Rivista Italiana di Paleontologia e Stratigrafia	volume 117	no. 3	pp. 509-520	December 2011

THE SMALL-SIZED RHINOCEROSES FROM THE LATE PLEISTOCENE OF APULIA (SOUTHERN ITALY)

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Received: July 8, 2011; accepted: October 6, 2011

Key words: *Stephanorhinus hemitoechus*, small size, late Pleistocene, Apulia.

Abstract. In this paper, rhinoceros remains from Apulian sites of the late Pleistocene have been analysed. The majority of these remains have been attributed to *Rhinoceros mercki* by several previous authors and later to *Stephanorhinus kirchbergensis*. The results of our analysis show how the remains are all referable to *S. hemitoechus*. This species, with the exception of *Coelodonta antiquitatis*, represent the only rhinoceros species occurring in Apulia from approximately 100.000 to 40.000 years BP. Furthermore, the considered specimens are relatively smaller than those referred to *S. hemitoechus* from several late Pleistocene European sites. However, the small size of the Apulian rhinoceroses seems not to be accompanied by variation in proportions and morphology. We propose that the presence of these small-sized rhinoceroses can be due to a weak effect of endemism, related to the geographic characteristics of Apulia.

Riassunto. In questo lavoro vengono analizzati i resti di rinoceronte rinvenuti nei principali siti del Pleistocene superiore della Puglia. Molti di questi resti sono stati assegnati in passato a *Rhinoceros mercki* e successivamente a *Stephanorhinus kirchbergensis*. I risultati dello studio morfologico e morfometrico dimostrano invece come queste segnalazioni, a parte quelle relative a *Coelodonta antiquitatis*, siano in realtà da riferire alla specie *S. hemitoechus*. Inoltre, le modeste dimensioni dei resti di rinoceronte esaminati potrebbero essere giustificate dal debole grado di isolamento che ha caratterizzato le faune della zona salentina nel corso del Pleistocene; nello stesso areale, oltre ad attardamenti di alcune specie rispetto agli altri territori della Penisola, sono infatti spesso associati altri taxa con leggere riduzioni di taglia.

Introduction

Several rhinoceros species are present in Europe during the Pleistocene and their taxonomy is debated. Guérin (1980, 1982) assigned them, with the exception of four species of the genera *Coelodonta* and *Elasmotherium*, to the genus *Dicerorhinus* and the species *D. jeanvireti*, *D. etruscus*, *D. etruscus brachycephalus* (= partially referred to *S. hundsheimensis*, see Fortelius et al. 1993 and Lacombat 2005), *D. mercki* (= *S. kirchbergensis*) and *D. hemitoechus*, to the new subgenus *Brandtorhinus*. The latter subgenus was later elevated to the genus rank (Guérin 1989).

According to Groves (1983), the Pleistocene European rhinoceroses show little similarity with the genus *Dicerorhinus* and they can be ascribed to the genus *Stephanorhinus*, introduced by Kretzoi (1942). This last viewpoint is followed by Fortelius et al. (1993), who referred to the genus *Stephanorhinus* the species *S. megarhinus*, *S. jeanvireti*, *S. etruscus*, *S. hundsheimensis*, *S. kirchbergensis* and *S. hemitoechus*. In this paper we follow this nomenclature.

During the late Pleistocene, two species of *Stephanorhinus* are present in Europe: *S. kirchbergensis* and *S. hemitoechus*.

The latter was described by Falconer as *Rhinoceros hemitoechus*, but the date of publication seems to be 1859 and not 1868, as usually reported. In the manuscript of Falconer (1868, p. 309) the following note is present "The important essay on *Rhin. hemitoechus* was written in 1859, but is now for the first time published". The name *R. hemitoechus* was used by Falconer in 1860 and Gaudin reported this name in 1859 (in schedis).

S. hemitoechus has often been confused in literature with the other Eurasian species *S. kirchbergensis*. Although many important studies aimed at distinguishing the two rhinoceroses have been published (see Azzaroli 1962; Fortelius et al. 1993 and references therein),

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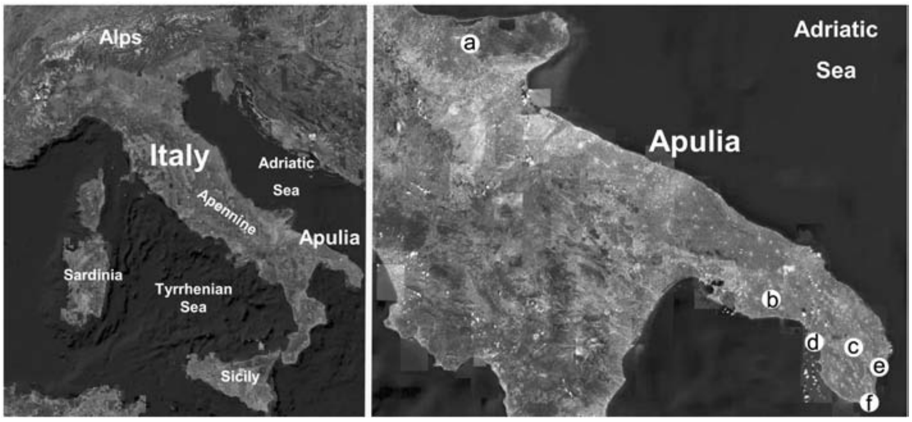

Fig. 1 - Location of some sites of the late Pleistocene in Apulia: a) Quarry of the Ferrovia, Ingarano (Apricena, Foggia); b) Avetrana (Taranto); c) Melpignano-Cursi and San Sidero area (Lecce); d) Uluzzo C. Cave, M. Zei Cave, Santa Caterina (Nardò, Lecce); e) Romanelli Cave, Striare Cave, Sarcofago Cave (Castro-Otranto, Lecce); f) Cave of the Giganti, Cave Tre Porte (Capo di Leuca, Lecce).

it has been common to identify both of them with the *nomen oblitum Rhinoceros* (or *Dicerorhinus*) *mercki* (or *merckii* or *Mercki*). The result has therefore been to refer all the Pleistocene rhinoceros remains not attributable to *R. etruscus* or *C. antiquitatis* to *R. mercki*. This last species was instituted by Kaup in 1841 to identify remains that had already been described by Jäger in 1839 as *R. kirchbergensis*. *Rhinoceros mercki* was thus considered a younger synonym of *S. kirchbergensis*. Because of this, many authors retain the opinion that the remains historically referred to *Rhinoceros* (or *Dicerorhinus*) *mercki* should be identified as *S. kirchbergensis*, without conducting a careful comparative study between this species and *S. hemitoechus.*

Furthermore, two subspecies of *S. hemitoechus* have been recognized by Azzaroli (1962). According to this author, *S. h. falconeri* (*D. h. falconeri* in Azzaroli 1962) is represented by the samples recovered in the middle Pleistocene sites such as Mosbach, Clacton and Bucine, while *S. h. aretinus* (*D. h. aretinus* in Azzaroli 1962) is present during the late Pleistocene (samples from the sites in Val di Chiana). Guérin (1980) notes that the valid name for the subspecies of the middle Pleistocene is *D. h. hemitoechus* and indicates Minchin Hole (Glamorganshire, UK) as the type locality (a skull from this locality was figured by Falconer in 1868). However, according to Sutcliffe & Bowen (1973) and Sutcliffe (1981), Minchin Hole is a typical Eemian locality (early late Pleistocene); thus, *S. h. hemitoechus* is the valid name for the specimens from Val di Chiana and Minchin Hole (late Pleistocene), while the name *S. h. falconeri* can be applied to the specimens from Mosbach, Clacton and Bucine (middle Pleistocene) (van der Made 2010). Finally, the two mentioned subspecies are partially identified with the evolutionary stages reported by Guérin (1980) and Lacombat (2005).

In the present paper, the rhinoceros remains from a number of Apulian sites dated to the late Pleistocene have been re-examined. These remains are often identified as *Rhinoceros* (or *Dicerorhinus*) *mercki* and then erroneously as *S. kirchbergensis*. Morphologic and morphometric analysis reveals the presence of only one small-sized species of the genus *Stephanorhinus* in Apulia.

The selected late Pleistocene *Stephanorhinus*-bearing sites of Apulia: geological and paleontological setting

Several Apulian sites referable to the late Pleistocene, where the presence of rhinoceros remains is reported, are located in the Salentinian area. In the rest of the region the occurrence is rare (Fig. 1). The majority of the sites are represented by infillings of karst cavities (ducts or sinkholes, and/or caves) prevalently set on faults that characterize the Salentinian coast.

Quarry of the Ferrovia, Ingarano, Apricena (Foggia) - The rhinoceros remains come from sandy clays with calcareous blocks, called level b (Petronio & Sardella 1998). The mammal fossil remains found in this level, besides the rhinoceros, consist of *Apodemus sylvaticus*, *Vulpes vulpes*, *Panthera spelaea*, *Palaeoloxodon antiquus*, *Coelodonta antiquitatis* and *Hippopotamus amphibius*. Petronio & Sardella (1998) refer this level to MIS 4/3 through radiometric dating and biochronological analyses.

Avetrana (Taranto) - Abundant remains of large and small mammals were found in a more or less funnel-shaped karst cavity, developed inside a Pleistocene calcarenite. Taking into account the species found at the site and their stage of evolution, this deposit is referred to the Melpignano FU (between 100.000 and 70.000 years ago) (Petronio et al. 2008). Petronio et al. (2008) distinguish different depositional levels at the site; the rhinoceros remains are found in levels 2, 6 and 7. Level 2 is characterized by sandy clay, including numerous remains belonging to *V. vulpes*, *Canis lupus*, *Crocuta crocuta*, *Lynx lynx*, *Bos primigenius*, *Dama dama dama*, *Cervus elaphus* ssp, and *H. amphibius*. Level 6 is a sandy deposit that yielded remains of *V. vulpes*, *C. lupus*, *B. primigenius*, *D. d. dama*, *C. e.* ssp., *Sus scrofa*, and *H.*

amphibius; in this level a single lithic artifact (Musterian) was also found (Petronio et al. 2008). Level 7, a clay layer, contains numerous bones of *V. vulpes*, *C. lupus*, *C. crocuta*, abundant *B. primigenius*, *C. elaphus*, *D. d. dama*, and a single phalanx of *Megaloceros* sp.

Melpignano-Cursi and San Sidero (Lecce) - The area between the cities of Melpignano, Cursi and Maglie is characterized by the presence of numerous karst cavities, generally developed on a subvertical axis, formed within the Pietra Leccese (Late-Miocene calcarenite). These cavities, mainly filled up by ”terre rosse” consisting of residual clays, probably functioned as traps for the fauna living in the surroundings, or functioned as gathering basins for the waters draining the surrounding areas. The faunal remains found in these cavities do not show any sign of human activity. In fact, whole bones and sometimes complete and anatomically connected skeletal elements are found. The fossil fauna present in the area (Mirigliano 1941; Cardini 1961b; De Giuli 1983; Bologna et al. 1994) is composed of *Erinaceus europaeus*, *Lepus europaeus*, *Oryctolagus cuniculus*, one tooth of *Homo* cf. *neanderthalensis*, *Meles meles*, *C. crocuta*, *Canis mosbachensis*, *C. lupus*, *V. vulpes*, *L. lynx*, *P. antiquus*, *Equus hydruntinus*, *Equus ferus*, *Stephanorhinus* sp., *S. scrofa*, *H. amphibius*, *D. d. dama*, *C. elaphus* ssp., *Capreolus capreolus*, *B. primigenius*, and *Bison priscus*.

A series of biochronological considerations and the correlation of these caves with coeval sites that are more easily datable allowed a chronological attribution between 100.000 and 70.000 B.P. (Bologna et al. 1994), and for which the Faunal Unit of Melpignano has recently been proposed (Petronio et al. 2007).

Santa Caterina, Nardò (Lecce) - Borzatti von Löewenstern (1966a) indicates the presence of a site with Mousterian industry and *Rhinoceros mercki* in the deposits of Santa Caterina. The deposit was contained in a karst pit within “Pietra Leccese”. Rhinoceros remains were found together with fragments of *Bos, Equus* and *Cervus*.

Striare Cave, Castro (Lecce) - The presence of a rhinoceros in this cave is attested to by a single third metacarpal, attributed to *Rhinoceros mercki* by Maviglia (1955) and Orlandi & Cigna (1956). The fossil fauna found in the cave is composed of *L. europeaus, L. timidus, O. cuniculus, C. crocuta, C. lupus, V. vulpes, L. lynx, Ursus* sp., *P. antiquus*, *E. ferus*, *S. scrofa, H. amphibius, D. d. dama, C. elaphus* and *B. primigenius* (Maviglia 1955; Orlandi & Cigna 1956; Bologna et al. 1994). Biostratigraphical considerations allow the attribution of this cave to the pre-glacial phase of the late Pleistocene.

Sarcofago Cave, Castro (Lecce) - Di Stefano et al. (1992) indicate the presence of a very compact ossiferous breccia, along the coast between Castro and Otranto. This breccia lies directly on the Neo-Tyrrhenian deposits and is correlated to the sites of Striare Cave, Romanelli Cave (lower levels), Cave of the Giganti and others. The faunal list includes *P. antiquus, E. ferus, E. hydruntinus, H. amphibius, B. primigenius, D. dama, C. elaphus, C. crocuta* and a rhinoceros assigned by Di Stefano et al. (1992) to *Dicerorhinus* sp. and identified as *Stephanorhinus* sp. and *S. kirchbergensis* in Bologna et al. (1994).

Materials and methods

The morphological characters considered in this paper are those listed as diagnostic by several authors, including Guérin (1980), Fortelius et al. (1993) and Lacombat (2005, 2006). The morphometric methodology is based on the work of those authors. The morphometric results obtained for the Apulian rhinoceroses are compared with those reported by Guérin (1980) for *S. hemitoechus* and with those from some Italian and European Pleistocene sites (all the morphometric values are expressed in millimeters). Ratio diagrams are made using data on extant *Diceros bicornis* (data from Guérin 1980) as a reference. This reference was chosen to better highlight differences in specimen proportions and avoid errors of attribution derived using fossil species.

The rhinoceros remains discovered in the Quarry of the Ferrovia at Ingarano probably all belong to the same young individual and consist of fragments of the cranium with the maxillae (s.n.), of a tibia (s.n.), one talus (s.n.) and of two metatarsal bones (s.n.). All the remains are preserved in the Museum of Paleontology of Sapienza, University of Rome.

The rhinoceros remains from Avetrana consist of a lower M3 (s.n.), a lower P4 (s.n.), a third metacarpus of a young rhinoceros, a calcaneum of a young rhinoceros and a second and third metatarsus of a young rhinoceros. The remains are preserved in the Museum of Paleontology of Sapienza, University of Rome and Sovrintendenza dei Beni Culturali di Taranto.

The specimens found in karst cavities of the Melpignano-Cursi and San Sidero area were attributed to in the past to *Rhinoceros mercki* by Cardini (1961b) and Mirigliano (1941), and to *Stephanorhinus* sp. by Bologna et al. (1994) and to *S. kirchbergensis* by Fortelius et al. (1993). A preliminary revision of the remains preserved at the Paleontology Museum at the Sapienza University, Rome and at the Museum of Paleontology at the University of Federico II, Naples allowed the attribution to *S. hemitoechus* (Petronio & Pandolfi 2008). The remains are more or less in good condition and include two upper premolars, one lower deciduous tooth, a fragmented scapula, three humeri, one fragmented ulna, two tibiae, two calcanei, two talii, one metatarsal and some phalanges. Furthermore, unpublished remains stored at the Museum of Paleontology, Sapienza University, Rome, consisting of parts of a cranium of a young rhinoceros (not considered in the present study) and of a fragmented mandible with M/1 and M/2, can be added to this list. The latter remains were found in 1994 in a karst cavity in the proximity of Melpignano called “Ventarola F”.

From Santa Caterina di Nardò (Lecce), an upper M3/ and a molar fragment of a young rhinoceros were found (Borzatti von Löewenstern 1966a). Guérin (1980) confirms the attribution of the M3/, depicted by Borzatti von Löewenstern (1966a, Fig. 3, p. 191), to *Dicerorhinus mercki* (intended by him as *Stephanorhinus kirchbergensis*).

Only one metacarpal has been found in the Striare Cave (Lecce) and at present the location of this specimen in unknown (Orlandi & Cigna 1956).

Finally, very fragmented maxillae were recovered from the Sarcofago Cave (Di Stefano et al. 1992). Only an upper P3/ (s.n.) is considered in this study.

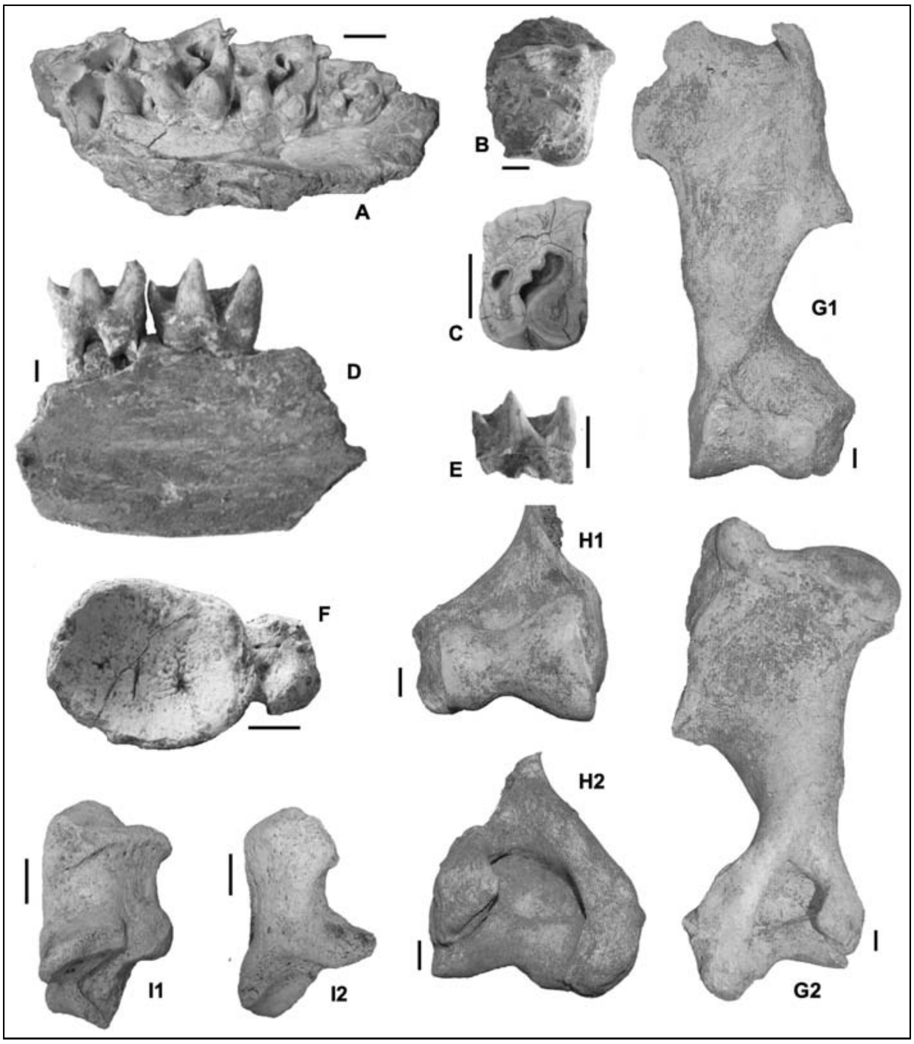

Fig. 2 - Rhinoceros remains from Apulia. (A) Maxillae from Ingarano, occlusal view; (B) P3/ from Sarcofago Cave, occlusal view; (C) P4/ from Melpignano (MPA R3), occlusal view; (D) fragmentary mandible from Melpignano, lingual view; (E) D/4 from Melpignano (MPA 22), lingual view; (F) fragmentary scapula from Melpignano (MPA R6), view of the articular surface; (G) complete humerus from Melpignano (MPA), (1) anterior view, (2) posterior view; (H) distal epiphysis of humerus from Melpignano (M8339), (1) anterior view, (2) posterior view; (I) calcaneum from Melpignano (MPD), (1) medial view, (2) posterior view. Scale bar = 2 cm.

Other rhinoceros remains are recorded from Cagnano Varano (Foggia) (Sorbini & Durante Pasa 1974), Grotta del Cavallo (Santa Caterina, Nardò, Lecce) (Palma di Cesnola 1966), Grotta Montani (Salve, Lecce) (Cremonesi 1974), M. Zei Cave (Nardò, Lecce) (Di Stefano et al. 1992), Uluzzo C. Cave (Nardò, Lecce) (Borzatti von Löwenstern 1965; Borzatti von Löwenstern & Magaldi 1969; Bologna et al. 1994), Cave of the Giganti (Capo di Leuca, Lecce) (Cardini 1961a), Cave Tre Porte (Capo di Leuca, Lecce) (Cardini 1961a), and Grotta di Torre dall'Alto (Nardò, Lecce) (Borzatti von Löewenstern 1966b; Borzatti von Löewenstern & Magaldi 1967). In all these cases, however, precise biochronological or stratigraphic information is lacking and the material does not allow attribution to the species level. The rhinoceros remains from Romanelli Cave (Castro, Lecce) are found in the lower levels of the cave, and were attributed to *Rhinoceros mercki* by Blanc (1920). Bologna et al. (1994) attributed the same remains to *S. kirchbergensis*. The remains are associated to *P. antiquus, E. ferus, H. amphibius, B. primigenius, D. dama, C. lupus, C. mosbachensis, C. crocuta, M. meles, Lutra lutra, Monachus monachus, O. cuniculus, Microtus arvalis, Otis tarda*, and *Otis tetrax* (Bologna et al. 1994). However, the attribution of the rhinoceros remains to *S. kirchbergensis* is very dubious. The morphology of some teeth preserved in the Museum of Maglie is similar to *S. hemitoechus*: presence of a prominent paracone fold in the upper P3, marked paracone fold in the upper molars, presence of distal cingulum in lower M1 (cf. Lacombat 2005). However, the remains are still under study.

Anatomical description of rhinoceros remains from selected late Pleistocene sites of Apulia

Maxillae. The two maxillae from Ingarano are well preserved; the right maxilla shows almost intact D3/, D4/ and erupting M1/, whereas the left maxilla shows D2/, D3/, D4/ and erupting M1/. The overall characteristics of the teeth, and in particular the rough enamel and the wavy trend of the ectolophs with distinct folds, the presence of crista and crochet, allow us to refer the remains to *S. hemitoechus* (Guérin 1980; Lacombat 2006). The measurements of the deciduous teeth are comparable to the smallest values of the species given by Guérin (1980) (Tab. 1; Fig. 2).

P3/. The P3/ from Sarcofago Cave has a very undulating ectoloph with a pronounced paracone fold. Slight mesial cingulum is present and also a lingual one on the hypocone; the occlusal surface is not completely visible because of the matrix. The characteristics of the tooth, and consequently of the maxillary fragments enclosed in the breccia, allow an attribution to *S. hemitoechus*. This tooth has measurements comparable to the minimum values of the species (Tab. 1; Fig. 2).

D1/		**Lmax**	**lmax**
Avetrana	s.n.	24	20
S. hemitoechus	min	21	20
	med	25	22,11
	max	29	24,5
D2/			
Ingarano dx	s.n.	32	31
S. hemitoechus	min	33	30
	med	35,38	34,41
	max	38	38,5
D3/			
Ingarano dx	s.n.	39	41
Ingarano sx	s.n.	40	.
S. hemitoechus	min	39	39
	med	42,89	41,78
	max	48	44,5
D4/			
Ingarano dx	s.n.	.	41
Ingarano sx	s.n.	44	.
S. hemitoechus	min	44	41
	med	48	46,54
	max	51,5	56
P3/			
Sarcofago	s.n.	38	42
S. hemitoechus	min	34	43
	med	41,8	48,2
	max	49	57
P4/			
Melpignano	M8453	39	53
Melpignano	MPA R3	35	51
S. hemitoechus	min	37	50
	med	44,49	54,96
	max	51	61,5

Tab. 1 - Dimensions of the upper teeth from Apulia and *S. hemitoechus* (data from Guérin 1980). Lmax = maximal length; lmax = maximal width.

P4/. The two upper fourth premolars from Melpignano are relatively worn and the enamel is quite rough (Tab. 1; Fig. 2). The lingual sides of the teeth are not bulbously inflated. No other characters can be observed. However, according to the diagnosis given by earlier authors (Guérin 1980; Lacombat 2006) the morphology of the teeth excludes an attribution to *S. kirchbergensis* or *C. antiquitatis*. The teeth are here referred to *S. hemitoechus*.

M3/. The M3/ from Santa Caterina is morphologically closer to *S. hemitoechus* because of the trend of the ectoloph, with a distinct, broad paracone fold, a strong mesial cingulum and the presence of a broad median valley. No metric characters are available and at present the whereabouts of the remains are unknown.

Mandible. The partial mandible from Melpignano is relatively thin, with a maximum width of 47 mm. The lingual side is vertical while the buccal side is slightly curved and the base is convex. The teeth are excellently preserved (Fig. 2). The M/1 is slightly worn, with a U-shaped mesial valley and a V-shaped distal valley. The difference in height between the bottoms of the valleys is relatively great. A small distal cingulum is present and the enamel is rough. The M/2 is slightly worn. The mesial valley is U-shaped, while the distal one is V-shape, the difference in height between the bottoms of the valleys is relatively small (0.72); the distal cingulum is distinct and the enamel is rough.

According to the diagnostic characters reported by Guérin (1980) and Lacombat (2006), the morphological characteristics of the mandible and of the teeth therefore clearly indicate attribution to *S. hemitoechus*.

Finally, the lower teeth have metric characters comparable to the minimum values of the species (Tab. 2).

D/4. The D/4 from Melpignano is well preserved and unworn. Two cingula are present, one in the mesial side and one on the distal side of the tooth. The lingual valleys are V-shaped. All these characters are present in *S. hemitoechus* (Lacombat 2006). The dimensions of the tooth are comparable to the minimum values given by Guérin (1980) (Tab. 2; Fig. 2).

		Lmax	**lmax**
D/4			
Melpignano	MPA 22	40	20
S. hemitoechus	min	37	22
	med	43,75	24,4
	max	50,5	27,5
P/4			
Avetrana	s.n.	38	22
S. hemitoechus	min	35	26
	med	38,08	28,31
	max	42	30,5
M/1			
Melpignano	s.n.	43	26
	min	36,5	26
S. hemitoechus	med	45,02	30,4
	max	52	35
M/2			
Melpignano	s.n.	47	25
S. hemitoechus	min	42,5	25,5
	med	52,76	30,65
	max	60,5	34
M/3			
Avetrana	s.n.	52	29
S. hemitoechus	min	45	26,5
	med	52,23	30,62
	max	58	34

Tab. 2 - Dimensions of the lower teeth from Apulia and *S. hemitoechus* (data from Guérin 1980). Lmax = maximal length; lmax = maximal width.

P/4. The fourth lower premolar from Avetrana is relatively small (Tab. 2) and has V-shaped lingual valleys and relatively rough enamel. The difference in height between the bottoms of the lingual valleys is small. No cingula are present. These characters allow the tooth to be referred to *S. hemitoechus*. Finally, the dimensions of the teeth are close to the minimum values given by Guérin (1980) for the species.

M/3. The third lower molar from Avetrana has rough enamel and a V-shaped distal valley while the mesial one is very damaged. Two lingual cingula are present ventral to the bottoms of the valleys. The morphology of the tooth excludes an attribution to *S. kirchbergensis* or *C. antiquitatis*. This specimen can be referred to *S.* cf. *hemitoechus*. The dimensions of the tooth are comparable to the mean values given by Guérin (1980) (Tab. 2).

Scapula. Only a distal portion of one scapula has been recovered from the karst cavities of Melpignano (Fig. 2). The articular surface of the scapula (transverse diameter of articular surface = 65 mm; anteroposterior diameter of articular surface = 75 mm) is well developed and the coracoid apophysis is not well demarcated. The sub-glenoid tubercle is rounded, as in *S. hemitoechus*. The dimensions of the articular surface are close to the smallest values of the species (min. transverse diameter of articular surface = 64.5 mm; min. anteroposterior diameter of articular surface = 87 mm).

Humeri. The three humeri from the Melpignano-San Sidero area are similar in morphology (Fig. 2). In anterior view, the medial lip of the trochlea is relatively wide, while the lateral lip is rounded and narrow. In the same view, the proximal outline of the medial lip of the trochlea points obliquely towards the trochlear trough. In posterior view, the olecranon fossa is wide in its distal portion. Furthermore, the lateral epicondyle appears massive and is larger than the medial one.

The metric characters of the humeri are close to the mean values of the species (Tab. 3).

Ulna. Only one fragmentary ulna has been recovered in the Melpignano karst cavities. The morphology of the ulna among different rhinoceros species seems to be relatively uniform. However, in the Melpignano specimen, the articular surface with the humerus has a central depression, that, according to Guérin (1980) allows to refer the remain to *S. hemitoechus*.

The dimensions of the ulna are smaller than the minimum values given by Guérin (1980) for the species.

Third metacarpal. The metacarpal from Striare Cave is highly mineralized and somewhat damaged proximolaterally. The morphology seen in Fig. 1 of Orlandi & Cigna (1956) is nearer to that of *S. hemitoechus*. The distal transverse diameter of the metacarpal is about 52.72 mm, while the transverse diameter of the diaphysis is approximately 44.4 mm. These dimensions differ from the classical ones of *S. kirchbergensis* and they approach those of *S. hemitoechus* (according to Guérin, 1980: DT distal = 52-69; DT diaphysis = 42.5-57).

Humerus		**Lmax**	**DTD**	**DAPD**
Melpignano	MPA R21	406	142	110
Melpignano	MPA R20		130	100
Melpignano	M8339		126	100
S. hemitoechus	min	341	117,5	91
	med	394,69	140,6	107,28
	max	425	158	122
Caune de L'Arago	min		140,46	106,41
	med		141,47	108,03
	max		142,99	111,57
Illford	45248		155	114
Illford	23111		166	125
Villavieja			134,5	112,5
Pinilla del Valle				93
Neumark-Nord		435 ~459,2	154,3	120,8

Tab. 3 - Dimensions of the humeri from Apulia, Caune de L'Arago (data from Lacombat 2005), Ilford, Villavieja and Pinilla del Valle (data from Cerdeño 1990), Neumark-Nord (data from van der Made 2010) and *S. hemitoechus* (data from Guérin 1980). Lmax = maximal length; DTD = distal transverse diameter; DAPD = distal anteroposterior diameter.

Tibia. The tibiae from Ingarano and Melpignano show the distal articular surfaces intact and the typical morphological characters of *S. hemitoechus* are evident (Fig. 3). The lateral distal articular surface is subelliptical, whereas the medial articular surface is more or less trapezoidal and less concave than the lateral. The tibiae have metric characters close to the minimum values of the species (Tab. 4).

Talus. In the talii from Ingarano and Melpignano, the lateral and medial lips of the trochlea are well developed (Fig. 3). In medial view, the distal tuberosities are located towards the plantar margin of the bones. In anterior view, the depression under the trochlea of the talii is slightly marked and the profile of the upper margin of the distal articular surface is slightly convex. In distal view, the outlines of the anterior margins of the distal articular surfaces of the talii are relatively straight, with a slight central depression. In posterior view, the articular surfaces with the sustentaculum are elliptical in shape. The metric characters of the talii are close to the minimum values of the species (Tab. 5).

Calcaneum. The two calcanei from Melpignano are relatively small (Tab. 5; Fig. 3). The tuber is less developed anteroposteriorly than the beak, as in *S. hemitoechus*. The lower articular surface with the talus is fused with the articular surface on the sustentaculum talii. The distal articular surface with the cuboid has a trapezoidal shape.

Second metatarsal. Only one second metatarsal has been recovered in the Melpignano-Cursi area. In the proximal epiphysis, in lateral view, the two articular surfaces are fused (Fig. 3). The posterior border of this

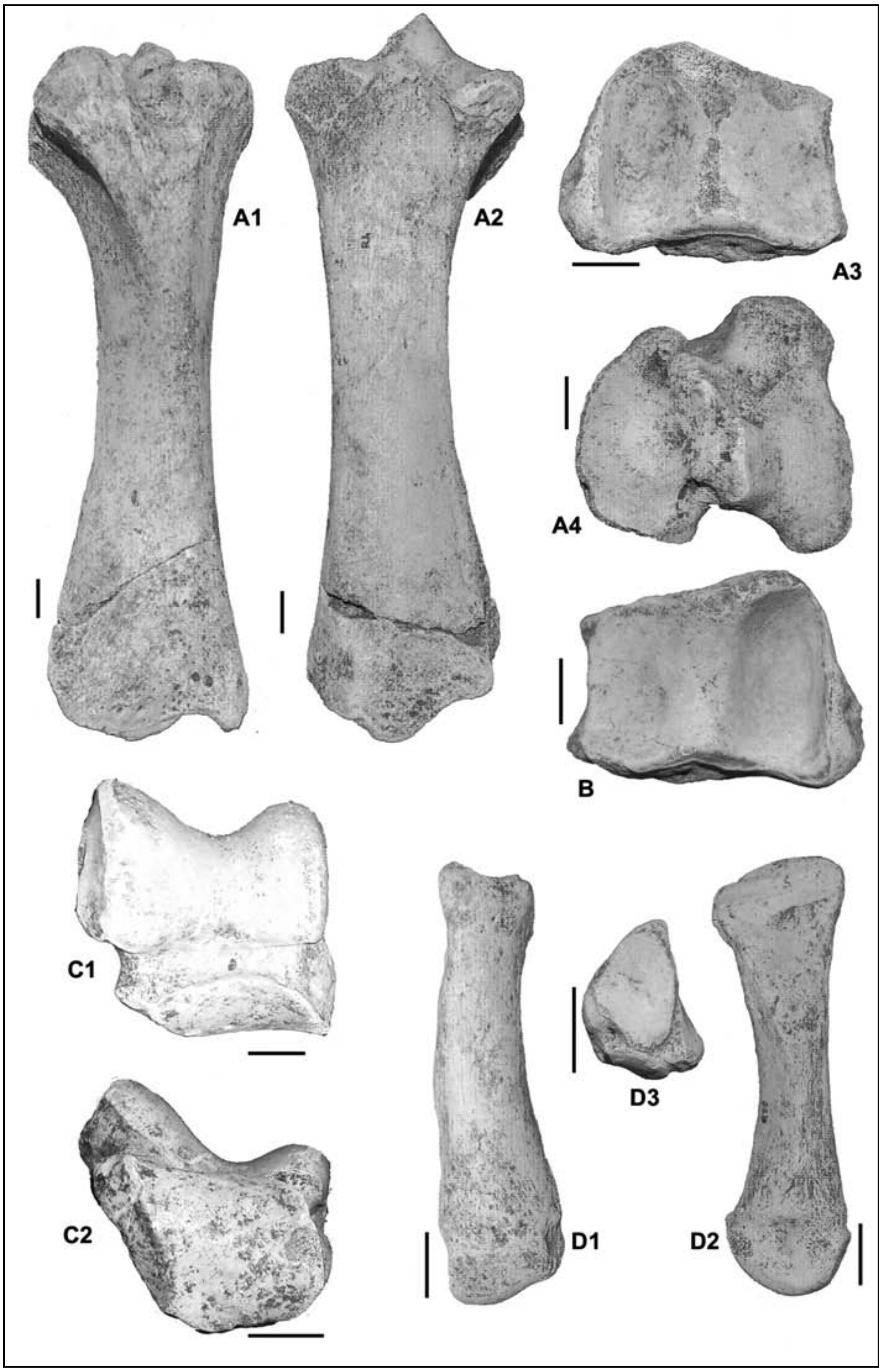

Fig. 3 - Rhinoceros remains from Apulia. (A) Tibia from Melpignano (MPA R4), (1) anterior view, (2) posterior view, (3) view of the distal articular surface, (4) proximal view; (B) tibia from Melpignano (MPA R5), view of the distal articular surface; (C) talus from Melpignano (MPA R15), (1) anterior view, (2) distal view; (D) second metatarsal from Melpignano, (1 anterior view, (2) lateral view, (3) proximal view. Scale bar = 2 cm.

surface is rectangular, while the anterior border is more rounded. The proximal articular surface is elongated anteroposteriorly in proximal view. The anterior tuberosity of the proximal epiphysis is slightly more developed than the anterior margin of the proximal articular surface. The metric characters of this bone are close to the minimum values of *S. hemitoechus* given by Guérin (1980) (Tab. 4).

Fourth metatarsal. The fourth metatarsal from Melpignano is relatively small (Tab. 4). The proximal epiphysis is trapezoidal in proximal view. In medial view, the two articular surfaces are partially fused. The anterior one is trapezoidal, while the posterior one has a more rounded outline. The posterior tubercle of the proximal epiphysis is well developed. All these characters are recognized in *S. hemitoechus* (Guérin 1980; Lacombat 2005).

Discussion and conclusions

The late Pleistocene sites of Apulia yielding remains of *S. hemitoechus*, cover a time span of approximately 100.000 to 35.000-40.000 years BP. Except for

Tibia		**Lmax**	**PTD**	**PAPD**	**DTD**	**DAPD**
Ingarano*	s.n.				87	64
Melpignano	MPA R5				89	68
Melpignano	MPA R4	323	101	105	86	68
	min	321	101	100	85	57
S. hemitoechus	med	358,88	121,26	123,61	98,38	73,08
	max	400	137,5	130	114	87
II Metatarsus						
Melpignano	MPA R18	130	27	40	33	35
	min	137	28	38,5	33	34
S. hemitoechus	med	148,78	31	42	37	37,57
	max	158	34,5	45	41	40,5
IV Metatarsus						
Melpignano	MPA R10	136			28	35
	min	136	33,5	33,5	27	32,5
S. hemitoechus	med	150,44	41,39	40,4	32,75	37,06
	max	169,5	48	46,5	39	43

Tab. 4 - Dimensions of the tibiae, second metatarsal and fourth metatarsal from Apulia and *S. hemitoechus* (data from Guérin 1980). Lmax = maximal length; PTD = proximal transverse diameter; PAPD = proximal anteroposterior diameter; DTD = distal transverse diameter; DAPD = distal anteroposterior diameter.

Talus		**H**	**TD**	**APD**
Ingarano*	s.n.	71	80	51
Melpignano	MPA R16	75	78	50
Melpignano	MPA R15	75	80	53
	min	72	72,5	48
S. hemitoechus	med	81,49	85,05	57,3
	max	94	95	67

Calcaneum		**Hmax**	**APDs**	**APDb**	**TDst**	**TDs**
Melpignano	M8454	114	53	60	65	43
Melpignano	MPD	110	59	62	70	49
	min	104	54	56	66	42
S. hemitoechus	med	120,43	62,83	66,54	75,18	50,16
	max	139	74	75	85	60

Tab. 5 - Dimensions of the talii and calcanei from Apulia and *S. hemitoechus* (data from Guérin 1980). H = height of the talus; TD = transverse diameter; APD = anteroposterior diameter; Hmax =maximal length; APDtc = anteroposterior diameter of the tuber calcanei; APDb = anteroposterior diameter of the beak; TDst = transverse diameter of the sustentaculum talii; TDtc = transverse diameter of the tuber calcanei.

the presence of *Coelodonta antiquitatis* at Ingarano (Foggia) and Cardamone (Lecce), the presence of a third rhinoceros species has not been ascertained in this area. All the suggestions of the presence of *S. kirchbergensis* seem to be unfounded. *S. hemitoechus* is the only one species of *Stephanorhinus* present in the Apulian sites of the late Pleistocene. This makes the presence of *S. kirchbergensis* in southern Europe even more doubtful, or at least much less common than maintained in the past. Records from Spain and Portugal have all been refuted, while those from Mediterranean France are rare, and those from Greece appear to be spurious (Guérin 1980; Cerdeño 1990; Lacombat 2005). Its also seems to be rare in the Italian peninsula. The species is recorded only in some northern and central Italian faunas from the Isernia FU (about 0.650-0.550 Ma) (in the terraces of the Tiber at Ponte Molle, Rome) to the earliest late Pleistocene (Billia & Petronio 2009). However, the presence of this species in the first assemblage of the Ponte Molle fauna is very doubtful. Some teeth described by Billia & Petronio (2009) do not have exact stratigraphic provenance, and some are reported from the "conglomerati tufacei" layer. The latter should probably be referred to the latest middle Pleistocene or to a time span later than 0.5 Ma (cf. Caloi et al. 1998).

The occurrence of *S. hemitoechus* in Europe is attested to at the middle Pleistocene sites of Caune de L'Arago (France) and Petralona (Greece) (Guérin 1980; Fortelius et al. 1993; Lacombat 2005), while the record of the species at Mosbach 2 (Germany) seems to be very doubtful (Koenigswald et al. 2007; Made 2010). In Italy, the first occurrence of *S. hemitoechus* is still debated. The species seems, however, to be present from the late

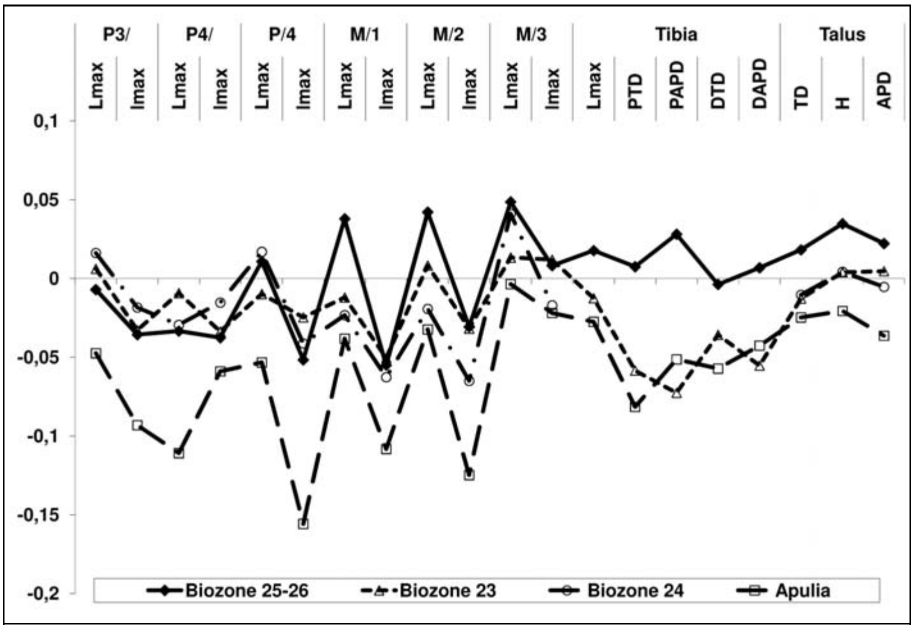

Fig. 4 - Ratio diagram for the teeth, tibia and talus from Apulia and *S. hemitoechus* from Guérin's biozones (data from Guérin 1980). Abbreviations in Tab.1-5.

middle Pleistocene (Torre in Pietra FU sensu Gliozzi et al. 1997; Petronio et al. 2011). The presence of *S. hemitoechus* in the early middle Pleistocene sites of Slivia (Trieste), Ponte Galeria (Rome) and Torrente Stirone (Parma) is unfounded and the remains from these sites can be referred to *S. hundsheimensis* (Petronio et al. 2011).

According to Guérin (1980), Fortelius et al. (1993) and Lacombat (2005), during the late Pleistocene (biozone 25-26 in Guérin 1980) *S. hemitoechus* is characterized by increasing in size. Very large samples are found in Europe, including Italy (for example Botro Maspino and Ponte alla Nave, Tuscany). This form can be identified with the subspecies *S. h. hemitoechus* (= *R. h. aretinus* in Azzaroli 1962). The analysed remains from Apulia, however, are smaller compared with other European specimens of the same chronological time span (Figs 4, 5, 6, 7). Furthermore, Guérin (1980) and Lacombat (2005) have recognized at least three evolutionary stages of the species: the first one, characterized by large size, is present in the middle Pleistocene sites chronologically earlier than MIS11 (about biozone 23 in Guérin 1980). The second, characterized by small size, is present during the late middle Pleistocene, until MIS8 (biozone 24 in Guérin 1980); the third evolutionary stage, characterized by large size, is present from MIS7 to the last glacial event (partially represented by biozones 25-26 in Guérin 1980). However, the correspondence between the Guérin's (1980) biozones and the chronological time spans of the evolutionary stages reported in Lacombat (2005) is relatively not well defined. For example, the first author includes the site of Terra Amata (France) in biozone 23 (related to the first stage of *S. hemitoechus*), while Lacombat (2005) includes the remains from the mentioned site in the second stage of the species.

According to Guérin (1980), differences in proportion and size of the teeth of *S. hemitoechus* from biozone 23 (middle Pleistocene) to biozone 25-26 are not statistically significant. However, according to the same author, the specimens from biozone 24 (late middle Pleistocene) seem to have P3/, P4/ and M1/ larger than those from the other biozones. The P4/ from biozone 24 and those from Melpignano have similar proportions, but the latter are smaller than the former (Fig. 4).

As regards the post-cranial bones, according to Guérin (1980) the humerus of *S. hemitoechus* is characterized, during the evolution of the species, by a decrease of maximum length and by an increase in the diameter of the distal epiphysis. However, according to the same author, the late middle Pleistocene (biozone 24) specimens have similar dimensions to those of the late Pleistocene (biozone 25-26). The humeri from Melpignano are smaller than those from the late Pleistocene site of Ilford (late Pleistocene, England) and are comparable to the minimum values of the specimens from Caune de L'Arago (middle Pleistocene, France), Pinilla del Valle and Villavieja (late middle Pleistocene, Spain) (Tab. 3). Unfortunately, remains of humeri referred to *S. hemitoechus* are relatively few and a detailed comparison is at present very difficult.

The third metacarpals of the species from biozone 24 are similar in size to those from the late Pleistocene. They are shorter and with larger epiphyses than the specimens from biozone 23 (Guérin 1980). The specimen from Striare Cave is relatively smaller than those from the late Pleistocene, but unfortunately no additional data are available about this bone.

The tibia of *S. hemitoechus* shows significant difference in size and proportions between the specimens from the middle Pleistocene and those from the late Pleistocene (Guérin 1980) (Fig. 4). The remains from Apulia seem to be closer in size to those from biozone 23 and in proportions to those from biozone 25-26. Unfortunately, no data are available about the specimens from biozone 24. The complete tibia from Melpignano is shorter than the specimens from the late Pleistocene (including Maspino, Ilford and Maastricht-Belvedere) (Fig. 5). Furthermore, the distal epiphyses of the three tibiae from Apulia are less developed than the late Pleistocene remains and are comparable to those from Torre del Pagliaccetto (Torre in Pietra), referred to the late middle Pleistocene (MIS10-8).

For the talus, Guérin (1980) reports an increase in the principal dimensions of the bone from the middle Pleistocene (biozone 23) to the late Pleistocene (biozone 25-26). According to the same author, the specimens from biozone 24 are closer to those from biozone 25-26. The talii from the different biozones seem not to

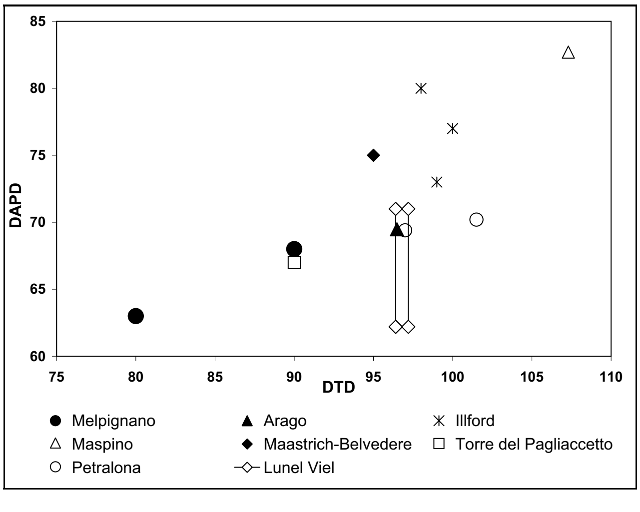

Fig. 5 - Scatter diagram of tibiae from Melpignano and Caune de L'Arago (data from Lacombat 2005), Torre del Pagliaccetto (data from Caloi & Palombo 1979), Petralona (data from Fortelius & Poulianos 1978), Maspino, Ilford, Maastrich-Belvedere (data from Fortelius et al. 1993) and Lunel Viel (data from Bonifay 1973). Abbreviations in Tab. 4.

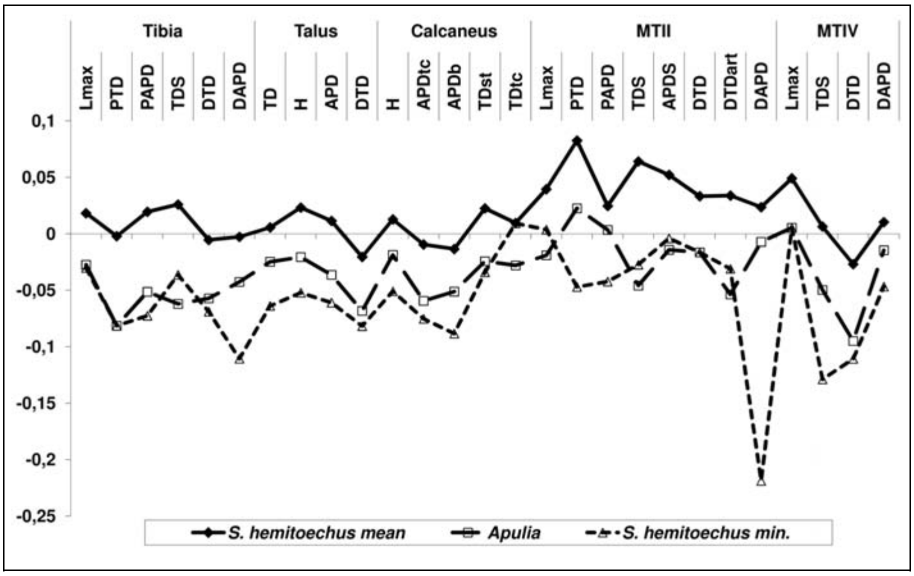

Fig. 6 - Ratio diagram of postcranial remains from Apulia and the mean and minimum values of *S. hemitoechus* (data from Guérin 1980). TDS = transverse diameter of the shaft; APDS = anteroposterior diameter of the shaft; DTDart = distal transverse diameter of the articular surface; other abbreviations in Tab. 4 and 5.

show significant variation in proportions, and the specimens from Apulia are closer in size to the mean of those from the middle Pleistocene (biozone 23) (Fig. 4).

In the calcaneum of *S. hemitoechus*, the maximal length seems to increase from the middle Pleistocene to the late Pleistocene and the tuber seems to be wider in the middle Pleistocene specimens than in the late Pleistocene ones (Guérin 1980). However, the maximal lengths of the calcanei from Apulia are smaller than the specimens from the late Pleistocene and seem to be closer to the values of the specimens from Lunel-Viel and La Fage (late middle Pleistocene, France). Furthermore, the transverse diameters of the tuber in the Apulian remains are smaller than the minimum values of the species (Fig. 6).

According to Guérin (1980), the second and fourth metatarsals of *S. hemitoechus* seem not to show significant temporal variation in size and proportions. The specimens from Melpignano are closer to the minimum values of the species, except for the proximal epiphysis of the second metatarsal, and are smaller than the metatarsals from the late Pleistocene reported by Fortelius et al. (1993).

Finally, the Apulian rhinoceroses seem to show an opposing trend with respect to the European populations of the species. The metric characters of the remains are closer to the late middle Pleistocene specimens than to the late Pleistocene ones. This is seen even if we compare the Apulian remains with other remains from the Italian peninsula. In fact, the size of the Apulian rhinoceroses is close to the specimens from Ponte Molle2, Torre del Pagliaccetto (Torre in Pietra) and Malagrotta (all referable to MIS10-8) and is smaller than the specimens from Maspino (late Pleistocene?, Arezzo), San Colombano al Lambro (late Pleistocene, Pavia) and Grotta Lina (MIS6, Maratea, southern Italy) (Fig. 5, 7). However, excluding the analysed remains, in Italy we can recognize at least two of the three evolutionary stages described by Guérin (1980) and Lacombat (2005). These can be equated with the two subspecies *S. h. hemitoechus* (late Pleistocene) and *S. h. falconeri* (late middle Pleistocene). Thus, the trend towards an increase in size is valid for both the Italian and European specimens. Furthermore, even in Italy, *S. h. hemitoechus*, characterized by large samples, is present before the beginning of the late Pleistocene. It is found in the sites of Grotta Lina (MIS6) and Vitinia (upper levels, MIS7, Rome). Specimens related to the small samples reported by Guérin (1980) (biozone 24) and Lacombat (second evolutionary stage) are found in late middle Pleistocene sites chronologically related to the Torre in Pietra FU (MIS10-8) (sensu Gliozzi et al. 1997) at Torre del Pagliaccetto and the second assemblage of

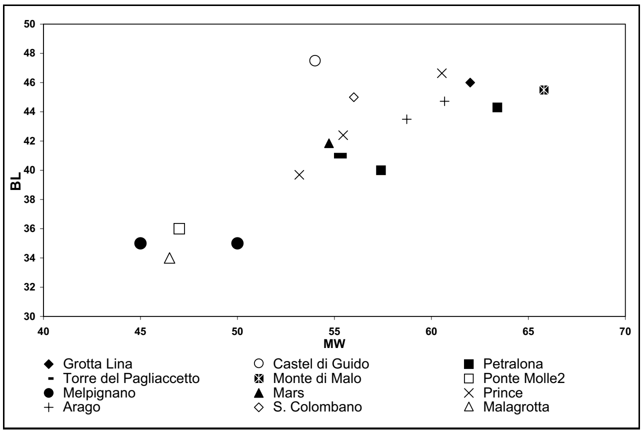

Fig. 7 - Scatter diagram of P4/ from Melpignano, Mars, Caune de L'Arago, Prince (data from Lacombat 2005), Petralona (data from Fortelius & Poulianos 1978), Torre del Pagliaccetto (data from Caloi & Palombo 1979), S. Colombano (data from Cantaluppi 1969), Ponte Molle2, Malagrotta, Castel di Guido, Grotta Lina and Monte di Malo. BL = buccal length; MW = mesial width.

Ponte Molle (assigned to the Vitinia FU in Capasso Barbato et al. 1998) (Fig. 5, 7).

Further, the small size of the Apulian rhinoceroses seems not to be followed by marked variation in proportions and morphology. The ratio diagrams of the post-cranial elements of the Apulian rhinoceroses show great affinity with the mean curve of *S. hemitoechus* (Fig. 6).

Finally, we can suppose that the small size of Apulian rhinoceroses can be explained through a "weak effect of insularism" due to the geographic characteristics of Apulia. Nevertheless, it has to be remembered that, in this region, the occurrence during the Pleistocene of mammals with particular characteristics indicating a certain degree of endemism is not uncommon. Examples include the small size of the populations of *Axis eurygonos*, from the quarries of Apricena (Foggia) of the early Pleistocene, or *Vulpes vulpes* and *Lynx lynx* from the late Pleistocene of Ingarano (Foggia) (Petronio & Sardella 1998), that, alongside the small size, show unusual morphological characters. Furthermore, the persistence of some middle Pleistocene taxa is also common in this region, such as for example *Canis mosbachensis*, which is present in the late Aurelian fossiliferous deposits of Ingarano and Grotta Romanelli (Lecce) (Di Stefano et al. 1992; Petronio & Sardella 1998). It may be also supposed that Apulian rhinoceroses represent a relict population of the late middle Pleistocene small-sized *S. hemitoechus*. The latter hypothesis seems to us to be less probable. In fact, large sized *S. hemitoechus* spread out in northern and central Italy from MIS7 and large samples of the species are discovered in southern Italy, as in Grotta Lina. Due to the absence of great ecological or geographic barriers it can not be excluded that the large *S. hemitoechus* reached the Apulia before the beginning of the late Pleistocene. Unfortunately, no data about sites of the late middle Pleistocene are available in Apulia. Time and additional material will be useful to investigate these small-sized populations that may be placed in a different subspecies.

Acknowledgements. We thank Prof. Lars Werdelin, Prof. M. Gaetani, Prof. A. Kotsakis and an anonymous reviewer for helpful comments of the manuscript.

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