

Rhinocerotidae (Mammalia, Perissodactyla) from the Middle Pleistocene site of Ponte Milvio, central Italy

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KEY WORDS - *Rhinocerotidae*, *Stephanorhinus*, *Biochronology*, *Pleistocene*, *Ponte Milvio*, *central Italy*.

ABSTRACT - Three rhinoceros species have been identified at Ponte Milvio: *Stephanorhinus hundsheimensis* (Toula, 1902), *Stephanorhinus hemitoechus* (Falconer, 1859) and *Stephanorhinus kirchbergensis* (Jäger, 1839). Remains ascribed to *S. hundsheimensis* were collected in gravels and sands deposits. They show morphological and morphometric affinities with the small-sized populations of the latest Early Pleistocene from Vallonnet. The occurrence of these small-sized specimens suggests the presence of a faunal assemblage chronologically related with the Early-Middle Pleistocene transition. The remains of *S. hemitoechus* and *S. kirchbergensis* were collected in volcanoclastic deposits. The specimens ascribed to *S. hemitoechus* show morphometric characters close to the small-sized specimens of the latest Middle Pleistocene. Moreover, *S. kirchbergensis* seems to be common in Italy during the late Middle Pleistocene and it has never been collected with certainty from Late Pleistocene sites. The co-occurrence of *S. kirchbergensis* and the small-sized *S. hemitoechus* suggests the presence of a faunal assemblage chronologically referable to a time span between MIS10 and MIS8.

RIASSUNTO - [Rhinocerotidae (Mammalia, Perissodactyla) dal sito del Pleistocene Medio di Ponte Milvio, Italia centrale] - L'analisi paleontologica dei resti di rinoceronte rinvenuti nei depositi terrazzati del fiume Tevere a Ponte Milvio ha permesso di riconoscere tre specie: *Stephanorhinus hundsheimensis* (Toula, 1902), *Stephanorhinus hemitoechus* (Falconer, 1859) e *Stephanorhinus kirchbergensis* (Jäger, 1839). I resti ascritti a *S. hundsheimensis* furono rinvenuti nei depositi di sabbie e ghiaie in cui non si osserva traccia di elementi vulcanoclastici. Tali resti mostrano affinità morfologiche e morfometriche con gli esemplari di taglia ridotta rinvenuti in siti europei riferibili al tardo Pleistocene Inferiore. La segnalazione di queste forme suggerisce la presenza di un'associazione faunistica attribuibile alla transizione Pleistocene Inferiore-Pleistocene Medio. I resti di *S. hemitoechus* e *S. kirchbergensis* furono invece rinvenuti in depositi vulcanoclastici. Gli esemplari ascritti a *S. hemitoechus* mostrano affinità morfometriche con quelli di taglia ridotta del tardo Pleistocene Medio mentre *S. kirchbergensis*, al momento non segnalato in Italia nel corso del Pleistocene Superiore, sembra essere una specie caratteristica del Pleistocene Medio terminale. La segnalazione di queste due specie suggerisce la presenza nel sito di un'associazione faunistica cronologicamente correlabile con un intervallo di tempo compreso fra il MIS10 ed il MIS8.

INTRODUCTION

Rhinoceroses represent a common element of the Plio-Pleistocene faunas of Europe and they have been usually used as a biochronological tool (e.g., Guérin, 1980; Lacombat, 2005, 2009; Petronio et al., 2011). During the Middle Pleistocene, four rhinoceros species have been identified in Europe: *Stephanorhinus hundsheimensis* (Toula, 1902), *Stephanorhinus hemitoechus* (Falconer, 1859), *Stephanorhinus kirchbergensis* (Jäger, 1839) and *Coelodonta tologijensis* Beliajeva, 1966.

S. hundsheimensis has been recorded from the late Early Pleistocene to the late Middle Pleistocene. This species is characterised, according to Fortelius et al. (1993) and Lacombat (2005, 2006a, b, 2009), by two evolutionary stages: a smaller late Early Pleistocene - early Middle Pleistocene form and a larger Middle Pleistocene form. These evolutionary stages, however, have been recognised only in Southern Europe; indeed the specimens of *S. hundsheimensis* recovered in the late Early Pleistocene sites of Central Europe (e.g., Untermassfeld, Germany) are larger than those of the coeval sites of Southern Europe (e.g., Vallonnet, France) (Lacomat, 2005, 2009).

S. hemitoechus has been first documented in the Middle Pleistocene deposits of Campagna Romana (Italy) and Caune de L'Arage (France) (Guérin, 1980; Moigne et

al., 2006; Pandolfi et al., 2013), while its last occurrence has been usually reported during the last glaciation (Guerin, 1980; Petronio et al., 2011; Pandolfi et al., 2013).

The very large sized *S. kirchbergensis* has been first recorded in the early Middle Pleistocene site of Soleilhac (France) (Guérin, 1980) and, according to Billia & Petronio (2009), in the Middle Galerian sites of Valdemino and Ponte Milvio (Italy).

Finally, according to Kahlke & Lacombat (2008) the first occurrence of the genus *Coelodonta* in Europe is documented in the site of Bad Frankenhausen (Germany) during MIS12. However, this record has been questioned by Guérin (2010) who reports the occurrence of *Coelodonta* in Europe during the latest Middle Pleistocene (MIS8) with *C. antiquitatis praecursor* Guérin, 1980. Nevertheless, in Italy the genus *Coelodonta* is unknown during the Middle Pleistocene and its first appearance in the Peninsula is documented, at present, during MIS4 (Pandolfi & Tagliacozzo, 2013).

The aim of the present paper is to describe several rhinoceros remains collected from the fluvial deposits cropping out at Ponte Milvio (= Ponte Molle) (Fig. 1) between the end of the 19th century and the beginning of the 20th century. Furthermore, an overview on the first and last occurrence of the Middle Pleistocene rhinoceros species in Italy is discussed.

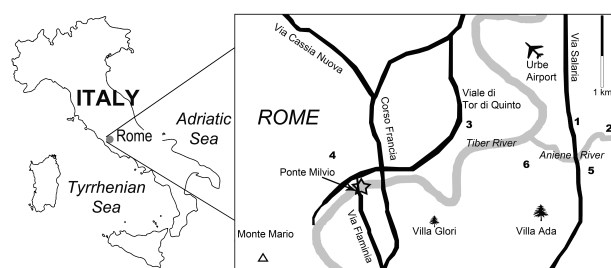


Fig. 1 - Location map of Ponte Milvio (Rome) and other fossiliferous sites in the Roman Urban area. 1) Prati Fiscali; 2) Monte Sacro; 3) Tor di Quinto; 4) Monti della Farnesina; 5) Villa Chigi; 6) Monte Antenne (for details see Di Stefano et al., 1998).

STRATIGRAPHIC AND PALEONTOLOGICAL FRAMEWORK OF THE PONTE MILVIO SITE

At the end of the 19th century and the beginning of the 20th century, several mammal remains referred to the Middle Pleistocene were collected from the fluvial deposits of the Tiber River near Ponte Milvio (= Ponte Molle) from outcrops that are now no more exposed, due to the intense urbanization of the area (Fig. 1). Ponzi (1867) studied for the first time both fossils and stratigraphy of the Ponte Milvio area. He observed two different deposits: a conglomerate with fossil mammals and sands with subfossil remains. Later, Portis (1893) described the Cava D'Alessandri deposits near Ponte Milvio, and noticed conglomerate and sands forming at least seven irregular levels; basal levels yielded the fossil remains. Ambrosetti & Bonadonna (1967) considered the faunal assemblage of Ponte Milvio as homogeneous. However, they had no opportunity to investigate the stratigraphy of the area. Capasso Barbato et al. (1998) examined the fossil fauna from the Ponte Milvio deposits to test the presence of different phases of fluvial sedimentation. They recognised at least three faunal associations. The oldest assemblage was characterised, according to Capasso Barbato et al. (1998), by the occurrence of *Cervus elaphus acoronatus* Beninde, 1937 and was correlated with the Early and/or Middle Galerian. A younger assemblage (called Ponte Milvio 2 in Capasso Barbato et al., 1998) was characterised by the occurrence of *Dama clactoniana* (Falconer, 1868) and was referred to Fontana Ranuccio or Torre in Pietra Faunal Units. In the end, Capasso Barbato et al. (1998) reported a third Pleistocene faunal assemblage chronologically correlated with the late Middle Pleistocene (Vitinia FU), basing on the occurrence of *Dama dama tiberina* Di Stefano & Petronio, 1997 and *Equus hydruntinus* Regalia, 1907.

Recently, an horn-core of Bovidae collected at Ponte Milvio during the end of the 19th century was referred to *Hemibos galerianus* (Petronio & Sardella, 1998) by Martinez-Navarro & Palombo (2007). This occurrence suggests the presence of a faunal assemblage chronologically related with the Ponte Galeria FU at Ponte Milvio. Indeed, *H. galerianus* was found just above the Early-Middle Pleistocene transition in the Ponte Galeria area (Petronio & Sardella, 1998). Moreover, Palombo et al. (2004) suggested to suppress the Vitinia FU and to refer the faunal complexes of the Latium coastal area, occurring in the Aurelia and Vitinia formations (late

Middle Pleistocene), to the Torre in Pietra FU. This FU, according to Palombo et al. (2004), is characterised by the first occurrence of *Canis lupus* Linnaeus, 1758, *Ursus spelaeus* Rosenmüller, 1794, *Megaloceros giganteus* Blumenbach, 1799, *D. dama tiberina* and by the persistence of *D. clactoniana*. This opinion is not followed by Petronio et al. (2011) who consider the Vitinia FU as a valid biochronological unit, characterised by the occurrence of *D. dama tiberina* and *E. hydruntinus* and the diffusion of *Capra ibex* Linnaeus, 1758, *Rupicapra rupicapra* Linnaeus, 1758 and *Mammuthus chosaricus* Dubrovo, 1964..

The rhinoceros remains collected at Ponte Milvio were ascribed to *Dicerorhinus mercki* (Kaup, 1841) and *D. hemitoechus* by Guérin (1980) and to *S. kirchbergensis* and *S. hemitoechus* by Capasso Barbato et al. (1998). Recently, Billia & Petronio (2009) confirmed the presence of *S. kirchbergensis* at Ponte Milvio.

MATERIALS AND METHODS

This work is based on fossil remains preserved in the Museo di Paleontologia, "Sapienza" Università di Roma (MPUR). The studied specimens consist of only one fragmentary femur, 18 upper teeth and 12 lower teeth (Tab. 1). The labels of the specimens report the locality of collection and, sometimes, the lithology. On the basis of this information, the studied specimens can be referred to two different deposits: a first one, characterised by the presence of gravels and sands, and a second one characterised by volcanoclastic material. Seven teeth, MPUR numbers 1420-97, 1454-117, 1454-118, 1412-8, 1444-95, 1416-42, 1416-43 and a small-sized femur

Specimen	Collection	Species
Fourth upper premolar	MPUR1420-97	<i>S. hundsheimensis</i>
Third upper molar	MPUR1454-117	<i>S. hundsheimensis</i>
Third upper molar	MPUR1454-118	<i>S. hundsheimensis</i>
First lower molar	MPUR 1412-8	<i>S. hundsheimensis</i>
Fourth upper deciduous	MPUR 1438-18	<i>S. hemitoechus</i>
Third upper premolar	MPUR 1439-134	<i>S. hemitoechus</i>
First upper molar	MPUR1451-26	<i>S. hemitoechus</i>
Fourth lower deciduous	MPUR 1448-51	<i>S. hemitoechus</i>
Fourth upper premolar	MPUR 1421-107	<i>S. kirchbergensis</i>
Fourth upper premolar	MPUR 1456-126	<i>S. kirchbergensis</i>
Second upper molar	MPUR 1417-115	<i>S. kirchbergensis</i>
First lower molar	MPUR 1446-49	<i>S. kirchbergensis</i>
Third lower molar	MPUR 1415-63	<i>S. kirchbergensis</i>
Fourth upper deciduous	MPUR 1445-27	<i>Stephanorhinus</i> aff. <i>S. hundsheimensis</i>
Femur	MPUR 1523-2	<i>Stephanorhinus</i> aff. <i>S. hundsheimensis</i>

Tab. 1 - List of specimens from Ponte Milvio ascribed to *S. hundsheimensis*, *S. hemitoechus*, *S. kirchbergensis* and *Stephanorhinus* aff. *S. hundsheimensis*.

MPUR 1415-63 can be referred to the first level. Five teeth (MPUR 1439-134, 1448-51, 1456-126, 1417-115 and 1415-63) can be referred to the second level. Unfortunately, the stratigraphic provenience of seventeen teeth (labelled as MPUR 1438-18, 1451-26, 1421-107, 1446-49, 1445-27, 1492, 1452-112, 1452-113, 1414-94, 1419-39, 1456-127, 1440-119, 1418-23, 1460-55, 1442-65, 1441-70 and 1450-64) is unknown. The morphological characteristics considered in the present paper are those listed by several authors, including Guérin (1980), Fortelius et al. (1993) and Lacombat (2005). The material used for direct comparison was obtained from the following institutions: MPUR, Museo di Paleontologia, "Sapienza" Università di Roma, Rome; IGF, Museo di Storia Naturale di Firenze, sezione di Geologia e Paleontologia, Florence; MSTB, Museo di Scienze della Terra, Università degli Studi di Bari, Bari; MPLB, Museo Paleontologico Luigi Boldrini, Pietrafitta, Perugia. Different specimens collected from Middle and Late Pleistocene European sites and published by Kahlke (1975, 1977), Guérin (1980), Fortelius et al. (1993) and Lacombat (2005, 2006a, b) have been also taken into account for the morphological comparison of the studied specimens.

Unfortunately complete proximal epiphysis of femurs of the small late Early Pleistocene *S. hundsheimensis* are unknown and, with the exception of the few data from Vallonnet, any comparison with this form is impossible.

The morphometric methodology is based on the works of Guérin (1980) and Lacombat (2005), and the results are compared with those reported by Kahlke (1975, 1977), Guérin (1980), Fortelius et al. (1993) and Lacombat (2005).

SYSTEMATIC PALEONTOLOGY

The systematic and taxonomy of the fossil rhinoceroses is still debated. As regarding the Plio-Pleistocene species, Guérin (1980) included into the new subgenus *Dicerorhinus* (*Brandtorhinus*) Guérin, 1980 the species *D. jeanvireti* Guérin, 1972, *D. etruscus* (Falconer, 1868) (with the two subspecies *D. etruscus etruscus* and *D. etruscus brachycephalus* Schroeder, 1903), *D. hemitoechus* (Falconer, 1859) and *D. mercki* (Kaup, 1841) (= *D. kirchbergensis* Jäger, 1839).

Later, Guérin (1989) raised *Brandtorhinus* to the genus rank. However, according to Heissig (1973, 1981) and Groves (1983) the European Pleistocene rhinoceroses (excluding the four species of the genus *Coelodonta* Bronn, 1831) cannot be referred to the genus *Dicerorhinus* Gloger, 1841. The above-mentioned authors allocated them into the genus *Stephanorhinus* Kretzoi, 1942. This last viewpoint was followed by Fortelius et al. (1993) who referred to the genus *Stephanorhinus* Kretzoi, 1942 the Plio-Pleistocene species *S. jeanvireti*, *S. etruscus*, *S. hundsheimensis* (identified with the specimens of *D. etruscus brachycephalus* in Guérin, 1980 but excluding the type-specimen), *S. hemitoechus* and *S. kirchbergensis*. According to Fortelius et al. (1993), the genus *Brandtorhinus* Guérin is identical to *Stephanorhinus* and the latter name "is preferable to Guérin's because it has priority and has been used quite extensively in literature" (Fortelius et al., 1993, p. 65). Recently, Deng

et al. (2011) included into *Stephanorhinus* the species *S. etruscus*, *S. hundsheimensis* and *S. hemitoechus* and referred to "*Dihoplus*" Brandt, 1878 the species *Rhinoceros kirchbergensis* Jäger, 1839, together with the Miocene species *Dihoplus ringströmi* (Kretzoi, 1942) and *Di. pikermiensis* (Toula, 1906) and the Pliocene *Di. megarhinus* (Christol, 1834). A direct connection between *S. kirchbergensis* and the Pliocene *Di. megarhinus* was suggested by Wüst (1922), Staesche (1941) and Guérin (1980). According to Fortelius et al. (1993), these two species represent a sister-group to the *S. jeanvireti*-*S. etruscus*-*S. hundsheimensis*-*S. hemitoechus* group. Nevertheless, the connection between *S. kirchbergensis* and *Di. megarhinus* could correspond to an independent clade or to a strong convergence of the characters (Lacombat, 2007).

Genus *Stephanorhinus* Kretzoi, 1942

Type species *Stephanorhinus etruscus* (Falconer, 1868)

Stephanorhinus hundsheimensis (Toula, 1902) (Fig. 2d-f)

- 1902 *Rhinoceros hundsheimensis* TOULA, p. 11, Pls 1-3; Pl. 4, figs 1-3; Pl. 5; Pl. 6, figs 1, 2a, 3-4; Pl. 7, figs 1, 4-5; Pl. 8; Pl. 9, figs 1-3; Pl. 10, figs 1-4, 9; Pl. 11, figs 1-5; Pl. 12, figs 1-5.
- 1914 *Rhinoceros etruscus* var. *heidelbergensis* FREUDENBERG, p. 480, Pls 1-2 (fig. 1).
- 1965 *Dicerorhinus etruscus* (Falconer) - KAHLKE, p. 454, Figs 1-35, Pls 24-31.
- 1976 *Dicerorhinus hemitoechus* (Falconer) - CIGALA-FULGOSI, p. 60, Pl. 1; Pl. 2, figs 1-10; Pl. 3.
- 1979 *Dicerorhinus* sp. - AMBROSETTI et al., p. 216.
- 1983 *Dicerorhinus etruscus brachycephalus* (Schroeder) - GUÉRIN, p. 47, Pls 1-2.
- 1993 *Stephanorhinus hundsheimensis* (Toula) - FORTELIUS et al., p. 66, Pl. 1, fig. 2; Pl. 2, fig. 2; Pl. 3, fig. 2; Pl. 4, fig. 3; Pl. 5, fig. 6; Pl. 6, figs 3-5; Pl. 7, fig. 3; Pl. 8, figs 3, 7, 10; Pl. 9, fig. 3; Pl. 10, fig. 3; Pl. 11, fig. 2; Pl. 12, fig. 3; Pl. 13, figs 3, 7; Pl. 14, figs 3, 6, 9; Pl. 15, figs 3, 7, 11; Pl. 16, figs 3, 7, 10, 14, 18, 22.
- 2009 *Stephanorhinus kirchbergensis* (Jäger) - BILLIA & PETRONIO, p. 27, fig. 4g.

Material - MPUR 1420-97, 1454-117, 1454-118 and 1412-8.

Description - The P4/(MPUR 1420-97) shows double crochet and a crista partially fused with the crochet (Fig. 2d). The antecrochet is represented by a slight fold; mesial and lingual cingula are present. The vestibular wall shows a slight salient paracone fold.

In the two M3/(MPUR 1454-117, MPUR 1454-118) crista and antecrochet are absent, the mediofossette is open (Fig. 2f). The crochet is simple and well evident in MPUR 1454-118 while it is slightly developed in MPUR 1454-117. In the latter specimen, a slight paracone constriction is present and the distal cingulum is well evident. The mesial cingulum is present in both the teeth and a vertical stile is observable in the median valley of MPUR 1454-117. The vestibular wall is slightly convex and the paracone fold is slightly marked in MPUR 1454-118.

In the M1/(MPUR 1412-8) the anterior and posterior valleys have a V-shaped morphology; the difference in

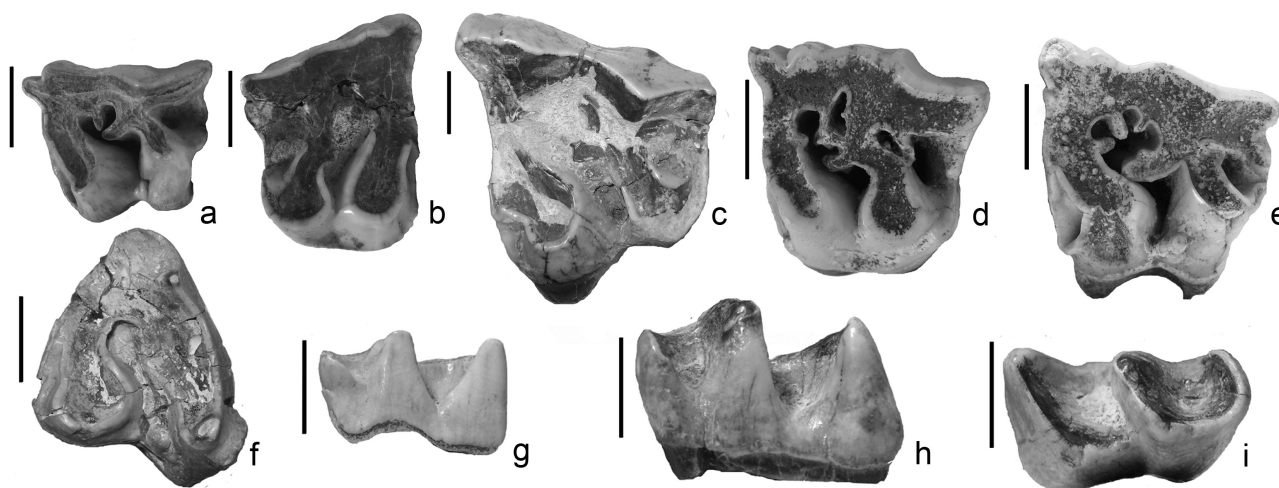


Fig. 2 - Selected rhinoceros teeth from Ponte Milvio. a) *Stephanorhinus hemitoechus* D4/MPUR 1438-18 in occlusal view; b) *Stephanorhinus kirchbergensis* P4/MPUR 1421-107 in occlusal view; c) *Stephanorhinus kirchbergensis* M2/MPUR 1417-115 in occlusal view; d) *Stephanorhinus hundsheimensis* P4/MPUR 1420-97 in occlusal view; e) *Stephanorhinus hemitoechus* M1/MPUR 1451-26 in occlusal view; f) *Stephanorhinus hundsheimensis* M3/MPUR 1454-117 in occlusal view; g) *Stephanorhinus hemitoechus* D/4MPUR 1448-51 in lingual view; h-i) *Stephanorhinus kirchbergensis* M/3MPUR 1415-63 in lingual (h) and occlusal (i) views. Scale bars correspond to 2 cm.

ratio height between the bottom of the valleys is small (about 0.86); mesial and distal cingula are present and they extend along the vestibular side of the tooth.

Remarks - The dimensional characters of the P4/ and M/1 are close to those reported by Lacombe (2005) for the specimens of Vallonnet and to the minimum values reported by Fortelius et al. (1993) and Guérin (1980) for the species (Tab. 2). As regards the M3/, the morphometric data are not useful to distinguish between the two evolutionary stages of *S. hundsheimensis*; however, as in Ponte Milvio, a slight paracone constriction is observable in the specimens from Vallonnet.

Finally, high values of the ratio height between the bottom of the posterior valley and the collar/height between the bottom of the anterior valley and the collar (Hvp/Hva) for the M/1 are recognised in the late Early Pleistocene specimens of *S. hundsheimensis* as in Ponte Milvio. Nevertheless, the values of the mesial width (MW) and distal width (DW) of the M/1 are closer to the Vallonnet samples.

Stephanorhinus hemitoechus (Falconer, 1859)
(Fig. 2a, e, g)

- 1859 *Rhinoceros hemitoechus* FALCONER in GAUDIN, p. 131.
- 1866 *Rhinoceros leptorhinus* OWEN - DAWKINS, p. 215, Pl. 10.
- 1874 *Rhinoceros leptorhinus* OWEN - WOODWARD, p. 398, Pl. 15.
- 1900 *Rhinoceros hemitoechus* FALCONER - OSBORN, p. 264.
- 1942 *Procerorhinus hemitoechus* (Falconer) - KRETZOI, p. 314, Fig. 1 (5-8).
- 1955 *Rhinoceros merckii* KAUP - MAVIGLIA, p. 93.
- 1989 *Brandtorhinus hemitoechus* (Falconer) - GUÉRIN, p. 9.
- 1990 *Stephanorhinus hemitoechus* (Falconer) - CERDEÑO, p. 468, Pls 1-3.
- 1993 *Stephanorhinus hemitoechus* (Falconer) - FORTELIUS et al., p. 66, Pl. 4, fig. 2; Pl. 5, figs 2, 5; Pl. 6, fig. 2; Pl. 7, fig. 2; Pl. 8, figs 2, 6; Pl. 9, fig. 2; Pl. 10, fig. 2; Pl. 11, fig. 4; Pl. 12, fig. 2;

Pl. 13, figs 2, 6; Pl. 14, figs 2, 5, 8; Pl. 15, figs 2, 6, 10; Pl. 16, figs 2, 6, 13, 17, 21.

Material - MPUR 1438-18, 1439-134, 1451-26 and 1448-51.

Description - The D4/(MPUR 1438-18) has a single and long crochet and a single crista (Fig. 2a). The antecrochet is absent; a slight protocone constriction is observable and a cingulum occurs in the medial side of the tooth. The profile of the vestibular wall is slight wavy with a marked paracone fold.

The P3/(MPUR 1439-134) is much worn; the mediofossette is close, the antecrochet and the cingula are absent.

In the M1/(MPUR 1451-26) a single and well developed crochet is present, the crista is double and the antecrochet and the mesial cingulum are present (Fig. 2g). The profile of the vestibular wall is wavy with marked folds.

In the D/4(MPUR 1448-51) the lingual valleys have a broad V-shaped morphology, mesial and distal cingula are present and the vestibular syncline is deep.

Remarks - The dimensional characters of the D4/ are close to the minimal values of the specimens from Caune de L'Arago (Tab. 2). The crista, present in the Ponte Milvio specimen, is absent in the Late Pleistocene specimens from some Italian localities (e.g., Ingarano & Manciano; MPUR) and in the latest Middle Pleistocene one (e.g., Maspino; IGF). Furthermore, the dimensional values of the P3/ and M1/ are closer to the minimal values of *S. hemitoechus* reported by Fortelius et al. (1993) and they are smaller than those from Caune de L'Arago (Tab. 2). M1/ shows morphological characters (presence of antecrochet) similar to those of the small-sized samples from the late Middle Pleistocene of Orgnac III. This character is absent in the large samples from Maspino

	LL	BL	MW	DW	Lmax	Wmax
P4/						
Ponte Milvio 1420-97	34.75	39.85	51.75	49.2	49.2	52.3
Ponte Milvio 1421-107	36	46.3	68.68	59.65	48.75	70.77
<i>S. hundsheimensis</i> Vallonnet	32.62-39.90	35.9-42.85	49.56-60.08	47.46-53.20	37.77-43.89	50.42-60.26
<i>S. hundsheimensis</i> Isernia			50.16-55.57	48.47-51.77	39.80-49.87	52.95-57.90
<i>S. hundsheimensis</i> 1	29-37	35-46	51-62	46-57		
<i>S. hundsheimensis</i> 2					43.5-54	47.5-61.5
<i>S. kirchbergensis</i> Ehringsdorf					42.50-52.20	62.20-70.20
<i>S. kirchbergensis</i> 1	34-43	40-52	59-73	53-70		
M1/						
Ponte Milvio 1451-26	44	37	54.4	53		
<i>S. hemitoechus</i> Arago	42.87	40.14-50.59	50.28-61.54	57.47-64.76	49.88-55.45	58.77-62.82
<i>S. hemitoechus</i> Orgnac	47.31-49.75	34.4-39.5	55.03-63.29	50.1-54	51-52.8	57.1-63
<i>S. hemitoechus</i> 1	42-53	36-41	55-68	51-64		
M1						
Ponte Milvio 1412-8	46.13	45.05	25.85	27.65	49.4	28.8
<i>S. hundsheimensis</i> Vallonnet	36.49-43.62	37.77-43.90	24.33-29.36	25.73-31.22	38.28-47.35	25.58-31.20
<i>S. hundsheimensis</i> Isernia			29.25-31.40	29.49-38.27	40.12-48	28-38.64
<i>S. hundsheimensis</i> 1	37-46	37-49	25-35	27-36		
<i>S. hundsheimensis</i> 2					40-56	26-37
D/4						
Ponte Milvio 1448-51	36.9	37.5	19.45	21.73	40.9	22.55
<i>S. hemitoechus</i> Arago		40.37-46.37	20.43-24.49	22.29-25.52	40.23-46.84	20.03-25.47
<i>S. hemitoechus</i> 2					37-50.5	22-27.5
M/3						
Ponte Milvio 1415-63	50	45	26	33	50	34
<i>S. kirchbergensis</i> Taubach					55.3-61.8	35.8-37.4
<i>S. kirchbergensis</i> Ehringsdorf					49.9-62.7	31.8-40.8
<i>S. kirchbergensis</i> Prince	51.94-60.05	48-57.62	29.53-32.69	26.21-38.18	55-61.74	30.56-36.97

Tab. 2 - Morphometric comparisons between selected specimens from Ponte Milvio and several specimens of *S. hundsheimensis*, *S. hemitoechus* and *S. kirchbergensis* collected in different European Pleistocene localities. Vallonnet, Isernia, Arago, Orgnac and Prince from Lacombat (2005); 1 = data from Fortelius et al. (1993); 2 = data from Guérin (1980); Ehringsdorf from Kahlke (1975); Taubach from Kahlke (1977). LL = lingual length; BL = buccal length; MW = mesial width; DW = distal width; Lmax = maximal length; Wmax = maximal width. All the values are in mm.

(IGF) and Monte Sacro (MPUR). The lower deciduous are smaller than the specimens from Caune de L' Arago and the ratio between the height of the posterior and anterior valleys ($Hvp/HvA = 0.54$) is relatively small. This last character is recognised in the Late Pleistocene specimens from the Salento Peninsula (Southern Italy; MPUR) ($Hvp/HvA = 0.52$).

Stephanorhinus kirchbergensis (Jäger, 1839)
(Fig. 2b-c, h-i)

- 1839 *Rhinoceros kirchbergense* JÄGER, p. 180, Pl. 16, figs 31-33.
 1864 *Rhinoceros Mercki* Kaup - VON MEYER, p. 235, Pls 35-38; Pl. 39, fig. 4.
 1877 *Rhinoceros Merckii* Kaup - BRANDT, p. 1, Pls 1; Pl. 2, figs 1-3; Pl. 3; Pl. 7, figs 14-16; Pl. 11.
 1911 *Rhinoceros Merckii* Kaup - WÜST, p. 133, Pl. 10, figs 4-6.
 1930 *Rhinoceros mercki* Kaup - SCHROEDER, p. 5, Pls 1, figs 4-9; Pls 2-9; Pl. 10, figs 45, 49-50; Pl. 11, figs 53-54; Pls 12-13, 16-21, 24-26.
 1942 *Stephanorhinus kirchbergensis* (Jäger) - KRETZOL, p. 312.

1972 *Dicerorhinus mercki* (Kaup) - BORSUK-BIALYNICKA & JAKUBOWSKI, p. 188, Fig. 1A; Fig. 2; Pls 1-4.

1983 *Dicerorhinus mercki* (Kaup) - GUÉRIN, p. 47, Pls 3-4.

1989 *Brandtorhinus mercki* (Kaup) - GUÉRIN, p. 9.

1993 *Stephanorhinus kirchbergensis* (Jäger) - FORTELIUS et al., p. 66, Pl. 1, fig. 3; Pl. 2, fig. 3; Pl. 4, fig. 4; Pl. 5, figs 3, 7; Pl. 8, figs 4, 8, 11; Pl. 9, fig. 4; Pl. 11, fig. 5; Pl. 12, fig. 4; Pl. 13, fig. 4; Pl. 15, figs 4, 8; Pl. 16, figs 4, 8, 11, 15, 19.

Material - MPUR 1421-107, 1456-126, 1417-115, 1446-49 and 1415-63.

Description - All the upper teeth show a smooth and thick enamel, without coronal cementum. Furthermore, the lingual sides of the upper teeth are bulbously inflated and the profile of the ectolophs are wavy.

The two P4/(MPUR 1421-107, MPUR 1456-126) are relatively large; the crochet is present; a slight lingual cingulum and a mesial one occur.

The M2/(MPUR 1417-115) shows a paracone constriction and the profile of the vestibular wall appears flat.

In the M/1 (MPUR 1446-49) the difference in height between the bottoms of the lingual valley is strong; a slight distal cingulum occurs in the tooth.

The M/3 (MPUR 1415-63) shows a U-shaped lingual valleys and a slight mesial and distal cingula. The difference in height between the bottoms of the valleys is strong and the vestibular syncline is deep.

Remarks - Smooth and thick enamel in the teeth and the presence of bulbosity in the upper teeth are typical of *S. kirchbergensis*. The dimensional characters of the P4/ and of the upper molars are close to the dimensional range of the specimens of *S. kirchbergensis* from Ehringsdorf and they are closer to the mean values of the species given by Fortelius et al. (1993) (Tab. 2). The dimensional characters of the lower molars are closer to the minimal values of the species from Ehringsdorf and Prince (Tab. 2).

Stephanorhinus aff. *S. hundsheimensis* (Toula, 1902)
Fig. 3

Material - MPUR 1445-27 and 1523-2.

Description - One D4/(MPUR 1445-27) has a large crochet, a small crista, a slight paracone constriction, a wavy profile of the vestibular wall with a marked paracone fold and a very smooth enamel.

A small-sized femur (MPUR 1523-2) (Fig. 3) has been collected at Ponte Milvio. The specimen lacks the distal epiphysis while the third trochanter is intact and well obvious. The proximal articular head is more developed transversally than the trochanter. Conglomerates and sands cover partially the posterior side of the bone.



Fig. 3 - Femur MPUR 1523-2 from Ponte Milvio, a) in dorsal view, b) in proximal view. Scale bar corresponds to 5 cm.

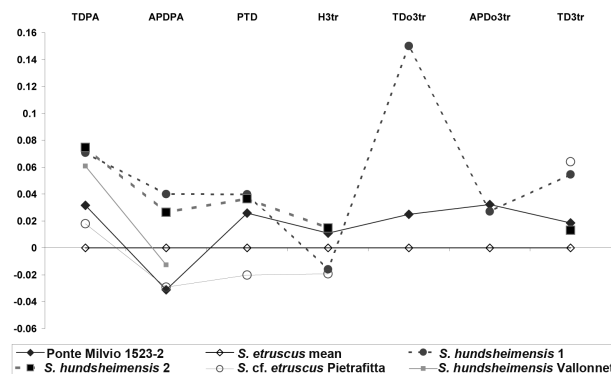


Fig. 4 - Ratio diagram of the femur MPUR 1523-2 from Ponte Milvio, *S. hundsheimensis* 1 (data from Lacombat [2005] and Fortelius et al. [1993]), *S. hundsheimensis* 2 (data from Guérin [1980]), *S. etruscus* (data from Fortelius et al. [1993]), *S. cf. S. etruscus* from Pietrafitta (data from Mazza et al. [1993]) and the small sized *S. hundsheimensis* from Vallonnet (data from Lacombat [2005]). TDPA = transverse diameter of the proximal epiphysis; APDPA = antero-posterior diameter of the proximal epiphysis; PTD = proximal transverse diameter; H3tr = height of the third trochanter; TDo3tr = transverse diameter over the third trochanter; APDo3tr = antero-posterior diameter over the third trochanter; TD3tr = transverse diameter at the third trochanter.

Remarks - The smooth enamel of the fourth deciduous is similar to that of *S. kirchbergensis*. However, the general morphological characters are similar to those of the fourth upper deciduous from Vallonnet. The dimensions of the tooth are close to the minimal values of the specimens from Vallonnet and they are relatively smaller than *S. kirchbergensis*. A sure specific attribution of the studied specimens is uncertain and it is referred to *S. aff. S. hundsheimensis* for its size.

The femur is proportionally more similar to the Pietrafitta (MPLB) specimens and to *S. etruscus* from Upper Valdarno (IGF) than to the large-sized *S. hundsheimensis* from Castellana (MSTB) and other localities (Fig. 4) (see also Mazza et al., 1993). Furthermore, the proximal articular head is proportionally similar to that of the small sized *S. hundsheimensis* from Vallonnet. In anterior view, the articular head of the femur MPUR 1523-2 appears slightly more developed than in the Pietrafitta specimens. Moreover, in proximal view, MPUR 1523-2 has a more elliptical shape of the articular surface respect to the specimens from Pietrafitta and the Upper Valdarno. In the end, the MPUR 1523-2 has a less massive trochanter than in the large-sized *S. hundsheimensis*.

The studied specimen shows some morphological resemblances with *S. hundsheimensis* but the size and the proportion are closer to *S. etruscus* from Upper Valdarno and to *S. cf. S. etruscus* from Pietrafitta. Well-preserved femurs of the small late Early Pleistocene *S. hundsheimensis* are unknown and only few fragmentary specimens from Vallonnet are available. Consequently, any comparison is prevented and, at present, the specimen is only tentatively referred to *Stephanorhinus* aff. *S. hundsheimensis*.

Stephanorhinus sp.

Material - MPUR 1465-114, 1444-95, 1452-112, 1452-113, 1492, 1414-94, 1419-39, 1416-43, 1416-42,

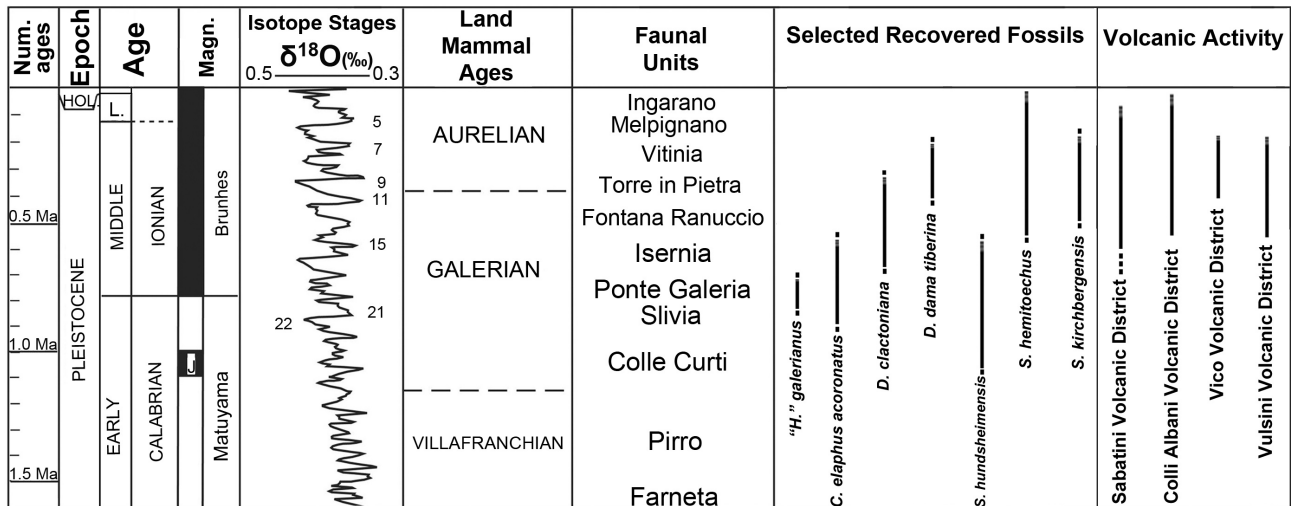


Fig. 5 - Biochronology of selected taxa recovered at Ponte Milvio (data from Petronio et al., 2011), including the three species of rhinoceros, and correlation with the Volcanic Activity in Latium (data from Sottili et al., 2010, 2011) and with the Marine Isotopic Stages.

1456-127, 1440-119, 1418-23, 1460-55, 1442-65, 1441-70 and 1450-64.

Description - Several teeth can be determined only at genus level and assigned to *Stephanorhinus* because of the absence of morphological characters useful to distinguish between *S. hundsheimensis* and *S. hemitoechus*. They are: one upper deciduous (MPUR 1465-114), three upper teeth (MPUR 1444-95, MPUR 1452-112, MPUR 1452-113), one P4 (MPUR 1492), one M2 (MPUR 1414-94), one lower molar (MPUR 1419-39), one M2 (MPUR 1416-43) and one M3 (MPUR 1416-42).

Other teeth referable to the genus *Stephanorhinus* are much worn or fragmented (upper tooth MPUR 1456-127, upper molar MPUR 1440-119, M1/? MPUR 1418-23, P4 MPUR 1460-55, M1-M2 MPUR 1442-65, M1-M2 MPUR 1441-70, M2-M3 MPUR 1450-64).

DISCUSSION

The paleontological analysis of the rhinoceros remains from Ponte Milvio allows to recognise three species namely *S. hundsheimensis*, *S. hemitoechus* and *S. kirchbergensis* whose biochronological significance is here discussed.

Stephanorhinus hundsheimensis

Four teeth of *S. hundsheimensis* (MPUR 1420-97, MPUR 1454-117, MPUR 1454-118 and MPUR 1412-8) and seven teeth of *Stephanorhinus* sp. report the stratigraphic indications “ghiaie alluviali” or “ghiaie e sabbie” in the labels. The gravels and sands in which the specimens were collected lack volcanoclastic materials which characterise all the sedimentological successions in the area of Rome from ca. 0.600 Ma (see Marra & Rosa, 1995; Caloi et al., 1998; Marra et al., 1998; Sottili et al., 2011). *S. hundsheimensis* is recorded in Europe during the latest Early and the Middle Pleistocene in several sites as Vallonnet, Untermassfeld, Soleilhac, Vergranne, Mosbach, Isernia La Pineta and Mauer (Guérin, 1980; Fortelius et al.,

1993; Kahlke, 2001; Lacombat, 2005; Schreiber, 2005). According to Pandolfi & Petronio (2011a) the species occurred in Italy during the Early Galerian (Colle Curti FU, approximately 1 Ma), while the rhino from Pietrafitta (late Villafranchian, Farneta FU), usually referred to *S. cf. S. hundsheimensis*, could be ascribed to an evolutionary stage of *S. etruscus*. The Toulas species disappeared from the Italian Peninsula during the MIS15-16 and it was replaced by *S. hemitoechus* about 0.500 Ma (Pandolfi et al., 2013) (Fig. 5).

The rhinoceros remains of *S. hundsheimensis* from Ponte Milvio are dimensionally and morphologically closer to the small-sized specimens of the latest Early Pleistocene (Vallonnet) than to the large-sized ones from the Middle Pleistocene (Isernia La Pineta). This suggests that the gravels and sands of Ponte Milvio can be referred to a time span older than the Isernia FU and supports the hypothesis of a faunal assemblage referable to the Slivia or Ponte Galeria FUs (Fig. 5).

The small-sized fragmentary femur MPUR 1523-2 can also be referred to the same levels yielding *S. hundsheimensis* while the deciduous tooth MPUR 1445-27, very similar to the specimens from Vallonnet, has an uncertain stratigraphic provenance.

Stephanorhinus hemitoechus and *S. kirchbergensis*

Two teeth of *S. hemitoechus* (MPUR 1439-134, MPUR 1448-51) and three teeth of *S. kirchbergensis* (MPUR 1417-115, MPUR 1456-126, MPUR 1415-63) report the same indication in the labels: “conglomerati tufacei e ghiaie e tufi”. Both species have been described from several European sites dated to the late Middle Pleistocene and the earliest Late Pleistocene (e.g., La Fage, Neumark-Nord, Burgtonna, Ehringsdorf, Grotte du Prince: see Guérin, 1973, 1980; Kahlke, 1978; Lacombat, 2005; Made, 2010). In Italy, the two species occur together only in few localities as in the terraced deposits of the Aniene River at Monte Sacro and at Castel di Guido (latest Middle Pleistocene). According to Billia & Petronio (2009), the first occurrence of *S. kirchbergensis* in Italy is referable to the Isernia FU, in

the site of Ponte Milvio. However, most specimens from the Ponte Milvio described by Billia & Petronio (2009) and included in this work lack stratigraphic information on the labels (MPUR 1421-107 has only the note “Cava Alessandri”, MPUR 1417-115 was recovered from a volcanoclastic level and MPUR 1445-27 has the generic information “Ponte Molle”). Moreover, some specimens show morphological and morphometric features closer to *S. hundsheimensis* than to *S. kirchbergensis*. Sala (1992) and Billia (2011) ascribed a fragmentary metapodial of large-sized rhinoceros from the Valdemino cave (Savona, Liguria) to *S. cf. S. kirchbergensis*. This cave was referred to the Middle Galerian on the basis of mammal assemblage which includes *Microtus breccensis* Giebel, 1874 and *Allocricetus bursae* Schaub, 1930 (Sala, 1992; Kotsakis et al., 2003; Billia & Petronio, 2009) but the specific attribution of the Valdemino rhino seems to be questionable because based on a fragmentary specimen. Then, the earliest occurrence of *S. kirchbergensis* s.s. in Italy is in the site of Visogliano, referable to MIS12 (Pandolfi et al., 2013) (Fig. 5). The species seems to be very common in Italy during the late Middle Pleistocene and it is recorded in several sites such as Riano (MIS10-8), Castel di Guido, Monte Sacro (terraced deposits) and Sedia del Diavolo (upper gravels, younger than 0.355 Ma) (Billia & Petronio, 2009; Pandolfi, 2011a, b). At present, *S. kirchbergensis* has never been recorded in the Late Pleistocene sites and several records of this species are actually referred to *S. hemitoechus* (Pandolfi & Petronio, 2011b) (Fig. 5).

The earliest occurrence of *S. hemitoechus* in the Italian Peninsula has been recently reported by Pandolfi et al. (2013) from the Campagna Romana, approximately at 0.500 Ma; the species seems to be very common in several late Middle and Late Pleistocene Italian localities. Guérin (1980) and Lacombe (2005, 2006a, b, 2009) recognised at least three evolutionary stages of the species: the first one, characterised by large size, is present in the Middle Pleistocene sites chronologically younger than the MIS11; the second one, characterised by small size, is present during the late Middle Pleistocene, until the MIS8; the third evolutionary stage, again characterised by large size, is present from MIS7 to the last glacial event. The remains of *S. hemitoechus* collected from the volcanoclastic deposits at Ponte Milvio show morphometric characters closer to the small specimens of the latest Middle Pleistocene. In Italy, Pandolfi & Petronio (2011b) reported the occurrence of this small-sized evolutionary stage of the species during the MIS10-8, while large size specimens are recorded during the MIS6 and during the Late Pleistocene (e.g., sites of Maspino, Vitinia upper levels, Grotta Lina) with the exception of the Salento Peninsula.

The co-occurrence of *S. kirchbergensis* and the small-sized *S. hemitoechus* suggests the correlation of Ponte Milvio volcanoclastic deposits with a time span referable with Torre in Pietra FU. This correlation also agrees with the presence in the site of the two species of archaic fallow deer (*D. clactoniana* and *D. dama tiberina*) (Di Stefano G. pers. comm.; see also discussion in Palombo et al., 2004) (Fig. 5) and with the age of several terraced fossiliferous deposits of the Tiber and Aniene Rivers near Ponte Milvio. These terraced deposits cover a bed of Tufo Litoide Lionato dated approximately to 0.355 Ma (e.g.,

Monte Sacro, Prati Fiscali, Sedia del Diavolo and others; see Caloi et al., 1998 and Palombo et al., 2004).

CONCLUSIONS

A large number of vertebrate fossil remains were collected between the end of the 19th century and the beginning of the 20th century from the deposits cropping out near Rome (e.g., Ponzi, 1878; Portis, 1893; Meli, 1896). The fossil remains were mainly referred to the Middle Pleistocene and were found in terraced deposits of the Tiber River and its tributaries (Di Stefano et al., 1998; Petronio et al., 2011). The biochronologic significance of the taxa recovered from these localities, combined with the few lithological information reported in the labels of the specimens, can be used to restore the stratigraphical succession of the fossiliferous localities. The paleontological analysis of the rhinoceros remains collected in the terraced deposits of the Tiber River at Ponte Milvio allows to identify three species: *S. hundsheimensis*, *S. hemitoechus* and *S. kirchbergensis*.

1. The specimens ascribed to *S. hundsheimensis* were collected in the gravels and sands of Ponte Milvio. They have morphological and morphometric affinities close to the latest Early Pleistocene individuals of the species. The occurrence of the first evolutionary stage of *S. hundsheimensis* allows to refer the gravels and sands to the Early-Middle Pleistocene transition (Slivia or Ponte Galeria FUs?); this age is also supported by the occurrence in the site of *H. galerianus* and *C. elephas acoronatus*.

2. The co-occurrence of *S. hemitoechus* and *S. kirchbergensis* in the volcanoclastic deposit, allows to refer this level to the late Middle Pleistocene (Torre in Pietra FU). This age is also supported by the occurrence of archaic fallow deer and by the presence of volcanoclastic materials. Furthermore, *S. kirchbergensis* is unknown in Italy during the Late Pleistocene and its first occurrence is surely younger than MIS12.

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