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Original article

Rhinocerotidae (Mammalia, Perissodactyla) from the chrono-stratigraphically constrained Pleistocene deposits of the urban area of Rome (Central Italy)☆

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ABSTRACT

In the present paper we provide a revision of the Pleistocene Rhinocerotidae remains collected so far in the sedimentary deposits of the urban area of Rome. Five Pleistocene species have been identified: *Stephanorhinus etruscus* (Falconer), *Stephanorhinus hundsheimensis* (Toula), *Stephanorhinus hemitoechus* (Falconer), *Stephanorhinus kirchbergensis* (Jäger), and *Coelodonta antiquitatis* (Blumenbach). By establishing correlations of the sedimentary sections hosting the fossil remains with the geochronologically-constrained, astronomically-forced aggradational successions of the Paleo-Tiber River, we frame the fossil remains within a detailed chronostratigraphic scheme with no equivalent in the previous literature. This approach leads to new considerations on the occurrences and paleobiogeography of the recovered species. Based on the studied material, the last occurrence of *S. etruscus* in Italy is here referred to a timespan between 0.86 and 0.82 Ma, thus suggesting a long persistence of this species. Recalibration of the considered deposits enabled us to refer the first evidence of *S. hundsheimensis* in Italy to approximately 0.8 Ma (Ponte Milvio gravels and sands; urban area of Rome). In the Roman area, specimens referred to *S. hundsheimensis* are coeval with relatively smaller and slender remains of an undefined rhinoceros species. *S. hemitoechus* is recorded in fossiliferous deposits earlier than 0.4 Ma and its persistence in the studied area is reported at least until 0.19 Ma. *S. kirchbergensis* occurs for the first time in Italy at ca. 0.56–0.5 Ma (Tor di Quinto deposit; urban area of Rome) and persists in the considered area until 0.37–0.29 Ma. *C. antiquitatis* is here reported for the first time within the Roman area, so adding a new record of this species in Italy. Unfortunately, the exact locality in which the specimens were collected is unknown, preventing from precise chronostratigraphic assessment.

1. Introduction

The knowledge of the chronology of different faunal assemblages, as well as those of different taxa, is significant for the paleobiogeography, paleoecology, and evolutionary history understanding of any fossil species. Nevertheless, terrestrial fossil remains are usually collected in continental deposits in which chronostratigraphic constraints are lacking or uncertain. When available, several methodologies (e.g., pollen analysis, magnetochronology, biochronology, geochemical analysis) are therefore used to obtain an absolute or relative chronology of the different findings (Ravazzi et al., 2005; Muttoni et al., 2009; Palombo et al., 2010; Petronio et al., 2011; Pandolfi et al., 2013a). In the present study, we apply a method of correlation of the sedimentary successions with the astronomically-forced, glacial sea-level oscillations (Marra et al., 2008), which has revealed particularly useful for biostratigraphic studies in the coastal area of Rome (Marra et al., 2014a), to perform a revision of the Pleistocene rhinoceros collected in the urban area of Rome (Fig. 1). By reviewing the taxonomy of the considered remains and by correlating the fossiliferous deposits in which they were collected with the Marine Isotopic Stages (MIS), we assess their age and discuss the consequent paleobiological implications of this newly established chronology.

2. Stratigraphic framework of the investigated area

The Roman area is among the most important sedimentary basins in Europe based on its richness in fossil mammal remains

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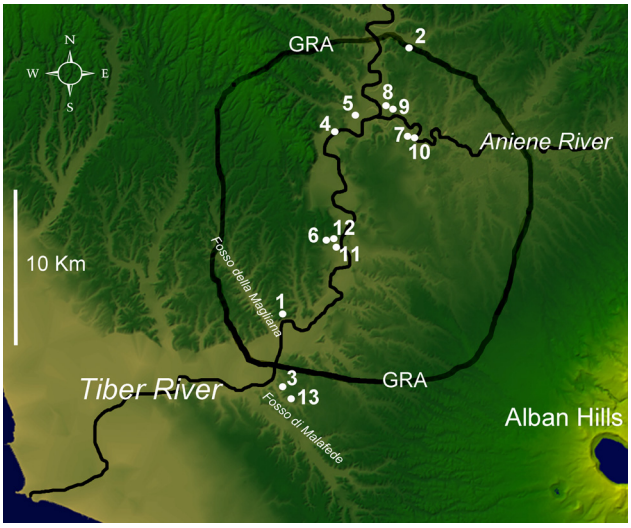

Fig. 1. Location of the fossiliferous localities within the urban area of Rome mentioned in the text. **1**: Monte delle Piche; **2**: Cava Redicicoli; **3**: Vitinia; **4**: Ponte Molle; **5**: Tor di Quinto; **6**: Monte Verde; **7**: Sedia del Diavolo; **8**: Monte Sacro; **9**: Prati Fiscali; **10**: Batteria Nomentana; **11**: Vigna San Carlo; **12**: Vigne Torte; **13**: Fosso di Malafede.

(Ambrosetti, 1967; Petronio and Sardella, 1999; Palombo, 2004; Milli and Palombo, 2005; Kotsakis and Barisone, 2008; Petronio et al., 2011; Marra et al., 2014a), and due to a number of stratigraphic studies (Marra and Rosa, 1995 and references therein) performed since the end of the 19th century. This area hosted the delta of the Paleo-Tiber River since the Middle Pleistocene through the Present; its evolution is the result of complex geological processes, which included tectonics, volcanism and glacio-eustatic fluctuations (Karner et al., 2001a). The continental to coastal sedimentary successions of the Paleo-Tiber River were deposited since 800 ka in response to sea-level rise during the Pleistocene glacial terminations, as demonstrated by a series of recent studies, which using the $^{40}Ar/^{39}Ar$ ages of tephra intercalated within the sedimentary deposits provided geochronologic constraints linking these aggradational successions to the different MIS (Karner and Renne, 1998; Karner and Marra, 1998; Marra et al., 1998; Florindo et al., 2007; Marra and Florindo, 2014). The aggradational successions in the area of Rome are therefore a discontinuous stratigraphic record, constituted by a succession of ten major aggradational units deposited during MIS 22-21 through MIS 2-1, plus several minor successions corresponding to more pronounced sub-stages, representing the physical remnant of as many glacio-eustatic sea-level cycles in this timespan. These aggradational successions fill the fluvial valleys and the coastal plain incisions that were excavated during the periods of sea-level lowstand, and interfinger with the pyroclastic products of the Colli Albani and Monti Sabatini Volcanic Districts, whose paroxismal activity spanned 600–250 ka (Marra et al., 2009, 2014b). It is noteworthy that the majority of the Middle Pleistocene fossil vertebrates assemblages of Italy have been sampled in the Roman area in these alluvial deposits of the Paleo-Tiber River and its tributaries (Fig. 1; Caloi et al., 1998; Di Stefano et al., 1998; Milli et al., 2004; Petronio et al., 2011), exposed by continuous tectonic uplift affecting this area (Karner et al., 2001a). A large number of vertebrate fossil remains were collected from the deposits cropping out in the area of Rome due to the intense urbanisation and quarry activities (e.g., Meli, 1896; Ponzi, 1878; Portis, 1896). These remains are mainly stored at the Museo di Paleontologia, Sapienza, University of Rome and were already mentioned in several contributions (e.g., Caloi et al., 1998; Di Stefano et al., 1998; Palombo et al., 2002; Kotsakis and Barisone, 2008; Pandolfi, 2011a, 2013). However, most of them lack of precise stratigraphic constraints since their finding is referred to a locality and, not always, is associated to a generic sedimentary level (gravel, sand, clay, etc.), preventing their direct correlation with a chronostratigraphic unit. In order to provide such correlation, in the present work we apply the method of correlation with the geochronologically-constrained aggradational units of the Paleo-Tiber described in Marra et al. (2014a). Based on this approach, any fossil that can be referred to an identified geochronologically-constrained sedimentary unit can be assigned a discrete age, corresponding to that of the associated MIS (Fig. 2). Identification of the glacio-eustatically forced sedimentary units can be achieved by:

- literature data, whenever the outcrop corresponds to published type-sections;
- the stratigraphic context, whenever the stratigraphic position of the outcrop with respect to other dated sections is determinable;
- recognition of pyroclastic deposits of known age within the outcrop.

3. Material and methods

The revised Quaternary time scale (Gibbard et al., 2010) is used for chronological references in this text. Therefore, the Pliocene spans approximately between 5.4 Ma and 2.6 Ma. The age of the sedimentary deposits hosting the fossil remains was established based on correlation with the geochronologically-constrained aggradational successions of the Paleo-Tiber, as summarized in Fig. 2 and Table 1. The time of deposition was therefore referred to an interval corresponding with a portion of the Oxygen Isotopes curve, indicated by the correspondent MIS(s) or, when available, by the $^{40}Ar/^{39}Ar$ age of tephra layers intercalated in the sedimentary deposit. All the radioisotopic ages in this paper were calculated according to the age of 28.201 Ma for the Fish Canyon Tuff sanidine standard (Kuiper et al., 2008).

The fossil specimens from the urban area of Rome are housed at Museo di Paleontologia, Sapienza, University of Rome (MPUR) and Museo di Geologia "Giovanni Capellini", Bologna (MGGC); they were mainly collected during the end of the 19th century and the beginning of the 20th century (Table 1). The specimens were morphologically compared with several Pliocene and Pleistocene remains referred to *Coelodonta antiquitatis* (Blumenbach, 1799), "*Dihoplus*" *megarhinus* (De Christol, 1834), *Stephanorhinus kirchbergensis* (Jäger, 1839), *S. hemitoechus* (Falconer, 1859), *S. etruscus* (Falconer, 1868), *S. hundsheimensis* (Toula, 1902), and *S. jeanvireti* (Guérin, 1972). These specimens were collected from a number of European localities and are currently housed in several European institutions. The morphometric methodology follows that introduced by Guérin (1980) and Fortelius et al. (1993); the anatomical descriptions and the dental terminology follow those of Guérin (1980) and Antoine (2002).

Institutional Abbreviations: **BSPG**, Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany; **HNHM**, Hungarian Natural History Museum, Budapest, Hungary; **IGF**, Museo di Storia Naturale, sezione di Geologia e Paleontologia, Florence, Italy; **IQW**, Institute für Quartärpaläontologie, Weimar, Germany; **MFGI**, Geological and Geophysical Institute of Hungary, Budapest, Hungary; **MfN**, Museum für Naturkunde, Berlin, Germany; **MGGC**, Museo di Geologia Giovanni Capellini, Bologna, Italy; **MGPP**, Museo di Geologia e Paleontologia, Padua, Italy;