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Propotamochoerus provincialis (Gervais, 1859) (Suidae, Mammalia) from the latest Miocene (late Messinian; MN13) of Monticino Quarry (Brisighella, Emilia-Romagna, Italy)

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KEY WORDS - Propotamochoerus provincialis *(Gervais, 1859), Suidae, dentition, post-cranial skeleton, Late Miocene, Messinian, Monticino Quarry, Brisighella, Italy.*

ABSTRACT - Nine specimens of fossil pigs are described here from the latest Miocene mammal assemblage of Monticino Gypsum Quarry (also referred to as Brisighella). The tooth remains consist of three elements of the upper dentition (I^1, M^3 and M^2), and two of the lower dentition (P_2 and M_1). There are four post-cranial elements (astragalus, cuboid, navicular and third phalanx). The degree of dental wear, the closure of the root of the incisor, as well as the relative dimensions of the post-cranial remains indicate that the fossils belong to at least two individuals, a juvenile and an adult. The specimens have been assigned to the species Propotamochoerus provincialis *(Gervais, 1859) based on a combinaton of dental morphometrics and morphological characters. Affinities may be shown with recent forms of* Sus scrofa *Linnaeus, 1758, based on aspects of the morphology of the post-cranial remains implying that the latter are quite homogenous within primitive or derived taxa of the family. As the post-cranial morphology of* Propotamochoerus *is poorly known the description given here of the findings at Brisighella is an important addition to the knowledge regarding the genus. The European distribution of* Propotamochoerus provincialis *(Gervais, 1859) ranges from the biochronological units MN13 to MN15. This description of the Brisighella specimens augments the knowledge of the Monticino Gypsum Quarry fauna, the most well-represented Messinian continental vertebrate assemblage in Italy.*

RIASSUNTO - [*Propotamochoerus provincialis* (Gervais, 1859) (Suidae, Mammalia) dal Miocene terminale (Messiniano superiore; MN13) della Cava dei Gessi del Monticino (Brisighella, Emilia-Romagna, Italia)] - *Si descrivono i resti di Suidae presenti nella associazione faunistica del Miocene terminale della Cava dei Gessi del Monticino (Brisighella). Il campione è costituito da nove elementi. I resti dentari documentano tre elementi della dentatura superiore (I^1, M^3 e M^2), e due di quella inferiore (P_2 e M_1). Lo scheletro postcraniale è invece rappresentato da quattro elementi (astragalo, cuboide, navicolare e una falange distale). Lo stadio di usura della dentatura, il grado di chiusura della radice dell'incisivo, e la taglia dei resti postcraniali dimostrano che i fossili appartengono almeno a due individui, un adulto ed un giovanile. La combinazione di caratteri morfometrici e morfologici ci permette di attribuire i resti alla specie* Propotamochoerus provincialis *(Gervais, 1859). La morfologia dei resti postcraniali presenta diversi aspetti comparabili con quanto osservabile nelle forme recenti di* Sus scrofa *Linnaeus, 1758 e quest'osservazione conferma che la morfologia del postcraniale è molto conservativa nei taxa primitivi e derivati della famiglia. Ad ogni modo, la morfologia dello scheletro postcraniale del genere* Propotamochoerus *è poco conosciuta e la descrizione dei resti di Brisighella contribuisce ad arricchire la conoscenza del genere.* Propotamochoerus provincialis *(Gervais, 1859) è un suide distribuito in Europa tra le unità biocronologiche MN13 e MN 15. La descrizione formale dei resti di Brisighella completa la nostra conoscenza della fauna del Monticino, l'associazione a vertebrati continentali del Messiniano meglio rappresentata nella documentazione fossile italiana.*

INTRODUCTION

The occurrence of a rich late Messinian fossil vertebrate assemblage in sediments filling karst cavities affecting the Messinian evaporites in the Monticino gypsum quarry near Brisighella (Ravenna Province, Cental Italy) was first reported by Costa et al. (1986). The vertebrate fauna has been the subject of a number of descriptive papers (De Giuli et al., 1988; De Giuli, 1989; Masini, 1989; Kotsakis, 1989; Kotsakis & Masini, 1989; Masini & Thomas, 1989; Torre, 1989; Rook et al., 1991; Rook, 1992a, 1992b, 1999, 2009; Masini & Rook, 1993; Rook & Masini, 1994) and, according to local and regional geological constrains (Marabini & Vai, 1989; Vai, 1989) the vertebrate assemblage is attributable to the late Messinian.

In this paper we report on the unpublished fossil suids from the Monticino Gypsum Quarry. Suids are rare in the assemblage. Until present they have not been formally described, although their recovery dates back to the early times of the Monicino fauna discovery (De Giuli et al., 1988).

The aim of this paper is to describe the Monticino Suidae remains and identify them at the specific level. The identification of this sample at the family level also has important biogeographic implications. The European Late Miocene (MN12-MN13 time equivalent) fossil suid record includes two sub-families: Hyotheriinae and Suinae (Van der Made, 1989-1990).

We also provide descriptions of the postcranials (elements always underconsidered in the literature) and a discussion of the significance of the Suidae occurrence in the latest Messinian of Italy.

METHODS AND ABBREVIATIONS

All the measurements were acquired with digital caliper and are given in millimetres (accuracy at nearest 0.05).

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The abbreviations used in the text (according to the scheme by Van der Made, 1996) are listed herein. Dentition: DAP (maximum length); DTa (transverse diameter of the first pillar pair); DTp (transverse diameter of the second pillar pair); DTpp (width of the talon/talonid); Ha (height of the parcone on the buccal side in upper molars/height of the metaconid on the lingual side in lower molars); Hp (height of the metacone on the buccal side in upper molars/height of the entoconid on the lingual side in lower molars); Hpp (height of the talon on the buccal side/height of the talonid, on the lingual side); DMD (mesio-distal diameter); DMDo (mesio-distal diameter measured along the occlusal surface); DLL (linguo-labial diameter); Hli (height at the lingual side); Tp (thickness of enamel measured at the entoconid).

Postcranial elements: DAP (maximum length); DAPp (proximal antero-posterior diameter); DAPpf (antero-posterior diameter of a facet at the proximal side); DAPps (maximum diameter at the proximal side); DT (transverse diameter); DTp (width of the proximal part in a bone); DTd (distal width of a bone); H (height); Ha (height at the anterior side); L (lenght); Lint (lenght at the internal side); Lext (length at the external side); Lm (length in the middle of the bone). For the identification of molars "Wear Stage" (W.S.) we follow the standard of Armour-Chelu et al. (2003).

The inventory number of the specimens is composed of a combination of letters and numbers. The acronym BRS (=Brisighella) indicates the general locality; the first number (e.g. BRS 25) indicates the specific site (the karst fissure), while the second number (e.g. BRS 25/1) indicates the catalogue number of the specimen.

For the terminology and description of the dental topographical characters, we follow Van der Made (1996), while for the description of the elements of the post-cranial skeleton, reference is made to Kratochvil (1973) and Leinders (1976).

The Brisighella sample has been compared with the main representatives of the subfamily Suinae in Eurasia and Africa during the Late Miocene (late MN12 - MN13 time equivalent).

SYSTEMATICS

Order Artiodactyla Owen, 1841
Family Suidae Gray, 1821
Subfamily Suinae Gray, 1821
Tribe Dicoryphochoerini Schmidt-Kittler, 1971
Genus *Propotamochoerus* Pilgrim, 1925

Propotamochoerus provincialis (Gervais, 1859)

1988 Suidae indet. De Giuli et al., p. 65.

Material examined - The Brisighella sample comprises nine specimens. BRS 25/1 is a left I^1; BRS 25/2 is a right

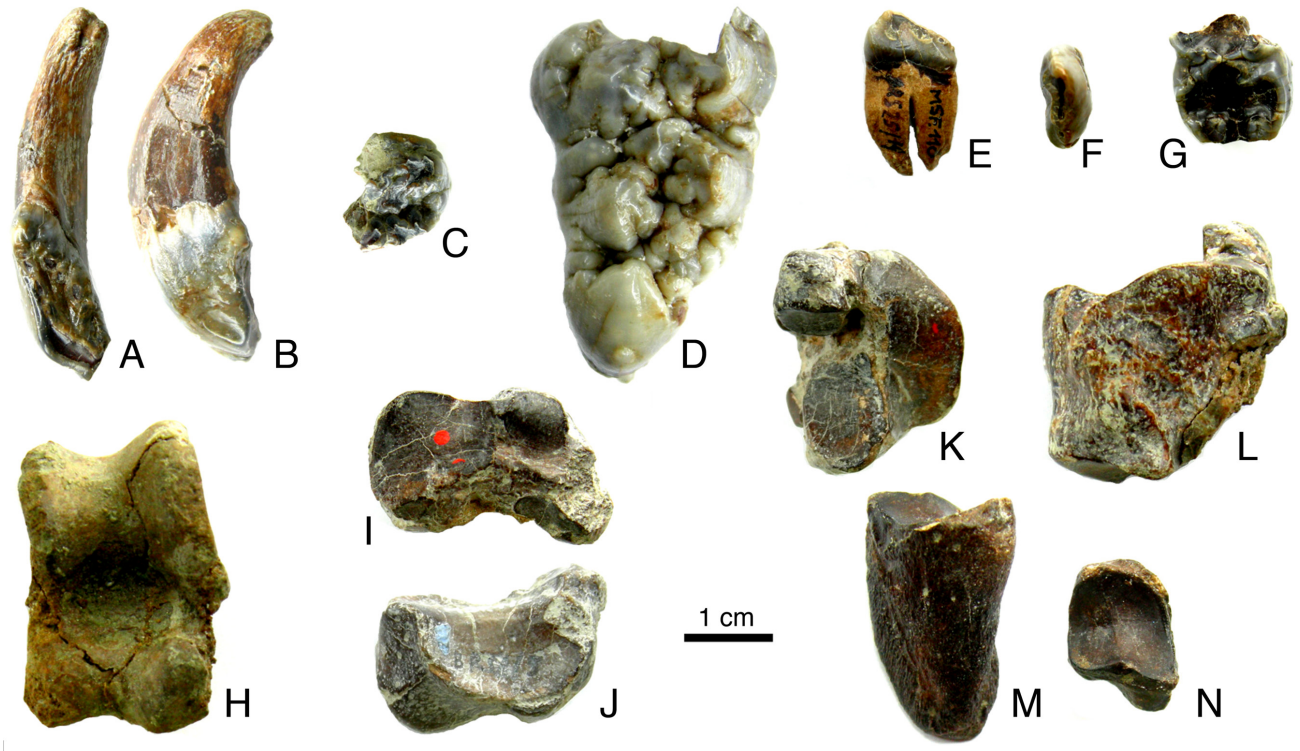

Fig. 1 - *Propotamochoerus provincialis* from Brisighella. Dentition: A: left I^1 (Brs25/1) occlusal view; B: left I^1 (Brs25/1) labial side; C: right M^2 fragment (Brs25/2) occlusal view; D: right M^3 (Brs25/3) occlusal view; E: right P_2 (Brs25/14) lingual side; F: right P_2 (Brs25/14) occlusal view; G: left M_1 fragment (Brs25/22) occlusal view. Post-cranium: H: left astragalus (Brs25/4) dorsal view; I: right navicular (Brs1/3) distal view; J: right navicular (Brs1/3) proximal view; K: left cuboid (Brs1/4) distal view; L: left cuboid (Brs1/4) lateral view; M: left phalanx distalis pedis digiti III or IV (Brs25/12) dorsal view; N: left phalanx distalis pedis digiti III or IV (Brs25/12) proximal view.

M^3; BRS 25/3 is a fragment of a right M^2; BRS 25/14 is a right P_2; BRS 25/22 is a fragment of a left M_1; BRS 25/4 is a left astragalus; BRS 1/3 is a left cuboid; BRS 1/4 is a right navicular; BRS 25/12 is a third phalanx.

Repository - All the described material (acronym BRS) is kept in the Museo Civico di Scienze Naturali, Faenza (RA).

Description of upper and lower dentition

BRS 25/1. *Left upper first incisor* (Figs 1A-B) - The tooth is strongly curved and presents little wear in the antero-labial ridge (paracone). The lingual cingulum (protocone) is affected by wear and shows many grooves that run parallel antero-posteriorly. The paracone and protocone are divided by a deep groove. The root is strong and nearly closed to its apex and, compared with extant *Sus scrofa* Linnaeus, 1758 (according to the pattern provided by Iff, 1978), would correspond to a fully grown adult over 36-48 months of age.

Measurements: DLL=9.35; DMD=17.45; DMDo= 17.84.

BRS 25/2. *Fragmentary right upper second molar* (Fig. 1C) - This specimen consists of a fragment of antero-lingual cusp in an advanced wear stage (W.S.= 3 sensu Armour-Chelu *et al*. 2003).The measure of enamel at the entoconid (Tp) is 0,5. The fragmentary status of the specimen does not allow us to provide further observation or measurement.

BRS 25/3. *Right upper third molar* (Fig. 1D) - The tooth, triangular in shape, is broken on the anterior side at the central part of the protopreconule, of which it is still possible to appreciate the labial and lingual extremity. Along the fracture it is possible to appreciate that the tooth is characterised by thin enamel. The tooth shows a limited stage of wear (W.S.=1). The four main cusps are still visible; the tooth morphology is complicated by the presence of many, smaller, accessory cusplets. There is a hypopreconulid distal to the first pair of main cusps (paracone-protocone) and two small pillars of enamel on either side of the hypopreconulid. On the distal side of the second pair of cusps (metacone-tetracone), there is a pentapreconule that shows many pillars labially. On the lingual side of this cusp there are three other pillars.

The cervical part of the tooth allows us to appreciate the roots. Shape and position of the roots are comparable to those of recent *Sus scrofa* Linnaeus, 1758.

Measurements: DAP= 38.10; DTa=26.50; DTp=21.40; DTpp=13.15; Ha=14.75; Hp=13.15; Hpp=13.30.

BRS 25/14. *Right lower second premolar* (Figs 1E-F) - This is an asymmetric, double rooted tooth with simple morphology and an oval occlusal surface. In the mesial part, the main cusp has a weak cingulum and in the distal part it has many accessory cusplets forming a cutting surface.

Measurements: DAP=11.10; DTa=4.95; DTp=4.50; Ha=6.40.

BRS 25/22. *Fragmentary left lower first molar* (Fig. 1G) - The distal part of the tooth is square-shaped with entoconid and tetraconid strongly affected by wear (W.S.=4). The mesial part of the tooth is lost.

Measurements: because of its poor preservation the only measurable dimension is DTp=13.20.

Discussion of dental remains - The right M^3 permits discrimination between Tetraconodontine and Suinae subfamilies. Tetraconodontinae are distinguishable from the Suinae in that they have very thick enamel with shallow furrows. The thin enamel of BRS 25/3 excludes an attribution to Tetraconodontine.

The first upper incisor is a tooth with high systematic and phylogenetic value in Suidae. According to Van der Made (1990), I^1 linguo-labial diameter (DLL) and mesio-distal diameter (DMD) are crucial to separate main taxa within Suoidea. The diagrams proposed by Van der Made (1997b, fig.7) shows that the systematic significance of I^1 decrease in Dicoryphochoerini tribe. Therefore, on the basis of only the first upper incisor measurements it would be impossible to decide if the Brisighella species is referable to *Microstonyx* or to *Propotamochoerus*. However since it is believed that in Europe *Microstonyx* became extinct early in MN13, it is reasonable an attribution of the specimen BRS 25/1 to the genus *Propotamochoerus*.

The genus *Propotamochoerus* includes the following six species: *P. palaeochoerus* (Kaup, 1833), *P. wui* (Van der Made & Defen, 1994), *P. hysudricus* (Stehlin, 1899-1900), *P. hyotherioides* (Schlosser, 1903), *P. provincialis* (Gervais, 1859), *P*. sp. (Fortelius et al., 1996). On the basis of the I^1 morphology, Van der Made (1997b) suggests that the presence of a lower crown and a distal accessory cusplet (a character absent in the Brisighella sample), is typical of *P. palaeochoerus* (Kaup, 1833). By morphology and dimensions other species of *Propotamochoerus* have similar I^1, with a narrow linguo-labial diameter and long mesio-distal one (Van der Made et al., 1999). Our Fig. 2A shows that the Brisighella specimen BRS 25/1 belongs to an advanced form with long incisors [*P. paleochoerus* (Kaup, 1833) has been excluded from the comparison]. Other dental elements from Brisighella agree with an attribution to the genus *Propotamochoerus*, especially in their dimensions and proportions. Among Suinae *Hippopotamodon* and *Microstonyx* are characterised by large size, while *Chleuastochoerus*, *Molarochoerus* and *Eumaiochoerus* are smaller.

As mentioned above, the genus *Propotamochoerus* includes a number of species. Among them the Brisighella specimens correspond to the larger sized species. Bivariate plots (Fig. 2B) show the comparison between the Brisighella upper third molar and all species known for the genus *Propotamochoerus*. Here the BRS 25/3 M^3 fits in the range of variability of *Propotamochoerus provincialis* (Gervais, 1859), the largest species of the genus. The scatter diagram in Fig. 2C shows that the BRS lower second premolar fits within the range of variability of *P. hyotherioides* (Schlosser, 1903) and *P. provincialis* (Gervais, 1859).

Description and discussion of postcranial remains

Generally speaking, suids are non-cursorial, and no species within the family, with exception of *Nyanzachoerus devauxi* (McCrossin, 1987), has developed a cursorial

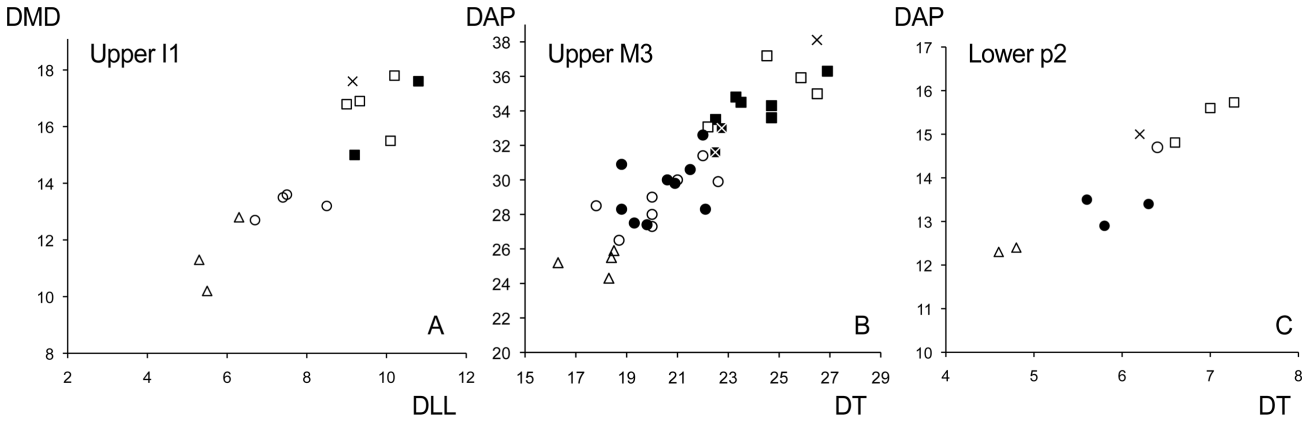

Fig. 2 - Brisighella specimens (*Propotamochoerus provincialis*) are compared with other *Propotamochoerus* species. A: DLL vs. DMD in I^1. B: DAP vs. DT in M^3. C: DAP vs. DT in P_2. Comparisons data from Hunermann (1968), Van der Made & Defen (1994), Van der Made et al. (1999) and Gallai (2006 and unpublished data). Legend: cross= Brisighella specimens; open triangle= *P. wui* (Van der Made & Defen, 1994); solid circle= *P. palaeochoerus* (Kaup, 1833); open circle= *P. hysudricus* (Stehlin, 1899-1900); solid square= *P. hyotherioides* (Schlosser, 1903); open square= *P. provincialis* (Gervais, 1859), slid square with cross= *P.* sp. from Baccinello V3.

adaptation to fast and long running. This implies that morphology of post-cranial elements is quite homogenous within primitive or derived taxa, with minor variations mainly related to differences in body mass (McCrossin, 1987; Van der Made, 1996).

Post-cranial remains of the genus *Propotamochoerus* are poorly known. Morphology and dimension of astragalus and metatarsus of *P. palaeochoerus* (Kaup, 1833) were described by Hunermann (1968), while information about metacarpal IV of *P. provincialis* (Gervais, 1859) were provided by Guerin et al. (1998). A first phalanx of pedal toe III or IV was tentatively attributed to *P. wui* Van der Made & Han Defen, 1994.

BRS 25/4. *Left astragalus* - This specimen is poorly preserved and is incomplete in the ventral part (Fig. 1H). Proximal and distal trochlea are easily recognizable and form, in the interior side, an angle of about 170 degrees. The sustentacular facet is not preserved. The Brisighella astragalus is small and comparable in shape with that of recent *Sus scrofa* Linnaeus, 1758. Table 1 shows a morphometrical comparison with *Propotamochoerus palaeochoerus* (Kaup, 1833) (data from Hunermann, 1968) and *Propotamochoerus provincialis* (Gervais, 1859) from Montpellier (MN 15, France; Faure & Guerin, 1982) and Venta del Moro (MN 13, Spain; Van der Made, 1997a). The specimen from Brisighella (possibly a young individual) is slightly smaller than both *P. palaeochoerus* (Kaup, 1833) and *P. provincialis* (Gervais, 1859).

Measurements: Lint=36.40; Lext=39.15; Lm=32.80; DTp=21.00; DTd=22.65.

BRS 1/3. *Right navicular* - The bone (Figs 1I-J) is transversely short and clearly preserves the proximal articular facets for the astragalus and cuneiform. This specimen is incomplete, lacking the tubercle located at the plantar extremity.

Measurements: DAP=32.25; DT=21.00; H=16.45; Ha=14.75.

BRS 1/4. *Left cuboid* - This bone (Figs 1K-L) is almost complete. Proximally, it bears the articular facet for the astragalus and calcaneum. On the lateral side, the groove for the tendon belonging to the peroneal muscle is not very developed (Fig. 1L). The distal parts are incomplete but in the anterior part they show the articular surface that articulates with the metatarsus. The cuboid is similar in morphology to that of recent *Sus scrofa* Linnaeus, 1758. We can observe that the Brisighella cuboid is very short in the anterior part, also having a lateral groove less developed when compared to extant *Sus scrofa* Linnaeus, 1758.

Measurements: DT=25.20; H=38.85; Ha=25.85; DAP=31.15.

BRS 25/12. *Left distal phalanx digit III or IV pedis* - Since the phalanx morphology of the genus *Propotamochoerus* seems to be comparable with that of

	P. palaeochoerus		*P. provincialis*					
	Eppelsheim	Wissberg	Brisighella	Montpellier			Venta del Moro	
Lint	43.90	47.30	36.40	42.40	42.70	40.40	46.10	46.10
Lext	49.90	51.80	39.15	46.00	43.50	42.45	51.40	50.90
DTp	25.60	28.40	21.00	23.60	24.20	23.80	25.10	27.80
DTd	26.00	29.20	22.65	28.10	26.90	25.10	29.40	29.50

Tab. 1 - Comparision between *Propotamochoerus provincialis* (Gervais, 1859) from Brisighella and *P. palaeochoerus* (Kaup, 1833) (data from Hunermann, 1968) and *P. provincialis* (Gervais, 1859) (G.G. unpublished data) from other European localities. See text for abbreviations.

the genus *Sus* (cfr. Kratochvil, 1973: fig. 9), the phalanx BRS 25/12 (Figs 1M-N) can be tentatively attributed to the left posterior III finger, because of its facet shape that articulates with the intermediate phalanx (Fig. 1N).

Interpretation of the Brisighella phalanx must be made cautiously. In the exhaustive study about recent wild and domestic forms of *Sus scrofa* Linnaeus, 1758 Kratochvil (1973) reported the difficulty to determine whether III or IV distal phalanx belongs to the hand or the foot. In addition, no comparative data are available for the distal phalanges of the genus *Propotamochoerus*. We observe major similarities in general morphology and in the angle between the articular surface and the plantar surface of the fossil with extant *Sus scrofa* Linnaeus, 1758.

Measurements: L= 31.00; DAP=20.65; DAPpf=15.20; DAPp=16.50; DAPps=21.75; DTp=13.95.

CONCLUSIONS

The Brisighella karst fissure fillings complex yielded very few Suidae remains (nine) from two sites, BRS 1 and BRS 25. These Suidae specimens are formally described and discussed. The degree of dental wear, closure of the root of the incisor in the dentition, as well as the relative dimension of post-cranial remains, reveal that at least two different individuals (a fully grown adult about 36-48 month in age, and a juvenile) are present in the sample from BRS 25.

On the basis of morphological and morphometrical comparisons we attribute the Brisighella sample to *Propotamochoerus provincialis* (Gervais, 1859), a species with a stratigraphic range from MN 13 (Spain, Van der Made, 1997a; Macedonia and Bulgaria, Geraads et al., 2008), to MN 15 (Montepellier in France, the type locality, Faure & Guerin, 1982; Ptolemais-Kardia in Greece, Van der Made & Moyà-Solà, 1989).

The description of the post-cranial remains from Brisighella adds new data about this taxon, and provides new evidence for an aspect of suid anatomy that is generally (and for *Propotamochoerus provincialis* in particular) disregarded in the paleontological literature.

The Italian Late Miocene fossil suid record, although relatively poor, contributes some to our knowledge of the peculiar paleobiogeographic evolution of the Italian peninsula. During Late Turolian (Late Miocene, MN 12 time equivalent), the endemic genus *Eumaiochoerus* is only known in Italy from the so-called V2 faunal assemblages of the Tusco-Sardinian bioprovince (Monte Bamboli in Tuscany and Fiume Santo in Sardinia; Rook et al., 1999, 2006; Bernor et al., 2001; Abbazzi et al., 2008).

The faunal turnover that occurred during the latest Miocene led to the extinction of all taxa typical of the Tusco-Sardinian area and was characterised by the dispersal (together with other European taxa characterising the latest Miocene Italian mammal assemblages) along the Italian peninsula of the genus *Propotamochoerus*. The latter is known from a few sites in Tuscany (Baccinello V3, Velona basin, Casino basin; Gallai, 2006) and from Gravitelli in Sicily (Gallai & Rook, 2006). The sample from Brisighella represents the northernmost record of the genus *Propotamochoerus* in Italy.

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