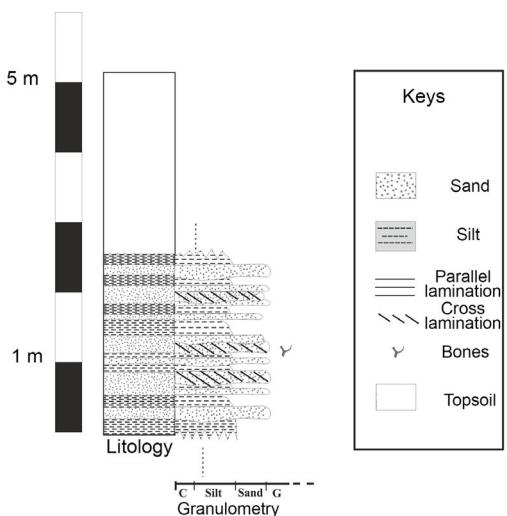


Figure 2. Bastardo (Umbria, central Italy): Sedimentological log of Molino creek. C: clay; G: gravel.

MATERIALS AND METHODS

The fossil remains, collected through the systematic excavation of the deposit, are preserved in the former Church of San Tommaso in Terni, a gathering place for numerous finds from various fossil deposits in Umbria on behalf of SABAPU. The mammal remains are stored in several boxes indicating the locality, but without inventory numbers. They were observed and when possible measured. Unfortunately, they were not in good preservation conditions, clean but not restored, and several fossil bones freed from the englobing sediment were divided into many fragments. Even for these reasons our observations are mainly based on the abundant photographic documentation carried out during the excavations in the summer 2009 (Fig. 3). In this work, therefore, the remains of the single taxa are described briefly and we will try to highlight mainly those essential morphological features that have allowed them to be recognized.

Afterwards, the paleontological data in addition to allowing the chronologic correlation of the Bastardo local fauna with several mammal assemblages from the south-western branch of the Tiberino Basin, will be interpreted to re-examine the lithostratigraphic relationships of the previous studies between the reference units of its two branches.

RESULTS

The mammals include the following taxa.

Macaca sylvanus florentinus Cocchi 1872

An almost complete mandible belongs to the Barbary macaque (Figs 3C and 4). It is very similar to the spec-

imen from Le Forre (Upper Valdarno, central Italy) on which Igino Cocchi (1827-1913) established the species *Inus florentinus* (Cocchi, 1872), today *Macaca sylvanus florentinus*, recently represented by Mazza *et al.* (2005) and Rook *et al.* (2013). Like both the hemimandibles from Le Forre, the right hemimandible from Bastardo is broken behind the third molar, while the left hemimandible keeps also a good part of the vertical branch. Furthermore, the Bastardo specimen preserves both the two canines and all the incisors, but show the two teeth-rows a little less converging forward (but it could be a post-depositional deformation) and a greater wear of the occlusal surface (clearly it belonged to an older individual). The incisors are unicuspites, slightly buccolingually flattened and protruding forward. The crown of canines is buccolingually compressed with an elliptical basal outline and without cingulid. In occlusal view, the crown walls are convex except by the flatter lingual wall, where it is observed a slight sulcus that progressively disappears before reaching the crown apex. The occlusal surface of p3 is sub-triangular and unicuspitate with the occlusal convex shape where the convex side is directed towards the buccal side. The p4 is sub-rectangular, with a two cusped trigonid and a flat talonid. The m1 and m2 display a more rectangular outline, a bilophodont occlusal pattern with the four cusps arranged two by two. The two lobes are approximately equally wide, and the buccal cleft is much more conspicuous than the lingual one. The lingual cusps are less rounded than the buccal ones. The m2 is somewhat bigger than m1. The m3 shows five cusps with the bilophodont shape and a well-developed talonid. The length of the m3 (~13 mm) is slightly larger than the finds from Quecchia and North Sea, and very close to that from Mugello, Basque Country and the maximum values from Untermassfeld, and falls in the upper part of the variability range of extant Barbary macaque (Rook, 1996; Castaños *et al.*, 2011; Bona *et al.*, 2016; Reumer *et al.*, 2018).

The Barbary macaque was widely distributed throughout North Africa and Europe during the Plio-Pleistocene, extending into Europe as far north as Netherlands and England (Elton & O'Regan, 2014; Reumer *et al.*, 2018). With the exception of *Macaca majori* Azzaroli, 1946 from Sardinia, currently considered a distinct, endemic species (Zoboli *et al.*, 2016), Plio-Pleistocene macaques from Europe are usually referred to several subspecies of *M. Sylvanus*: The Pliocene *M. sylvanus prisca* Gervais, 1859, the late Pliocene to early Pleistocene *M. sylvanus florentinus*, and the middle to late Pleistocene *M. sylvanus pliocena* Owen, 1846 (Rook, 2009; Alba *et al.*, 2011). According to Delson (1980), *M. sylvanus florentinus* is essentially comparable to the extant *M. sylvanus sylvanus* and larger than *M. sylvanus prisca*, while *M. sylvanus pliocena* is very close to *M. sylvanus florentina*, except for its slightly broader dentition. In It-

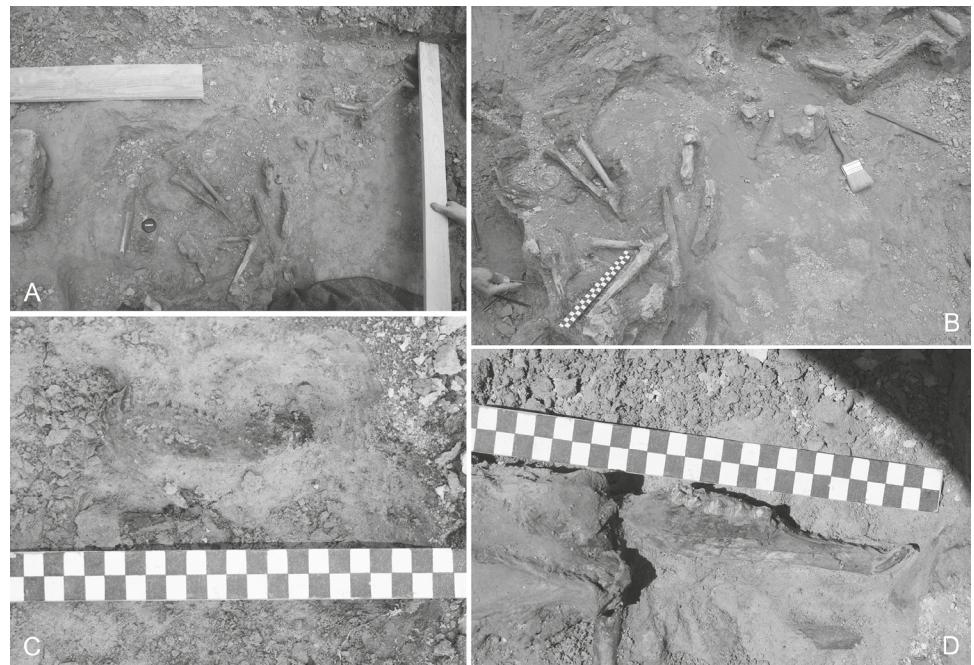


Figure 3. Bastardo (Umbria, central Italy), late Villafranchian: Photographic documentation carried out during the excavations in the summer 2009: A), B) stages of progress of the excavation; C) mandible of *Macaca sylvanus florentinus*; D) mandible of *Axis nestii* (photo by F. Famiani).

aly, *M. sylvanus* remains come mostly from deposits dating back to the late Pliocene - early Pleistocene (Basilici *et al.*, 1991; Rook, 1996, 2009; Gentili *et al.*, 1998; Rook *et al.*, 2001, 2013), but also middle and late Pleistocene (Mazza *et al.*, 2005; Sanso & Sardella, 2008; Bona *et al.*, 2016). The best preserved and complete fossil remains comes from Villafranca d'Ascoli (Piedmont, early Villafranchian, Triversa Faunal Unit =FU) (Rook *et al.*, 2001), various sites of Upper Valdarno (Tuscany, late Villafranchian, Tasso FU) (Rook *et al.*, 2013) and Pietrafitta (Umbria, late Villafranchian, Farneta FU) (Gentili *et al.*, 1998). So far, in Umbria it is reported, referred to *M. sylvanus florentinus*, at Pietrafitta and Monte Peglia (Argenti, 2004; Petronio *et al.*, 2020). Outside Africa, the Barbary macaque survived until the late Pleistocene in some localities in southern Europe (Castaños *et al.*, 2011; Elton & O'Regan, 2014), including Italy (Mazza *et al.*, 2005). Known in the Hellenistic age in the Greek and Latin world (Goudsmit & Brandon-Jones, 1999; Salari, 2006), in the Middle Ages a small population was introduced to Gibraltar, probably by the Arabs, and almost replaced at the end of the Second World War (Modolo *et al.*, 2005). Once widespread throughout North Africa, the Barbary macaque is the only macaque species found outside Asia, and it is now restricted to forest patches in northern Morocco and Algeria, besides the Gibraltar Rock (Fa, 1984, 1986; Camperio Ciani, 2005).

Canis sp.

Only a particularly sharp upper canine, which would indicate a predominantly carnivorous diet, can be as-

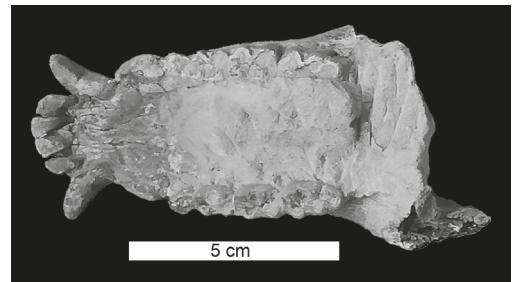


Figure 4. Bastardo (Umbria, central Italy), late Villafranchian: mandible of *Macaca sylvanus florentinus* (photo by F. Famiani).

cribed to this genus. Probably, by the small size (Fig. 5A), it could be connected to *Canis arnensis* Del Campana, 1913, one of the two canids that, together with *C. etruscus* Forsyth Major, 1877, was present in Italy during the late Villafranchian (Cherin *et al.*, 2013b; Petrucci *et al.*, 2013; Rook *et al.*, 2013), followed by *C. mosbachensis* Sörgel, 1925 (Petronio *et al.*, 2011; Petrucci *et al.*, 2013; Sardella *et al.*, 2018). The distinction among the Villafranchian species of the genus *Canis* can be made with certainty only through the cranial features, the shape and size of the cheekteeth and, to a lesser extent, the postcranial skeleton (e.g., Cherin *et al.*, 2013b; Bartolini Lucenti & Rook, 2016). Therefore, a single canine does not allow precise systematic indications. The first occurrence of the genus *Canis*, in Western Europe, is quoted around 3 Ma, in correspondence with our early Villafranchian, Triversa FU (Lacombat *et al.*, 2008), following its early appearance in North American Late Miocene and its dispersal and radiation throughout Asia (Bartolini Lucenti *et al.*, 2020).

During the so-called “Wolf event” (Torre, 1979; Azzaroli, 1983; Azzaroli *et al.*, 1988; Torre *et al.*, 1992; Rook, 1993; Rook & Torre, 1996; Spassov, 1998; Sardella & Palombo, 2007; Wang & Tedford, 2008; Rook & Martinez Navarro, 2010; Sotnikova & Rook, 2010), placed from the middle and late Villafranchian, there are numerous specific attributions of some remains, but there is disagreement between the different authors. For example, Martin (1973) considers *C. michauxi* Martin, 1973 from early Pliocene of Perpignan, France, the ancestor of *C. falconeri* Forsyth Major, 1877, and *C. adoxus* Martin, 1973 from early Pliocene of Saint Estève, France, the ancestor of *C. etruscus*. Conversely, both Torre (1979) and Cherin *et al.* (2014) identify different phyletic lines, and *C. adoxus* is currently ascribed to the primitive genus *Eucyon* (see Spassov & Rook, 2006) and *C. falconeri* to the genus *Lycaon* (see Rook, 1994; Martinez Navarro & Rook, 2003). This do not help to clarify the relationships between the phyletic complexes nor to completely resolve among the various genealogical trees of the different species.

Therefore, apart from the above relationships and from those that link these taxa to the more recent canids, such as *C. aureus* Linnaeus, 1758 and *C. lupus* Linnaeus, 1758 (Spassov, 1989; Salari *et al.*, 2017), also considering the recent research on canids in the complex scenario of Plio–Pleistocene mammalian faunal turnovers (Bartolini Lucenti *et al.*, 2020), the biochronology of the three species found in the late Villafranchian of Tiberino Basin is taken into consideration here: *C. etruscus*, *C. arnensis* and *C. mosbachensis*.

The first species, *C. etruscus*, morphologically close to the extant *C. lupus* (appeared in the middle Pleistocene during MIS 11; Petronio *et al.*, 2019) is reported in Italy from Coste San Giacomo site, Latium (Bellucci *et al.*, 2012), and biochronologically connected to the homonymous FU. Indeed, in this locality it is associated in stratum with some taxa that first occur in Italy during this interval time, such as *Gazellospira torticornis* (Aymard, 1854), *Eucladoceros teguliensis* Dubois, 1904 and *Sus strozzi* Forsyth Major, 1881. This canid is widely represented in the sites of Valdarno and Tiberino Basin referred to the two successive FUs, Olivola and Tasso (Rook & Martinez-Navarro, 2010; Bartolini Lucenti & Rook, 2016; Cherin *et al.*, 2013a, 2013b, 2014, 2016), and it seems that the last occurrences were during Tasso FU.

Canis arnensis is a canid with jackall-like morphological features and therefore closer to the extant *C. aureus* (see Bartolini Lucenti & Rook, 2016), and it is reported only in the Olivola and Tasso FUs (Petronio *et al.*, 2011; Bartolini Lucenti & Rook, 2016, 2018; Petronio & Salari, 2021), replaced in the final Villafranchian (Pirro FU) by another canid morphologically close to the extant *C. latrans* Say, 1823 (Sotnikova, 2001). Finally, also *C. mosbachensis* first appears in the last stages

of the Villafranchian, Pirro FU (Petronio *et al.*, 2011; Petrucci *et al.*, 2013), and occurs until the late Galerian (Petronio *et al.*, 2019, 2020; Mecozzi *et al.*, 2020).

Equus stenonis Cocchi, 1867

A third metacarpus of equid can be referred to the Stenon’ horse (Fig. 5B). The dimensions of the specimen (maximum length: ~240 mm; proximal breadth: ~52 mm; minimum breadth at half diaphysis: ~34 mm; distal breadth: ~49 mm) are very close to the mean values of the corresponding measures of *E. stenonis stenonis* from Upper Valdarno (Alberdi *et al.*, 1998). It is different from *E. livenzovensis* Bajgusheva, 1978 in slightly smaller size, conversely from *E. stehlini* Azzaroli, 1965 in larger size, and from *E. altidens* von Reichenau, 1915 and *E. suessenbornensis* Wüts, 1901, of approximately similar length, due to the different proportions of the epiphyses, more slender in the first and slightly more squat in the second (Alberdi *et al.*, 1998; Alberdi & Palombo, 2013a, 2013b; Petronio & Salari, 2021).

Equus stenonis has a long biochronological timespan in the Italian peninsula, ranging from the middle Villafranchian to part or the whole late Villafranchian (Gliozzi *et al.*, 1997; Petronio *et al.*, 2011, Boulbes & van Asperen, 2019, Cirilli *et al.*, 2021), until the Tasso FU (Rook & Martinez-Navarro, 2010; Alberdi & Palombo, 2013a). Except *E. stehlini*, who seems limited to Tasso FU (Alberdi & Palombo, 2013a, Cirilli *et al.*, 2021), the other Villafranchian equids also have long biochronological intervals, *E. livenzovensis* from the early to middle Villafranchian, *E. altidens* and *E. suessenbornensis* from the latest Villafranchian to the middle Galerian (Gliozzi *et al.*, 1997; Rook & Martinez-Navarro, 2010; Petronio *et al.*, 2011; Alberdi & Palombo, 2013a; Boulbes & van Asperen, 2019; Cirilli *et al.*, 2021).

So far, in Umbria, equid remains referred to the Stenon’ horse are recorded in several local faunas ascribed to the Olivola and Tasso FUs, such as Torre Picchio, Villa San Faustino, Frattaguida, Colle Lame and Podere San Lorenzo (Petronio *et al.*, 2002; Argenti, 2004; Cherin *et al.*, 2019; Petronio & Salari, 2021). The *Equus* record from Pantalla, pending the results of ongoing geo-chronological studies at the site, can be correlated with the middle Villafranchian also, between Coste San Giacomo and Olivola FUs (Cherin *et al.*, 2021).

Sus cf. S. strozzi Forsyth Major, 1881

The suids are represented only by two fragmentary lower canines (Fig. 5C) compatibles in morphology with this middle and late Villafranchian species present in many central Italy mammal assemblages, such as Pantalla, Villa San Faustino and Podere S. Lorenzo in the Tiberino Basin (Sardella *et al.*, 1995; Gentili *et al.*, 1997; Cherin *et al.*, 2019). *Sus strozzi* was described briefly for the first time by Forsyth Major (1881) and more widely by Azzaroli (1954). It is probably derived



Figure 5. Bastardo (Umbria, central Italy), late Villafranchian: A) upper canine of *Canis* sp.; B) third metacarpus of *Equus stenonis*; C) lower canine fragment of *Sus* cf. *S. strozzii* (photo by F. Famiani).

by *S. minor* Depéret, 1885 of the early Villafranchian, and it does not have a great biochronological significance due to its long presence ranging from the middle Villafranchian to throughout the late Villafranchian, to be later replaced by *S. scrofa* Linnaeus, 1758 in the Galerian (Gliozzi *et al.*, 1997; Petronio *et al.*, 2011; Cherin *et al.*, 2018).

Eucladoceros ctenoides (Nesti, 1841) vel *Eucladoceros dicranios* (Nesti, 1841)

In some images relating to the excavations, few remains of antler portions of considerable size and fragments of metapodial bones attributable to a large cervid are seen (Figs 3A-B and 6A). These remains could belong to *Eucladoceros dicranios* or to *E. ctenoides*, particularly due to the proximal anteroposterior diameter of the epiphyses of the metapodial bones that are compatibles with those of these massive cervids. Both *E. dicranios* and *E. ctenoides* occur in many deposits of central Italy (Tuscany and Umbria particularly) in the Olivola and Tasso FUs (Gliozzi *et al.*, 1997; Girotti *et al.*, 2003; Rook & Martínez-Navarro, 2010; Petronio *et al.*, 2011; Petronio & Pandolfi, 2011; Petronio & Salari, 2021).

Axis nestii (Azzaroli, 1947)

The remains of cervids attributed to this species are present in the fossiliferous deposit with numerous skeletal elements, some of which appear to be partially anatomically connected (Fig. 3A-B) or, in any case, seem not to have undergone a long transport. The images taken during the excavation phases show various fragments of several mandibles (Fig. 3D) with premolar and molar brachiodonts, and with parameters compatibles with this genus. Even the morphological features of the metapodial bones seem to fall within the morphology of *Axis*. But it is mostly the basal frag-



Figure 6. Bastardo (Umbria, central Italy), late Villafranchian: A) portions of metapodial bones of *Eucladoceros dicranios* vel *ctenoides* (up) and *Axis nestii* (down); B) portion of basal antler of *Axis nestii* (photo by F. Famiani).

ment of antler (Fig. 6B) in which it is clearly possible to see the on average long peduncle, a section "b" of the beam, also this moderately long and, above all, an acute angle between the beam and the brow tine. All these unequivocal morphological features are typical of the *A. nestii* antler (Azzaroli, 1947, 1992; Di Stefano & Petronio, 1998, 2002).

The synonymy of this taxon is quite complex because for a long time it was assimilated to the genus *Dama* or *Pseudodama* (see Azzaroli, 1947, 1992; Di Stefano & Petronio, 1998, 2002; Cherin *et al.*, 2019). Actually, it has been demonstrated its close phylogenetic relationship with the Chinese *Axis* genus that migrated to Europe in the early Villafranchian (Di Stefano & Petronio, 1998, 2002) and this is accepted by a part of the scientific community (e.g., Made, 1999). During this migration, in the middle Villafranchian (Coste San Giacomo FU), in various sites of the peninsula the more archaic species *A. lyra* (Azzaroli, 1992) occurs. Among the best-known sites, beyond Coste San Giacomo in Latium, we remember Montopoli in lower Valdarno, Tuscany, and Cava Toppetti in the south-western branch of Tiberino Basin, Umbria (Argenti, 2004). This primitive cervid, as is known, had a frontal peduncle very long, a section "b" of the beam generally greater than two centimeters and above all a brow tine separated from the beam by a very acute angle (Di Stefano & Petronio 1998, 2002).

A subsequent speciation referable to the late Villafranchian (Olivola and Tasso FUs) is *A. nestii* with the morphological features of the basal part of the antler mentioned above. This species mainly occurs in numerous late Villafranchian mammal assemblages such as Olivola and Matassino in Tuscany (Rook *et al.*, 2013), Villa San Faustino, Torre Picchio, Podere San Lorenzo and Pantalla in Umbria (Petronio *et al.*, 2002; Girotti

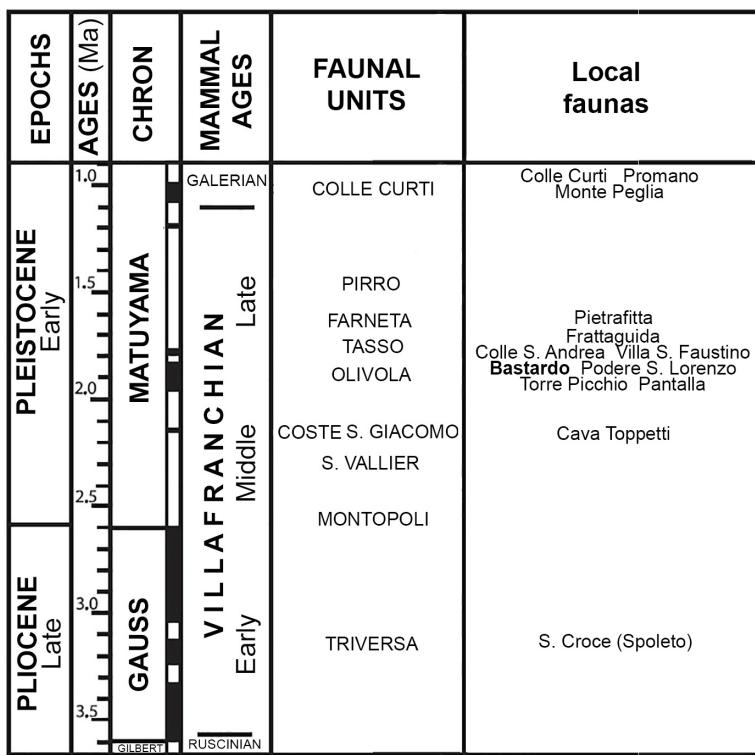


Figure 7. Biochronologic position of the mammal assemblage from Bastardo (Molino creek site) and other selected mammal assemblages from Umbria (Italy) (by Petronio & Salari, 2021, modified).

et al., 2003; Argenti, 2004; Cherin *et al.*, 2019), Fontana Acetosa and Monte Riccio in Latium (Mazzini *et al.*, 2000; Petronio *et al.*, 2011). Finally, always in the late Villafranchian (Farneta FU) *A. eurygonos* (Azzaroli, 1947) appears in many Italian localities. In this evolved species, the lower part of the antler has a completely different structure, with the peduncle almost non-existent, as well as the section “b” of the beam, while the angle between this and the brow tine is decidedly obtuse (Di Stefano & Petronio 1998, 2002). This species has been the longest-lived and its remains are in fact found in various deposits throughout the peninsula up to the late Galerian (Gliozi *et al.*, 1997; Petronio *et al.*, 2011, 2019).

DISCUSSION AND CONCLUSIVE REMARKS

All the taxa represented in this site have a biochronological distribution that can be traced back to the late Villafranchian. In particular, most of these, such as *Macaca sylvanus florentinus*, *Canis* sp., *Equus stenonis* and *Sus* cf. *S. strozzii*, have a rather wide time interval. Instead, *Eucladoceros dicranios vel ctenoides*, even if the sure systematic position has not been ascertained, indicates a restricted biochronological interval, entirely included in the Olivola and Tasso FUs (Gliozi *et al.*, 1997; Girotti *et al.*, 2003; Rook & Martínez-Navarro, 2010; Petronio *et al.*, 2011).

Even the canine of Canidae, if it belonged to *C. arvensis*, would indicate the same chronological interval (Petronio *et al.*, 2011; Bartolini Lucenti & Rook, 2016, 2018; Petronio & Salari, 2021). Finally, according to the Authors (e.g., Gliozi *et al.*, 1997; Petronio *et al.*, 2011; Cherin *et al.*, 2019) also *Axis nestii*, identified with confidence, indicates the Olivola and Tasso FUs. This short time interval is compatible with the biochronology of the other taxa.

The biochronology ascertained (Fig. 7), particularly through the occurrence of *A. nestii* and *E. dicranios vel ctenoides*, indicates the temporal correlation (~1.8–1.7 Ma) with other mammal assemblages from the south-western branch of Tiberino Basin, such as Pantalla, Torre Picchio, Villa San Faustino, Colle Sant’Andrea and Podere San Lorenzo (Sardella *et al.*, 1995; Girotti *et al.*, 2003; Cherin *et al.*, 2019; Petronio & Salari, 2021). Most of these mammal assemblages were found in the sands of the Santa Maria di Ciciliano Formation. This would allow to confirm the chronologic correlation between Bevagna Unit and Santa Maria di Ciciliano Subsyntheme, already hypothesized by Petronio *et al.* (2002) on the basis of continental gastropods. Moreover, it is further evidence of a still quite similar paleoenvironment in the late Villafranchian between the two branches of the Tiberino Basin, or at least between the southern portion of the south-western branch and the Bastardo “gulf” in south-eastern branch.

In particular, the landscape seems to be characterized by a forest environment, as confirmed by the occurrence of the macaque and the browsing deer (*E. diocerous* vel *ctenoides* and *A. nestii*), but with the gradual enlargement of open spaces, as suggested by the presence of grassland / steppe taxa (*Canis* and *E. stenonis*). Furthermore, the occurrence of *Sus* cf. *S. strozzii*, taxon with great ecological adaptability due to its diet, indicates a certain variety of environments ranging from open humid forest, grasslands, to the alluvial plain (Faure & Guerin, 1984).

As described in the geostratigraphic synthesis, the Plio-Pleistocene neotectonics influenced the formation of the Bastardo basin causing a strong distortion of the surface runoff of the water network and also the paleogeography of the eroding areas of the entire Tiberino Basin. This probably had a high influence on the numerical disparity of fossiliferous deposits of the Tiberino Basin. In fact, the vast majority of mammal assemblages are localized in the south-western branch of this vast basin (Petronio *et al.*, 2002; Girotti *et al.*, 2003; Argenti, 2004; Cherin *et al.*, 2013a, 2016, 2019; Bizzarri *et al.*, 2018). These deposits are almost all biochronologically referable to the late Villafranchian, Olivola and/or Tasso FUs (Ambrosetti *et al.*, 1987, 1995; Basilici, 1992; Argenti, 1999, 2004; Petronio & Salari, 2021; Fig. 7). The one exception is Cava Toppetti (Todi), in which the occurrence of *E. livenzovenensis* and *A. lyra*, among others, indicate a biochronologic interval related to the middle Villafranchian, Coste S. Giacomo FU (Abbazzi *et al.*, 1997; Argenti, 1999, 2004; Petronio *et al.*, 2002, 2011).

Therefore, the mammal assemblage from Bastardo is found almost unique in the south-eastern branch, in the same branch as the paleontological site from Santa Croce mine (Spoleto) attributed to the early Villafranchian, Triversa FU (Kotsakis, 1986; Petronio *et al.*, 2002; Argenti, 2004; Fig. 7), in a geological moment just before the typical quaternary tectonics.

If the biochronological framework of Bastardo fauna will be confirmed, this mammal assemblage represents the passage to the late Villafranchian faunas, which took place starting from the end of the first part of the early Pleistocene (~1.8-1.7 Ma). Therefore this assemblage would seem to add to the most representative deposits located in those Apennine areas that at time were occupied by more or less extensive continental sedimentation basins, such as the Tiberino Basin.

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REFERENCES

- ABBAZZI L., ALBIANELLI A., AMBROSETTI P., ARGENTI P., BASILICI G., GENTILI S., MASINI F., PONTINI M.R., 1997. Paleontological and sedimentological records in Pliocene distal alluvial fan deposit at Cava Toppetti (Todi, Central Italy). *Bollettino della Società Paleontologica Italiana* 36: 5-22.
- ALBA D.M., CALERO J.A.C., MANCHEÑO M.A., MONTOYA P., MOREALES J., ROOK L., 2011. Fossil remains of *Macaca sylvanus florentina* (Cocchi, 1872) (Primates, Cercopithecidae) from the Early Pleistocene of Quibas (Murcia, Spain). *Journal of Human Evolution* 61: 703-718.
- ALBERDI M.T., ORTIZ JAUREGUIZAR E., PRADO J.L., 1998. A quantitative review of European stenonoid horses. *Journal of Paleontology* 72: 371-387.
- ALBERDI M.T., PALOMBO M.R., 2013a. The late Early to early Middle Pleistocene stenonoid horses from Italy. *Quaternary International* 288: 25-44.
- ALBERDI M.T., PALOMBO M.R., 2013b. The Early Pleistocene Equidae from Pirro Nord (Apricena, Southern Italy). *Palaeontographica Abt. A* - 298: 147-167.
- AMBROSETTI P., BASILICI G., CAPASSO BARBATO L., CARBONI M.G., DI STEFANO G., ESU D., GLIOZZI E., PETRONIO C., SARDELLA R., SQUAZZINI E., 1995. Il Pleistocene inferiore nel ramo sud-occidentale del Bacino Tiberino (Umbria): aspetti litostratigrafici e biostratigrafici. *Il Quaternario - Italian Journal of Quaternary Sciences* 8: 16-36.
- AMBROSETTI P., CARBONI M.G., CONTI M.A., ESU D., GIROTTI O., LA MONICA G.B., LANDINI B., PARISI G., 1987. Il Pliocene ed il Pleistocene inferiore del bacino del fiume Tevere nell'Umbria meridionale. *Geografia Fisica e Dinamica del Quaternario* 10: 10-33.
- ARGENTI P., 1999. *La biocronologia dei roditori del PlioPleistocene dell'Umbria e l'evoluzione del genere Apodemus in Italia*. Ph. D. Thesis, Università degli Studi di Perugia, 240 pp.
- ARGENTI P., 2004. Plio-Quaternary mammal fossiliferous sites of Umbria (Central Italy). *Geologica Romana* 37: 67-78.
- AZZAROLI A., 1947. I cervi fossili della Toscana con particolare riguardo alle specie villafranchiane. *Palaeontographia Italica* 43: 45-82.
- AZZAROLI A., 1954. Revisione della fauna dei terreni fluvio-lacustri del Valdarno Superiore, V. Filogenesi e biologia di *Sus strozzii* e di *Sus minor*. *Palaeontographia Italica* 48: 41-76.
- AZZAROLI A., 1983. Quaternary mammals and the "End-Villafranchian" dispersal event. A turning point in the history of Eurasia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 44: 117-139.
- AZZAROLI A., 1992. The cervid genus *Pseudodama* n.g. in the Villafranchian of Tuscany. *Palaeontographia Italica* 79: 1-41.
- AZZAROLI A., DE GIULI C., FICCARIELLI G., TORRE D., 1988. Late Pliocene to early Mid-Pleistocene mammals in Eurasia: faunal succession and dispersal events. *Palaeogeography, Palaeoclimatology, Palaeoecology* 66: 77-100.
- BARTOLINI LUCENTI S., ROOK L., 2016. A review of the Late Villafranchian medium-sized canid *Canis arnensis* based on the evidence from Poggio Rosso (Tuscany, Italy). *Quaternary Science Reviews* 151: 58-71.
- BARTOLINI LUCENTI S., ROOK L., 2018. The fossil record of the genus *Canis* (Canidae, Carnivora, Mammalia) from the Up-

- per Valdarno: a critical revision in the frame of the Early and Middle Pleistocene canids of Eurasia. *Alpine and Mediterranean Quaternary* 31, 169-172.
- BARTOLINI LUENTI S., BUKHSIANIDZE M., MARTÍNEZ-NAVARRO B., LORDKIPANIDZE D., 2020. The wolf from Dmanisi and Augmented Reality: review, implications and opportunities. *Frontiers in Earth Science (Paleontology)* 8: 131.
- BASILICI G., 1992. *Il bacino continentale tiberino (Pliocene-Pleistocene, Umbria): analisi sedimentologica e stratigrafica*. Ph.D. Dissertation, Università degli Studi di Bologna, 323 pp.
- BASILICI G., 1997. Sedimentary facies in an extensional and deep-lacustrine depositional system: the Pliocene Tiberino Basin, Central Italy. *Sedimentary Geology* 109: 73-94.
- BASILICI G., 2000. Pliocene Lacustrine Deposits of the Tiberino Basin (Umbria, Central Italy). *American Association of Petroleum Geologists* 46: 505-514.
- BASILICI G., FARAOONE A. G., GENTILI S., 1991. Un nuovo reperto di *Macaca* nelle brecce ossifere pleistoceniche di Monte Peglia (Terni, Italia centrale). *Bollettino della Società Paleontologica Italiana* 30: 251-254.
- BELLUCCI L., MAZZINI I., SCARDIA G., BRUNI L., PARENTI F., SEGRE A.G., NALDINI E.S., SARDELLA R., 2012. The site of Coste San Giacomo (Early Pleistocene, central Italy): palaeoenvironmental analysis and biochronological overview. *Quaternary International* 267: 30-39.
- BIZZARRI R., ALBIANELLI A., ARGENTI P., BALDANZA A., COLACICCHI R., NAPOLEONE G., 2011. The latest continental filling of Valle Umbra (Tiber Basin, central Italy) dated to one million years ago by magnetostratigraphy. *Il Quaternario* 24, 51-65.
- BIZZARRI R., CORRADO P., MAGRI D., MARTINETTO E., ESU D., CAPRAI V., COLACICCHI R., NAPOLEONE G., ALBIANELLI A., BALDANZA A., 2018. Palaeoenvironmental and climatic inferences from the late early Pleistocene lacustrine deposits in the eastern Tiberino Basin (central Italy). *Quaternary Research* 90: 201-221.
- BONA F., BELLUCCI L., CASALI D., SCHIROLI P., SARDELLA R., 2016. *Macaca sylvanus* Linnaeus 1758 from the Middle Pleistocene of Quecchia quarry (Brescia, Northern Italy). *Hystrix, the Italian Journal of Mammalogy* 27: 158-162.
- BOULBES N., VAN ASPEREN E.N., 2019. Biostratigraphy and Palaeoecology of European *Equus*. *Frontiers in Ecology and Evolution* 7: 301.
- BUCCI F., MIRABELLA F., SANTANGELO M., MAURO M., GUZZETTI F., 2016. Photo-geology of the Montefalco Quaternary Basin, Umbria, Central Italy. *Journal of Map* 12 (suppl): 314-322.
- CAMPERIO CIANI A., PALENTINI L., ARAHOU M., MARTINOLI L., CAPILUCCI C., MOUNA M., 2005. Population declines of *Macaca sylvanus* in the middle Atlas of Morocco. *Biological Conservation* 121: 635-641.
- CASTAÑOS P., MURELAGA X., ARRIZABALAGA A., IRIARTE-CHIAPUSO M.J., 2011. First evidence of *Macaca sylvanus* (Primates, Cercopithecidae) from the Late Pleistocene of Lezetxiki II cave (Basque Country, Spain). *Journal of Human Evolution* 60: 816-820.
- CATTUTO C., CENCETTI C., GREGORI L., 1988. Lo studio dei corsi d'acqua minori dell'Italia Appenninica come mezzo di indagine sulla tettonica del Plio/Pleistocene. *Bollettino Museale di Storia Naturale della Lunigiana* 6/7: 7-10.
- CHERIN M., AZZARÀ B., BREDA M., ANSOLEAGA A.B., BUZI C., PANDOLFI L., PAZZAGLIA F., 2019. Large mammal remains from the Early Pleistocene site of Podere San Lorenzo (Perugia, central Italy). *Rivista Italiana di Paleontologia e Stratigrafia* 125: 489-515.
- CHERIN M., BERTÈ D.F., ROOK L., SARDELLA R., 2014. Re-defining *Canis etruscus* (Canidae, Mammalia): a new look into the evolutionary history of Early Pleistocene dogs resulting from the outstanding fossil record from Pantalla (Italy). *Journal of Mammalian Evolution* 21: 95-110.
- CHERIN M., BERTÈ D.F., SARDELLA R., ROOK L., 2013b. *Canis etruscus* (Canidae, Mammalia) and its role in the faunal assemblage from Pantalla (Perugia, central Italy): comparison with the late Villafranchian large carnivore guild of Italy. *Bollettino della Società Paleontologica Italiana* 52: 11-18.
- CHERIN M., CIRILLI O., AZZARÀ B., BERNOR R.L., 2021. *Equus stenonis* (Equidae, Mammalia) from the Early Pleistocene of Pantalla (Italy) and the dispersion of stenonine horses in Europe. *Bollettino della Società Paleontologica Italiana* 60: 1-18.
- CHERIN M., IURINO D.A., SARDELLA R., 2013a. New well-preserved material of *Lynx issiodorensis valdarnensis* (Felidae, Mammalia) from the Early Pleistocene of Pantalla (central Italy). *Bollettino della Società Paleontologica Italiana* 52: 103-111.
- CHERIN M., IURINO D.A., WILLEMSSEN G., CARNEVALE G., 2016. A new otter from the Early Pleistocene of Pantalla (Italy), with remarks on the evolutionary history of Mediterranean Quaternary Lutrinae (Carnivora, Mustelidae). *Quaternary Science Reviews* 135: 92-102.
- CHERIN M., SORBELLI L., CROTTI M., IURINO D.A., SARDELLA R., SOURN A., 2018. New material of *Sus strozzii* (Suidae, Mammalia) from the Early Pleistocene of Italy and a phylogenetic analysis of suines. *Quaternary Science Reviews* 194: 94-115.
- CIRILLI O., SAARINEN J., PANDOLFI L., ROOK L., BERNOR R.L., 2021. An updated review on *Equus stenonis* (Mammalia, Perissodactyla): new implications for the European Early Pleistocene *Equus* taxonomy and paleoecology and remarks on the Old World *Equus* evolution. *Quaternary Science Reviews* 269: 107-155.
- COCHI I., 1872. Su di due Scimmie fossili italiane. *Bollettino del Regio Comitato Geologico d'Italia* 3: 59-71.
- COLTORTI M., PIERUCCINI P., 1997. The southeastern Tiber Basin (Spoleto, Central Italy): geology and stratigraphy of Plio-Pleistocene sediments. *Il Quaternario - Italian Journal of Quaternary Sciences* 10: 159-180.
- COLTORTI M., PIERUCCINI P., 2006. The last interglacial pedocomplexes in the litho-and morpho-stratigraphical framework of the central-northern Apennines (Central Italy). *Quaternary International* 156: 118-132.
- CONTI M.A., GIROTTI O., 1977. Il Villafranchiano nel "lago Tiberino", ramo sud-occidentale: schema stratigrafico e tettonico. *Geologica Romana* 16: 67-80.
- DELSON E., 1980. *Fossil macaques, phyletic relationships and a scenario of deployment*. In: Lindburg D.E. (ed.), *The Macaques. Studies in Ecology, Behavior and Evolution*: 10-30. Van Nostrand, New York.
- DI STEFANO G., PETRONIO C., 1998. Origin of and relationships among the *Dama*-like cervids in Europe. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen* 207: 37-55.
- DI STEFANO G., PETRONIO C., 2002. Systematics and Evolution of the Eurasian Plio-Pleistocene tribe cervini (Artiodactyla, Mammalia). *Geologica Romana* 36(2000-2002): 311-334.

- ELTON S., O'REGAN H.J., 2014. Macaques at the margins: The biogeography and extinction of *Macaca sylvanus* in Europe. *Quaternary Science Reviews* 96: 117-30.
- ESU D., GIROTTI O., 1974. La malacofauna continentale del Plio-Pleistocene dell'Italia centrale. I: Paleontologia. *Geologica Romana* 13: 203-293.
- FA J.E., 1984. Habitat distribution and habitat preference in Barbary macaque (*Macaca sylvanus*). *International Journal of Primatology* 5: 273-86.
- FA J.E., 1986. On the ecological status of the Barbary macaque *Macaca sylvanus* L. in North Morocco: Habitat influences versus human impact. *Biological Conservation* 35: 215-258.
- FAMIANI D., BRUNORI C.A., PIZZIMENTI L., CARA F., CACIAGLI M., MELELLI L., MIRABELLA F., BARCHI M.R., 2020. Geophysical reconstruction of buried geological features and site effects estimation of the Middle Valle Umbra basin (central Italy). *Engineering Geology* 269: 105543. <http://doi.org/10.1016/j.enggeo.2020.105543>.
- FAURE M., GUERIN C., 1984. *Sus strozzii* et *Sus scrofa*, deux mammifères artiodactyles, marqueurs des paleoenvironnements. *Palaeogeography, Palaeoclimatology, Palaeoecology* 48: 215-228.
- FLYNN L.J., 2002. Can the wolf event be recognized in north China? *Annales Géologiques des Pays Helléniques* 39: 317-326.
- FORSYTH-MAJOR C., 1881. Studi sugli avanzi pliocenici del genere *Sus* (*Sus strozzii* Menegh.). *Atti della Società Toscana di Scienze Naturali* p.v. 2: 227.
- GE.MI.NA. 1963. *Lignite e torbe dell'Italia centrale*. ILTE, Torino, 322 pp.
- GENTILI S., AMBROSETTI P., ARGENTI P., 1997. Large carnivore and other mammal fossils from the Early Pleistocene alluvial plain of the Tiberino Basin (Pantalla, central Italy). Preliminary reports. *Bollettino della Società Paleontologica Italiana* 36: 231-238.
- GENTILI S., MOTTURA A., ROOK L., 1998. The Italian fossil primate record: recent finds and their geological context. *Geobios* 31: 675-686.
- GIROTTI O., CAPASSO BARBATO L., ESU D., GLIOZZI E., KOTSAKIS T., MARTINETTO E., PETRONIO C., SARDELLA R., SQUAZZINI E., 2003. The section of Torre Picchio (Terni, Umbria, Central Italy): a Villafranchian site rich in vertebrates, molluscs, ostracods and plants. *Rivista Italiana di Paleontologia e Stratigrafia* 109: 77-98.
- GLIOZZI E., ABBAZZI L., ARGENTI P., 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 ostracods from Middle Pliocene to the Late Pleistocene in Italy. The state of art. *Rivista Italiana di Paleontologia e Stratigrafia* 103: 369-388.
- GOUDSMEIT J., BRANDON-JONES D., 1999. Mummies of Olive Baboons and Barbary Macaques in the Baboon Catacomb of the Sacred Animal Necropolis at North Saqqara. *The Journal of Egyptian Archaeology* 85: 45-53.
- GREGORI L., 1988. Il Bacino di Bastardo: genesi ed evoluzione nel quadro della tettonica recente. *Bollettino della Società Geologica Italiana* 105: 173-184.
- GREGORI L., CATTUTO C., 1986. Elementi geomorfologici ed episodi di tettonica recente nei dintorni di Spoleto (Umbria). *Bollettino della Società Geologica Italiana* 105: 173-184.
- LACOMBAT F., ABBAZZI L., FERRETTI M.P., MARTÍNEZ-NAVARRO B., MOULLÉ P.E., PALOMBO M.R., ROOK L., TURNER A., VALLI A.M.F., 2008. New data on the Early Villafranchian fauna from Viallette (Haute-Loire, France) based on the collection of the Crozatier Museum (Le Puy-en-Velay, Haute-Loire, France). *Quaternary International* 179: 64-71.
- LOTTI B., 1917. L'antico Lago Tiberino e le ligniti dell'Umbria. *La Miniera Italiana* 7: 1-8.
- LOTTI B., 1926. *Descrizione geologica dell'Umbria*. Ministero dell'Economia Nazionale, Regio Ufficio Geologico, Provveditorato generale dello Stato, Roma, 320 pp.
- KOTSAKIS T., 1986. Elementi di paleobiogeografia dei mammiferi terziari dell'Italia. *Hystix, the Italian Journal of Mammalogy* 1: 25-68.
- MADE J. VAN DER, 1999. On *Euraxis*, on the rules of the ICZN, on Methodology. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte* 11: 676-678.
- MARTIN R., 1973. Trois nouvelles espèces de Caninae (Canidae, Carnivora) du gisements Plio-Villafranchiens d'Europe. *Documents des laboratoires de Géologie de la Faculté des Sciences de Lyon* 57: 87-96.
- MARTINEZ-NAVARRO B., ROOK L., 2003. Gradual evolution in the African hunting dog lineage. Systematic implications. *Comptes Rendus Palevol* 2: 695-702.
- MAZZA P., RUSTIONI M., AGOSTINI S., ROSSI A., 2005. An unexpected Late Pleistocene macaque remain from Grotta degli Orsi Volanti (Rapino, Chieti, central Italy). *Geobios* 38: 211-217.
- MAZZINI I., PACCARA P., PETRONIO C., SARDELLA R., 2000. Geological evolution and biochronological evidences of the Monte Riccio section (Tarquinia, Central Italy). *Rivista Italiana di Paleontologia e Stratigrafia* 106: 247-256.
- MECOZZI B., IURINO D.A., PROFICO A., ROSA C., SARDELLA R., 2021. The wolf from the Middle Pleistocene site of Ostiense (Rome): the last occurrence of *Canis mosbachensis* (Canidae, Mammalia) in Italy. *Historical Biology* 33(10): 2031-2042.
- MIRABELLA F., BUCCI F., SANTANGELO M., CARDINALI M., CAIELLI G., DE FRANCO R., GUZZETTI F., BARCHI M.R., 2018. Alluvial fan shifts and stream captures driven by extensional tectonics in central Italy. *Journal of the Geological Society* 175: 788-805.
- MODOLO L., SALZBURGER W., MARTIN R.D., 2005. Phylogeography of Barbary macaques (*Macaca sylvanus*) and the origin of the Gibraltar colony. *PNAS* 102: 7392-7397.
- PETRONIO C., ANGELONE C., ATZORI P., FAMIANI F., KOTSAKIS T., SALARI L., 2020. Review and new data of the fossil remains from Monte Peglia (late Early Pleistocene, central Italy). *Rivista Italiana di Paleontologia e Stratigrafia* 126: 791-819.
- PETRONIO C., ARGENTI P., CALOI L., ESU D., GIROTTI O., SARDELLA R., 2002. Updating Villafranchian Molluscs and Mammal Faunas of Umbria and Latium (Central Italy). *Geologica romana* 36(2000-2002): 369-387.
- PETRONIO C., BELLUCCI L., MARTINETTO E., PANDOLFI L., SALARI L., 2011. Biochronology and palaeoenvironmental changes from the Middle Pliocene to the Late Pleistocene in Central Italy. *Geodiversitas* 33: 485-517.
- PETRONIO C., DI STEFANO G., KOTSAKIS T., SALARI L., MARRA F., JICHA B.R., 2019. Biochronological framework for the late Galerian and early-middle Aurelian Mammal Ages of peninsular Italy. *Geobios* 53: 35-50.

- PETRONIO C., PANDOLFI L., 2011. First occurrence of the genus *Arvernoceros* Heintz 1970 from the late early Pleistocene of Italy. *Rivista Italiana di Paleontologia e Stratigrafia* 117: 501-508.
- PETRONIO C., SALARI L., 2021. Fossil remains of Villafranchian mammals from Frattaguida (Parrano, Terni, central Italy). *Revue de Paléobiologie* 40: 199-209.
- PETRUCCI M., CIPULLO A., MARTÍNEZ-NAVARRO B., ROOK L., SARDELLA R., 2013. The late Villafranchian (Early Pleistocene) carnivores (Carnivora, Mammalia) from Pirro Nord (Italy). *Palaeontographica Abt. A* 298: 113-145.
- REGIONE UMBRIA, 2014. *Cartografia geologica*. Retrieved from <http://www.regione.umbria.it/paesaggio-urbanistica/cartografia-geologica>
- REUMER J.W.F., MOL D., KAHLE R.D., 2018. First finds of Pleistocene *Macaca sylvanus* (Cercopithecidae, Primates) from the North Sea. *Revue de Paléobiologie* 37: 555-560.
- ROOK L., 1993. *I cani dell'Eurasia dal Miocene superiore al Pleistocene medio*. Ph.D. Thesis, Università di Modena, Bologna, Firenze, Roma "La Sapienza", 131 pp.
- ROOK L., 1994. The Plio-Pleistocene Old World *Canis* (*Xenocyon*) ex gr. *falconeri*. *Bollettino della Società Paleontologica Italiana* 33: 71-82.
- ROOK L., 1996. *Macaca sylvanus florentina* (Cocchi, 1872) from the Pleistocene Mugello basin (Northern Apennines, Italy). *Bollettino della Società Paleontologica Italiana* 35: 357-359.
- ROOK L., 2009. The Italian fossil primate record: an update and perspective for future research. *Bollettino della Società Paleontologica Italiana* 48: 67-77.
- ROOK L., CROITOR R., DELFINO M., FERRETTI M.P., GALLAI G., PAVIA M., 2013. The Upper Valdarno Plio-Pleistocene vertebrate record: An historical overview, with notes on palaeobiology and stratigraphic significance of some important taxa. *Italian Journal of Geosciences* 132: 104-125.
- ROOK L., MARTÍNEZ-NAVARRO B., 2010. Villafranchian: The long story of a Plio-Pleistocene European large mammal biochronologic unit. *Quaternary International* 219: 134-144.
- ROOK L., MOTTURA A., GENTILI S., 2001. Fossil *Macaca* remains from RDB quarry (Villafranca d'Asti, Italy): new data and overview. *Journal of Human Evolution* 40: 187-202.
- ROOK L., TORRE D., 1996. The wolf event in Western Europe and the beginning of the Late Villafranchian. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte* 8: 495-501.
- SALARI L., 2006. *Mosaico Nilotico di Palestrina: animali reali o fantastici? Archeozoologia di una produzione artistica di età ellenistica*. Circolo Culturale Prenestino R. Simeoni, Palestrina, 92 pp.
- SALARI L., ACHINO K.F., GATTA M., PETRONIO C., ROLFO M.F., SILVESTRI L., PANDOLFI L., 2017. The wolf from Grotta Mora Cavorso (Simbruini mountains, Latium) within the evolution of *Canis lupus* L., 1758 in the Quaternary of Italy. *Palaeogeography, Palaeoclimatology, Palaeoecology* 476: 90-105.
- SANSO I., SARDELLA R., 2008. *Macaca sylvanus* from the early Middle Pleistocene site of Cava di Breccia di Casal Selce (Roma). *Giornate di Paleontologia VIII edizione, Siena 9-13 settembre 2008, Riassunti dei lavori*: 144-146.
- SARDELLA R., DI STEFANO G., PETRONIO C., 1995. The Villafranchian mammal faunas from the Tiber River Basin (Umbria, Central Italy). *Il Quaternario* 8, 509-514.
- SARDELLA R., BELLUCCI L., BONA F., CHERIN M., IURINO D.A., ROOK L., 2018. Before and after the earliest Homo dispersal in Europe: Evidence from the early Pleistocene sites of the Italian Peninsula. *Comptes Rendus Palevol* 17: 287-295.
- SARDELLA R., PALOMBO M.R., 2007. The Pliocene-Pleistocene boundary: which significance for the so called "Wolf Event"? Evidences from Western Europe. *Quaternaire* 18: 65-71.
- SOTNIKOVA M.V., 2001. *Remains of Canidae from the Lower Pleistocene site of Untermassfeld*. In: Kahlke R.D. (ed.), *Das Pleistozän von Untermassfeld bei Meiningen (Thüringen)*, 2: 607-632, Römisch-Germanisches Zentralmuseum, Mainz.
- SOTNIKOVA M.V., ROOK L., 2010. Dispersal of the Canini (Mammalia, Canidae: Caninae) across Eurasia during the Late Miocene to Early Pleistocene. *Quaternary international* 212: 86-97.
- SPASSOV N., 1989. The position of jackals in the *Canis* genus and life history of the golden jackal (*Canis aureus* L.) in Bulgaria and on the Balkans. *Historia Naturalis Bulgarica* 1: 44-56.
- SPASSOV N., 1998. A new Late Villafranchian locality of vertebrate fauna – Slivnitsa (Bulgaria) and the carnivore dispersal events in Europe on the Pliocene/Pleistocene boundary. *Historia Naturalis Bulgarica* 9: 101-113.
- SPASSOV N., ROOK L., 2006. *Eucyon Mariana* sp. nov. (Mammalia, Carnivora), a new canid species from the Pliocene of Mongolia, with a review of forms referable to the genus. *Rivista Italiana di Paleontologia e Stratigrafia* 112: 123-133.
- TORRE D., 1979. The Ruscinian and Villafranchian dogs of Europe. *Bollettino della Società Paleontologica Italiana* 18: 162-165.
- TORRE D., FICCARELLI G., MASINI F., ROOK L., SALA B., 1992. Mammal dispersal events in the early Pleistocene of western Europe. *Courier Forschungsinstitut Senckenberg* 153: 51-58.
- WANG X., TEDFORD R.H., 2008. *Dogs: their fossil relatives and evolutionary history*. Columbia University Press, New York, 209 pp.
- ZOBOLI D., PILLOLA G.L., ROOK L., 2016. New remains of *Macaca majori* Azzaroli, 1946 (Primates, Cercopithecidae) from Is Oreris (Fluminimaggiore, southwestern Sardinia). *Bollettino della Società Paleontologica Italiana* 55: 227-230.

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