

Insectivores (Erinaceidae, Soricidae, Talpidae; Mammalia) from the Pliocene of Capo Mannu D1 (Mandriola, central-western Sardinia, Italy)

Marc Furió, Barcelona and Chiara Angelone, Roma

With 5 figures and 1 table

FURIÓ, M. & ANGELONE, C. (2010): Insectivores (Erinaceidae, Soricidae, Talpidae; Mammalia) from the Pliocene of Capo Mannu D1 (Mandriola, central-western Sardinia, Italy). – N. Jb. Geol. Paläont. Abh., **258**: 229–242; Stuttgart.

Abstract: Capo Mannu D1 (often cited as Mandriola) is a key site to reconstruct Sardinian Plio-Quaternary faunal evolution and origin. After 35 years of the discovery of the site, the insectivore component of the Capo Mannu D1 fauna has been studied resulting in the identification of *Parasorex depereti*, *Asoriculus gibberodon*, cf. Soricini indet. and *Talpa* cf. *minor*. *P. depereti* and cf. Soricini indet. are not present in younger Corso-Sardinian assemblages. On the other hand, *A. gibberodon* and *Talpa* cf. *minor* are the oldest known possible ancestors recorded so far of the Late Pliocene-Quaternary Corso-Sardinian endemic “*Nesiotites*” spp. and *Talpa tyrrhenica*. The insectivores from capo Mannu D1 are not affected by modifications due to the permanence in an insular domain and resemble MN14-15 insectivore assemblages of SW Europe. Their arrival in Sardinia may have occurred at the Early/Middle Pliocene boundary in concomitance with *R. azzarolii*, a murid from Capo Mannu D1 that appears very slightly modified with respect to its continental ancestors.

Key words: Insectivores, systematics, palaeobiogeography, Pliocene, Sardinia, Italy.

1. Introduction

The Neogene vertebrate palaeontological record of Sardinia is both scanty and poorly dated, constituting a challenge for a satisfactory reconstruction of the Sardinian Neogene palaeofauna and regional palaeobiogeography. In this respect the Capo Mannu D1 fossil vertebrate assemblage (central western Sardinia; Fig. 1) is of fundamental importance. Although often cited in literature as “Mandriola”, the site is here called Capo Mannu D1 following the denomination proposed by ABBAZZI et al. (2008) because it allows a more precise discrimination between the different faunal assemblages of the Capo Mannu peninsula.

The Capo Mannu D1 faunule was recovered in a clayey deposit interpreted as a damp or pond accu-

mulation at the base of the first dune unit (D1) of the Capo Mannu Formation dune complex (ABBAZZI et al. 2008 and references therein). For a long time its age has been matter of debate. On a biochronological basis, it was firstly estimated as Early Pliocene (Early Ruscinian, MN14) because of the supposed presence of the murid *Rhagapodemus hautimagnensis* (PECORINI et al. 1974). Later it was estimated as Early and/or Middle Pliocene based on non-marine molluscs (ESU 1986), as early Middle Pliocene based on regional stratigraphy data (CARBONI & LECCA 1995), and as close to the Early-Middle Pliocene boundary (MN15-MN16) because of the evolutionary degree of the murid *Rhagapodemus azzarolii* (formerly classified as *R. hautimagnensis*) (ANGELONE & KOTSAKIS 2001). Recent overviews of the Sardinian Plio-Pleistocene

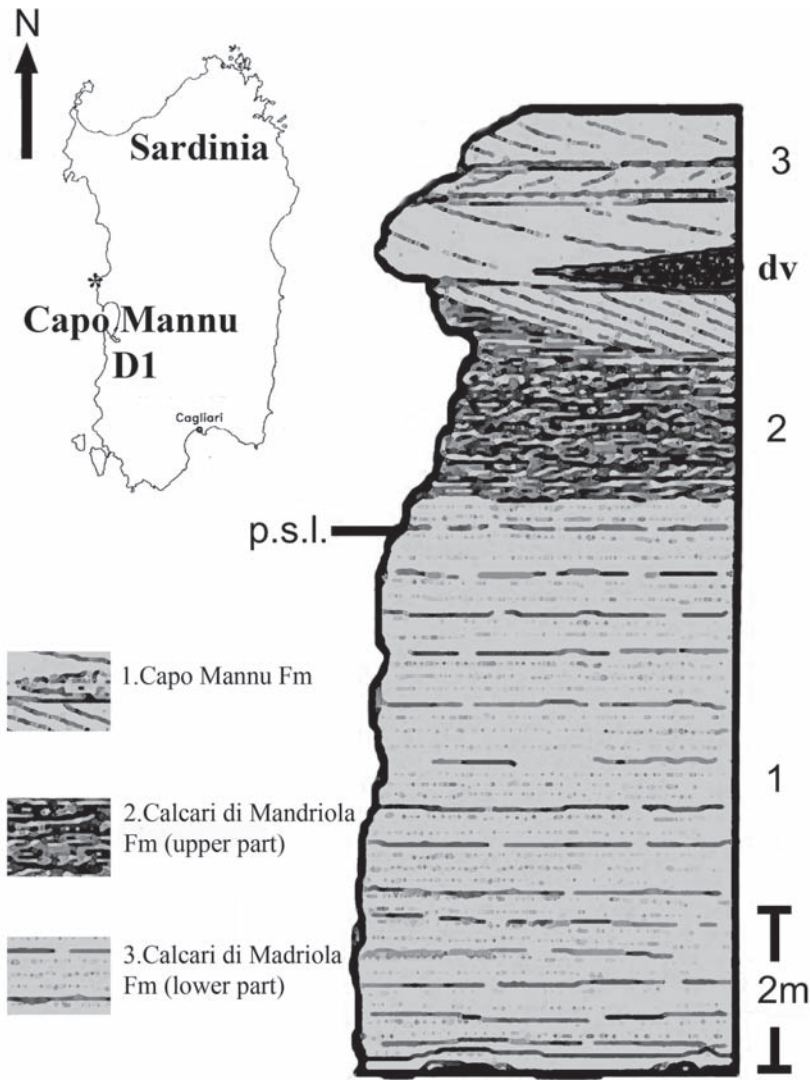


Fig. 1. Geographical localization of Capo Mannu D1 fossiliferous site (formerly known as Mandriola, central-western Sardinia, Italy) and stratigraphical position of the vertebrate deposit in the Capo Mannu D1 section (from CARBONI & LECCA 1995). 1. Capo Mannu Formation: cross-bedded aeolic sandstones; 2. Calcari di Mandriola Formation (upper part): laminated or cross-bedded calcarenites with levels and channels of sandstones and conglomerates; 3. Calcari di Mandriola Formation (lower part): calcarenites with quartzite sandstones levels; dv: vertebrate-bearing lens; p.s.l.: present sea level.

faunas and biochronology include the Capo Mannu D1 fauna in the “Mandriola” faunal subcomplex (?Early/Middle Pliocene) of the “*Nesogoral*” complex (PALOMBO 2006).

A preliminary taxonomy of the Capo Mannu D1 fossil assemblage and the description of a new murid species, exclusive of Capo Mannu D1 (*Apodemus mannu*) was published by PECORINI et al. (1974). Later some taxa were studied in detail: glirids (ZAMMIT

MAEMPEL & DE BRUIJN 1982), non-marine molluscs (ESU 1986), and another murid (ANGELONE & KOTSAKIS 2001).

The insectivores from Capo Mannu D1 needed a systematic revision. The aim of this paper is to study this material within the framework of published fossil insectivore data from Sardinia (BATE 1944, 1945; DE BRUIJN & RÜMKE 1974; ESU & KOTSAKIS 1979; GLIOZZI et al. 1984; ABBAZZI et al. 2004 and

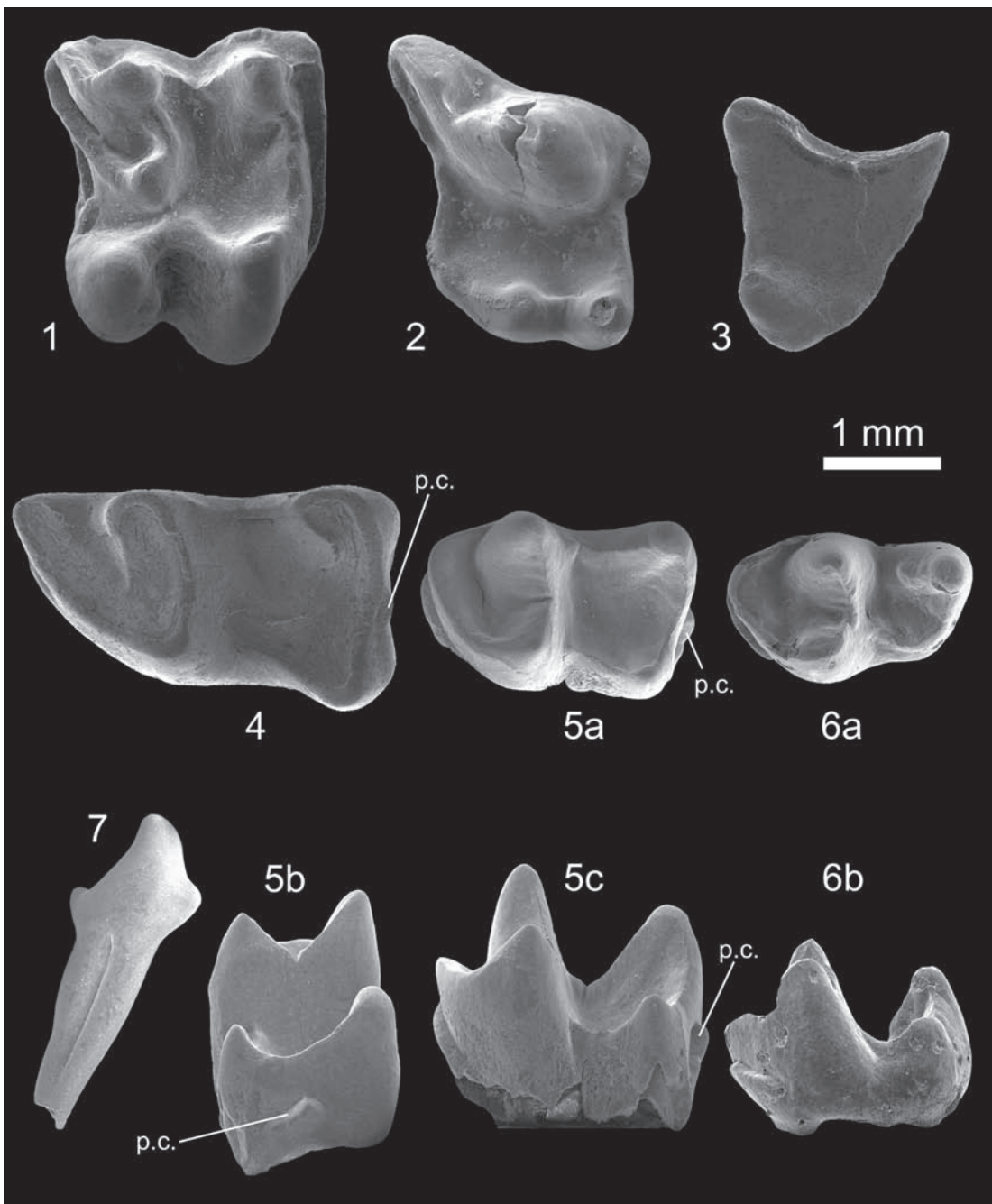


Fig. 2. *Parasorex depereti* from Capo Mannu D1. **1** – CPM53 right M2 (occl.); **2** – CPM48 right P4 (occl.); **3** – DSG/URT-053/40 left D3? (occl.); **4** – DSG/URT-053/42 left m1 (occl.); **5** – CPM41 left m2 (a- occl.; b- post.; c- lab.); **6** – CPM46 left m3 (a- occl.; b- lab.); **7** – CPM40 right p2 (lab.) (p.c. - posterior cingulum).

PALOMBO 2006 both with references therein), in order to extend the current knowledge of Sardinian palaeobiodiversity and palaeobiogeography.

2. Material and methods

The examined material was collected in the early '80ies of the last century during two campaigns, one led by

Table 1. Measurements of *Parasorex depereti* *Asoriculus gibberodon*, cf. *Soricini* indet. and *Talpa* cf. *minor* from Capo Mannu D1. L: length; LT: length of the I1 talon; BL: buccal length; LL: lingual length; PE: posterior emargination; H: height; W: width; AW: anterior width; TRW: trigonid width; TAW: talonid width (in mm) (from REUMER 1984, MEIN & MARTÍN-SUÁREZ 1994, and FURIÓ 2007).

<i>Parasorex depereti</i>			
	N inv.	L	W
P4	CPM48	3.00	2.44
M2	CPM52	2.35	2.70
	CPM53	2.78	3.26
m1	DSG/URT-053/42	3.37	1.97
	CPM41	2.65	1.78
m3	CPM44	2.26	1.40
	CPM46	2.32	1.44
	CPM47	2.33	1.48

<i>Asoriculus gibberodon</i>									
	N inv.	L	LT	BL	W	AW	TRW	TAW	H
I1	CPM01	1.76	0.59						1.32
M1	CPM04			1.64		1.75			
M3	CPM06	0.75			1.37				
m1	CPM07	1.62					0.95	0.99	
	CPM10	1.56					0.88	1.00	
m2	CPM08	1.58					0.83	0.87	
	CPM09	1.50					0.91	0.96	
	CPM11	1.49					0.91	0.92	
m3	CPM13	1.24			0.67				
	CPM14				0.70				

cf. *Soricini* indet.

	N inv.	L	BL	LL	PE	W	PW
P4	DSG/URT-053/50		1.51	1.10	1.00	1.33	
	CPM02		1.42				
M1	CPM03		1.35	1.46	0.99		1.78
M2	CPM05			1.23	0.94		
M3	DSG/URT-053/51	0.76					1.13

Talpa cf. *minor*

	N inv.	L	H	W
C	CPM28	0.83	0.54	
M3	CPM27	1.43		2.03
p4	CPM29	1.08		0.50

T. KOTSAKIS with a team of “La Sapienza” University of Rome and one led by PAUL SONDAAR from Utrecht University (T. Kotsakis, pers. com.). The samples are housed in the Laboratory of Vertebrate Palaeontology, Geological Department, Roma Tre University (inventory number prefix DSG/URT) and in the Department of Earth Sciences of Utrecht University (IVAU) (herein preliminarily referred with the inventory number prefix CPM). Given the double origin of the fossil material it is possible that it was sampled from different parts of the same level. However, the minimal differences between the insectivore faunal contents of both collections and the lack of evidences of a taphonomic mixing, justify their taxonomical treatment as a whole.

The nomenclature and the measurements used in this paper follow REUMER (1984) for the soricid remains, MEIN & MARTÍN-SUÁREZ (1994) for the erinaceid teeth and FURIÓ (2007) for the talpid teeth.

3. Systematics

- Order Erinaceomorpha GREGORY, 1910
- Family Erinaceidae FISCHER VON WALDHEIM, 1817
- Subfamily Galericinae POMEL, 1848
- Tribe Galericipini POMEL, 1848
- Genus *Parasorex* VON MEYER, 1865

Parasorex depereti CROCHET, 1986
Fig. 2.1-2.7

Material: D3?: DSG/URT-053/40; P4: CPM48; CPM49 (fragment), CPM50 (fragment); M2: DSG/URT-053/41 (fragment); CPM51, CPM52, CPM53; Mandible: CPM54 (teeth-less fragment); p2: CPM40; m1: DSG/URT-053/42; m2: CPM41, DSG/URT-053/43; m3: DSG/URT-053/44, CPM44, CPM45, CPM46, CPM47; m: DSG/URT-053/45, DSG/URT-053/46, DSG/URT-053/47, ?DSG/URT-053/48, ?DSG/URT-053/49; Isolated m trigonids: CPM42, CPM43. For measurements see Tab. 1.

Description and comparison. – D3? (Fig. 2.3): The occlusal outline is almost triangular, with a rounded lingual corner. The paracone is high, vertical, and occupies the anterolabial corner of the tooth. There is a continuous posterior crest connecting the paracone to the posterolabial corner. The protocone is low and isolated from any other cusp. There is no hypocone. There is no anterolabial cuspule (parastyle) either, but in its place, surrounding the base of the paracone, there is a slight bulge of the occlusal contour. There are three roots, each one of them being placed under one of the three corners. The lingual root is somewhat thicker than the labial one, but it is difficult to

ensure it in the case of the posterolabial one because it is partially broken in the only specimen available.

P4 (Fig. 2.2): The lingual part bears two cusps, the protocone and the hypocone. The hypocone is placed quite anteriorly, near the protocone, occupying an intermediate position at the lingual border of the tooth. The parastyle is reduced and it does not connect with the paracone. The posterior crest of the paracone is notched at its middle point. There is a thin cingulum covering the posterior border of the tooth.

M2 (Fig. 2.1): DSG/URT-053/41 is a posterolingual fragment, which partially preserves the protocone and the metacone. The protocone is connected to the hypocone by a continuous ridge. The metaconule does not connect with these lingual cusps due to the presence of an intermediate valley. The metaconule is moon-shaped, and its anterior arm ends close to the base of the metacone-mesostyle connection. The distal end of the posterior arm of the metaconule is not completely preserved, but its orientation points towards the posterolabial corner of the tooth. Nor the lingual, neither the posterior margin of the molar shows any cingulum. CPM52 and CPM53 show rather squared occlusal outlines. In these specimens, the posterior arm of the metaconule reaches the posterolabial corner of the tooth, interrupting the posterior cingulum. The metaconule is not connected to the protocone in two of the three specimens. In CPM51 the connection is formed by means of a faint and short crest. The mesostyle is completely divided, without an inflexion, usually present in other Miocene Galericipini.

p2 (Fig. 2.7): The root is tilted respect to the base of the crown. The root shows an intermediate groove like separating two formerly independent ones. The crown bears three cusps in line, a small one in each extreme, anterior and posterior, and a main one well-elevated between both.

m1 (Fig. 2.4): The talonid is slightly wider than the trigonid. The metaconid and the protoconid are the highest cusps, both reaching similar heights. The paralophid does not show any strong inflexion, but is connected to the protoconid and the paraconid with a constant curvature. The talonid basin is not completely open. The entoconid is very high. The posterior margin of the tooth is relatively straight, showing a relict of a cingulum which slightly protrudes from the outline in occlusal view. The oblique crest reaches the posterior face of the trigonid at a position half the protoconid height. There are no cingula surrounding the base of the tooth.

m2 (Fig. 2.5): The talonid is longer than the trigonid, but they have a similar width. The trigonid is triangular-shaped and the talonid relatively squared. The entoconid is the highest cusp of the talonid. A small cingulum is present on the posterior face of CPM41. There are no other cingula present. These teeth are smaller than the m1.

m3 (Fig. 2.6): DSG/URT-053/44 is extremely worn. The lingual margin of the tooth is bent at the trigonid-talonid junction, thus providing a “bean-like” aspect to the tooth. The talonid is shorter and narrower than the trigonid. The enamel is only preserved around the trigonid and the talonid external surfaces (i.e. labial and lingual faces), while on the

whole internal area of the tooth the strong wear has made the dentine to crop out everywhere. A buccal cingulum seems to have been present in the anterolabial side of the tooth. CPM44, CPM45, CPM46, CPM47 all have broad and rounded trigonid occlusal contours. The metaconid is the highest cusp of the tooth. The entoconid is much higher than the hypoconid and occupies a more posterior position. Only a thin relict labial cingulum covers the base of the tooth under the paralophid.

Remarks: The presence of a moon-shaped metaconule on M2 indicates that this erinaceid belongs to the tribe Galericipini. The absence of a connection between the metaconule and the protocone, the presence of a connection between the protocone and the hypocone, and the posterior arm of the metaconule reaching the posterolabial corner of the tooth, indicate that these remains belong to the genus *Parasorex*. The rather quadratic outline of the M2, with the paracone more anteriorly placed than the protocone and non-inflexed mesostyle, added to the absence of the labial cingula in m1 and m2 other than relict short-and-low posterior ones under the hypolophids, support their ascription to *P. depereti*. There are, however, some slight differences between *P. depereti* from Capo Mannu D1 and the remains from southern France detailed by CROCHET (1986). In relation to the size of the teeth, some of the Sardinian specimens are up to a 10% smaller than the average of type material. Moreover, the specimens from Capo Mannu D1 show no trace of labial cingula in m1 and m2, and only a hint of the labial cingulum is present at the base of the trigonid of m3. According to MEIN & MARTÍN-SUÁREZ (1994) the labial cingulum in the talonid is an apomorphic character present in the oldest species of the genus (*P. socialis*) but missing in its supposed descendants *P. ibericus* and *P. depereti*. If this assumption is correct, the absence of labial cingula in the lower molars from Capo Mannu D1 (not even in the trigonid) should be interpreted as a derived character, since no other species of the genus *Parasorex* shows a similar degree of reduction.

A problematic element, herein preliminary referred as a deciduous third upper premolar, is very interesting. Its general morphology and dimensions exclude an assignment to soricids or talpids, the other insectivores present in Capo Mannu D1, and thus this tooth is allocated to *P. depereti*. In the original description of the species CROCHET (1986) made reference to a similar enigmatic element. Describing this tooth, identified as a possible D3 or D4, the author highlighted the fact of having just one cusp on the lingual flange. Unfortunately there were no more characters detailed in the description and the tooth was not figured. If the equivalence with the Sardinian element could be confirmed, this observation would reinforce the specific ascription of the material. In that case, such a rare character in *Parasorex* should be added to the diagnosis of the species.

Order Soricomorpha GREGORY, 1910

Family Soricidae FISCHER VON WALDHEIM, 1817

Subfamily Soricinae FISCHER VON WALDHEIM, 1817

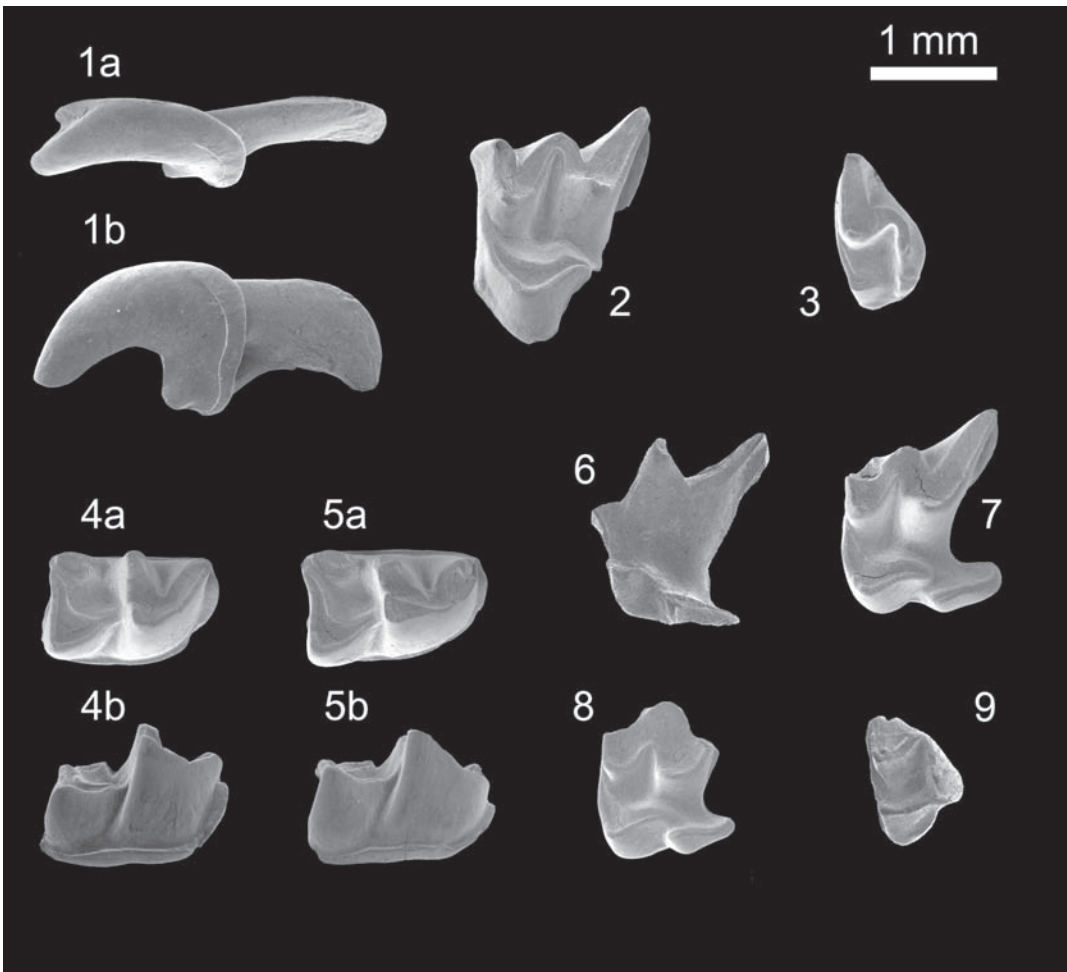


Fig. 3. *Asoriculus gibberodon* from Capo Mannu D1. **1** – CPM01 left I1 (a- dors.; b- lab.); **2** – CPM04 left M1 (occl.); **3** – CPM06 left M3 (occl.); **4** – CPM11 right m2 (a- occl.; b- lab.); **5** – CPM07 (a- occl.; b- lab.). cf. Soricini indet from Capo Mannu D1. **6** – DSG/URT-053/50 left P4 (occl.); **7** – CPM03 left M1 (occl.); **8** – CPM05 left M2 (occl.); **9** – DSG/URT-053/51 left M3 (occl.).

Tribe Nectogalini ANDERSON, 1879

Genus *Asoriculus* KRETZOI, 1959

Asoriculus gibberodon (PETENYI, 1864)

Fig. 3.1-3.5

Material: I1: CPM01; M1: CPM04; M3: CPM06; m1: CPM07, CPM10; m2: CPM08, CPM09, CPM11. For measurements see Tab. 1.

Description and comparison. – I1 (Fig. 3.1): The crown is antero-posteriorly curved, slightly fissident due to the addition of a secondary cusp situated medially from the apex. In dorsal view, the root and the crown are positioned in a straight line. There is a wide and well-defined cingulum covering the labial base of the crown.

M1 (Fig. 3.2): The only element recovered does not preserve the hypoconal flange, and therefore it is impossible to inspect whether the hypocone is isolated or connected to the posterior ridge (i.e., morphotype “A” or “B” in REUMER 1984).

M3 (Fig. 3.3): It is rather short compared to its width, and it is triangular in occlusal view with a convex posterior margin. There is a small cusp posteriorly to the protocone and lingually to the metacone.

m1-2 (Fig. 3.4-3.5): These elements have a stout appearance. In the worn parts it becomes evident that the enamel is somewhat thicker than in the other forms. Wear strongly affects the entoconid crests, with the dentine cropping out in form of a tear at the lingual side of the talonid basin.

Remarks: Unfortunately no posterior parts of soricid mandibles were recovered. Therefore, it is not possible to observe the shape of the articular condyle, a major feature in the recognition of soricid taxa. No trace of the original pigmentation is present in any tooth, but the proportions between length and width of the upper teeth exclude the ascription to Crocidurinae or Crocidosoricinae. The dimensions of the m1 and m2 and the presence of well-developed entoconid crests exclude an ascription to the Allo-soricinae. The general size of the dental elements, between medium and small, discards their ascription to Beremendiini, to Anousoricini and to *Blarinoides*, which is the most frequent genus of Blarinini in Europe. The possibility of being another of the European Blarinini is rather small, since *Mafia* and *Sulimskia* are unfrequent taxa hitherto only reported from eastern European sites and they lack entoconid crests. The species from Capo Mannu D1 does not belong to Blarinellini because the upper teeth have pronounced posterior emarginations. Thus, only the options of belonging to the Nectogalini or to the Soricini cannot be refused. Within all the candidates of these two groups, the shape of the I1 and the M3, the presence of high entoconid crests, and the rather stout aspect of the lower molars of the specimens from Capo Mannu D1 indicate that they belong to *Asoriculus*.

The oldest occurrences of *Asoriculus* probably coincide with the Messinian Salinity Crisis (FURIÓ 2003, 2007) and the most recent ones date to the Early Pleistocene. *Asoriculus* was a common and widely spread genus of Nectogalini in the peri-Mediterranean area during all the Pliocene (continental Europe: REUMER 1984; RZEBIK-KOWALSKA 1998; ROFES & CUENCA-BESCÓS 2006); North Africa: RZEBIK-KOWALSKA 1988; GERAADS 1995), and present with endemic insular descendants in Mediterranean islands during Plio-Quaternary (among others BATE 1944; PONS-MOYÀ & MOYÀ-SOLÀ 1980; REUMER 1980; ABBAZZI et al. 2004). Some of these insular species have been often grouped into the genus *Nesiotites*, but the use of this generic name in Italian islands has been questioned (KOTSAKIS 1980; FANFANI 2000; MASINI & SARÀ 1998). For this reason we will refer to the Quaternary Sardinian endemic soricids as “*Nesiotites*”, also due to their complex, still unsolved specific taxonomy (ABBAZZI et al. 2004). *Asoriculus* from Capo Mannu D1 differs from these endemic insular species by its slightly smaller size. A mandibular remain of *Asoriculus* was reported from the Middle Pliocene locality of Nuraghe su Casteddu (quoted as *Episoriculus* aff. *gibberodon* in ESU & KOTSAKIS 1979), but no direct comparison is possible as no teeth have been reported from this site.

Indeed, among the peri-Mediterranean Pliocene species of *Asoriculus*, the morpho-dimensional features of the specimens from Capo Mannu D1 correspond to *A. gibberodon*. (e.g., the posterior margin of the M3 occlusal outline straighter than in *A. burgioi*, the lower molars smaller than those of *A. thenii*, and the buccal cingulum of the m1 less wavy than in *A. maghrebiensis*). *A. gibberodon* from Capo Mannu D1 is completely different from the soricid from the Early Miocene of Oschiri (*Crocidosorex antiquus*; DE BRUIJN & RÜMKE 1974; it is worth to notice that also this soricid shows no trace of endemic insular morpho-dimensional modifications).

Tribe Soricini FISCHER VON WALDHEIM, 1817

cf. Soricini indet.

Fig. 3.6-3.9

Material: P4: DSG/URT-053/50; M1: CPM03; M2: CPM05; M3: DSG/URT-053/51. For measurements see Tab. 1.

Description and comparison. – P4 (Fig. 3.6): The general appearance of the tooth is rather slender, without any bulbous cusp. The paracone is conical and connects with the highest point of the tooth at the posterolabial corner by means of a “V-shaped” crest. The parastyle is small and there is no parastilar crest present. The protocone is not connected to any other cusp. The hypocone is placed much anteriorly, determining the outline of the lingual margin, at a position halfway of the total length. The hypoconal flange is not very large. The posterior emargination is somewhat pronounced. There is no cingulum covering the posterior margin or the hypoconal flange.

M1-2 (Fig. 3.7-3.8): The ectoloph is very asymmetric in M1. The posterior emargination is quite pronounced. The protocone and the hypocone are not connected. The hypocone lies in the most anterior part of a ridge which covers the lingual side of the hypoconal flange.

M3 (Fig. 3.9): The outline is triangular in occlusal view. The ectoloph is continuous. It extends from a small parastyle to a non-reduced metacone. The metacone and the paracone are of similar size. The mesostyle is undivided. The protocone is not as high as the other two main cusps. The protocone extends anteriorly at the labial margin to form a cingulum, and posteriorly until the base of the metacone acquiring the form of a single crest. The central basin is thus completely closed.

Remarks: The dental remains of cf. Soricini indet. from Capo Mannu D1 have a rather small size, a M3 slightly longer but less wide than that of *Asoriculus*, and a P4 with more faint crests and cusps than this species. The generic and specific ascription is difficult in the absence of unequivocal diagnostic characters. Thus, these teeth are tentatively ascribed to the tribe Soricini, and could probably belong to a species of *Sorex*. According to the data compiled by RZEBIK-KOWALSKA (1998), the first occurrences of this genus in Europe date back to the Early Pliocene, being represented by small forms like *S. bor*, *S. casimiri*, *S. minutus* and *S. subminutus*, or resembling (aff./cf.) ones.

Family Talpidae FISCHER VON WALDHEIM, 1817

Subfamily Talpinae FISCHER VON WALDHEIM, 1817

Tribe Talpini FISCHER VON WALDHEIM, 1817

Genus *Talpa* LINNAEUS, 1758

Talpa cf. *minor* (FREUDENBERG, 1914)

Fig. 4.1-4.6

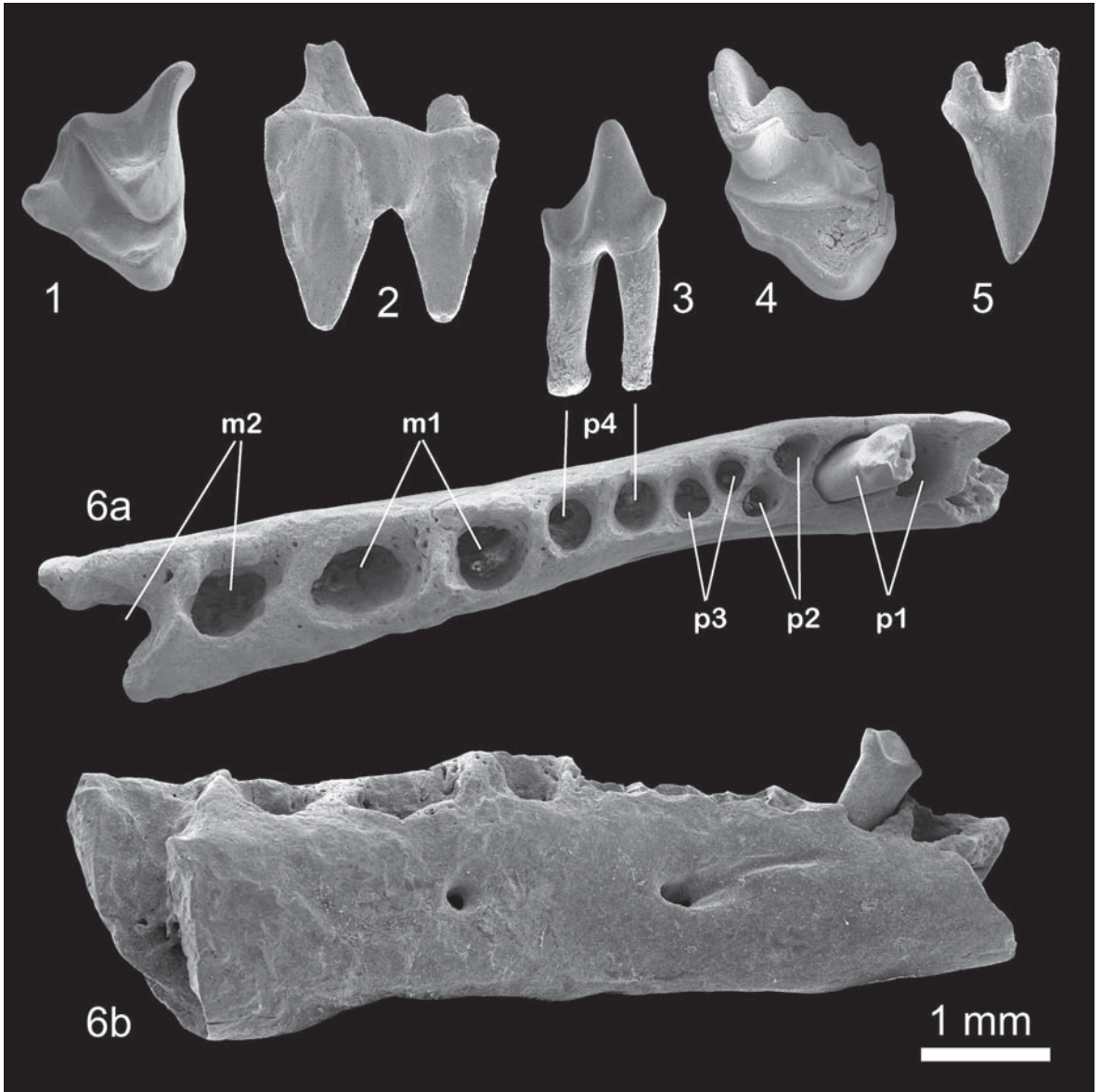


Fig. 4. *Talpa cf. minor* from Capo Mannu D1. **1** – CPM27 right M3 (occl.); **2** – DSG/URT-053/52 fragment of right M2 (lab.); **3** – CPM29 right p4 (lab.); **4** – CPM26 partial right M1 (occl.); **5** – CPM28 right C (lab.); **6** – CPM30 edentulous fragment of right hemimandible (a- occl.; b- lab.).

Material: C: CPM28; M1: CPM26 (fragment); M2: DSG/URT-053/52; M3: CPM27; Mandible: CPM30 (fragment); p4: CPM29. For measurements see Tab. 1.

Description and comparison. – C (Fig. 4.5): It is labio-lingually compressed, and has a posterior cutting shearing blade. It is double-rooted with diverging roots.

M1 (Fig. 4.4): The only specimen available is too worn and partially broken, so it does not provide relevant information about the species.

M2 (Fig. 4.2): Only the labial side of the tooth is preserved. The metacone is the highest cusp, although there is not a noticeable difference in height compared to the other labial cusps. The ectoloph is a bit asymmetrical by having longer metacrista than postmesocrista, and shorter paracrista than paramesocrista. The parastyle is only slightly curved, and the metastyle is completely straight. The mesostyle is not completely divided, but a small interruption of the mesocrista can be discerned in its position. The anterior and the posterior margins are both rather concave.

M3 (Fig. 4.1): This tooth has a triangular-shaped outline. The parastyle is somewhat curved anteriorly. A small interruption of the mesostyle is discernible, but the wear of the paramesocrest and the postmesocrest in the only specimen available makes this observation difficult. The anterior arm of the protocone is connected to the anterior position of the base of the paracone. The posterior arm of the protocone is longer than the anterior one.

p4 (Fig. 4.3): It is double-rooted, with faintly divergent roots. There is a crest connecting the main central cusp with the middle point of the posterior cingulum.

Mandible (Fig. 4.6): The part of horizontal ramus preserved includes the alveoli from the posterior root of the m2 to the one of the lower “incisor-like” canine. The alveoli corresponding to the premolars are quite close to one another, not leaving space between the teeth. The posterior root of the “canine-like” p1 is preserved. The p4 recovered perfectly fits with its corresponding alveoli, thus allowing the ascription of the alveoli to the roots of the p3 and the p2. Attending to the exposure of the corresponding alveoli, the double-rooted p2 acquires a transverse position. The p2 appears to have been compressed between the p3 and the p1, due to a reduction of the space available between adjacent teeth. There are two mental foramina discernible. The posterior one is placed between the two roots of the m1. The anterior one is slightly larger and elongated, continues anteriorly as a longitudinal groove, and is placed under the anterior root of the p4.

Remarks: The talpid remains from Capo Mannu D1 are completely different from the endemic Sardinian moles *Nuragha schreuderai* and “*Geotrypus*” *oschiriensis* from the Lower Miocene of Oschiri (DE BRUIJN & RÜMKE 1974; the generic allocation of “*Geotrypus*” from Oschiri has been questioned by ZIEGLER 1999). Instead, the morphology of the upper molars and the shape of the fourth lower premolar allow their attribution to the genus *Talpa*. The specific ascription is more complicated due to the scarcity of material available.

Dealing with Sardinian material, it must be considered the possibility that these elements might belong to the insular species *T. tyrrhenica*. Judging by the original diagnosis of BATE (1945) two characters could support such ascription. The first one is the oblique alignment of the p2 and the p3 to the lower tooth row, as can be deduced by the four alveoli posterior to the caniniform p1 (Fig. 4.6a). The second one is the size, which is clearly smaller than that of recent *T. europaea*.

However, other characters specified in the diagnosis of *T. tyrrhenica*, like the robust teeth and the high-crowned molars have not been observed in the teeth from Capo Mannu D1. We find these two characters sufficient to reject the specific ascription of *Talpa* from Capo Mannu D1 to *T. tyrrhenica*.

In general, comparisons with the Corso-Sardinian Plio-Pleistocene talpids *Talpa* sp. and *T. tyrrhenica* are difficult (PALOMBO 2006, and references therein). Actually, no data about single teeth dimensions are available in literature. Moreover, the only available pictures of dental occlusal

surface of *T. tyrrhenica* are the sketchy drawings in BATE (1945), who formalized this species already introduced by MAJOR probably soon after 1880, and cited by LYDEKKER (1887), PASSEMARD (1925), VAUFREY (1929) and TOBIEN (1935). In last term, difficulties in specific determinations are probably enhanced by the continuous delay to update the taxonomy of the European fossil moles already encouraged by DOUKAS et al. (1995) and VAN CLEEF-RODERS & VAN DEN HOEK OSTENDE (2001).

One thing that can be absolutely ascertained is that the size of the elements of *Talpa* from Capo Mannu fits quite well those of *T. minor*. Among all the Plio-Pleistocene species of the genus, *T. minor* is the only one in which size can be considered a definitive character to separate it from the other species (REUMER 1995, 1996; REUMER & HORDIJK 1999; RZEBIK-KOWALSKA 2000). This small form of *Talpa* has been widely documented in Plio-Pleistocene SW and central European localities (KOWALSKI 1956; CROCHET 1986; MEIN et al. 1990; REUMER 1995, 1996; REUMER & HORDIJK 1999; RZEBIK-KOWALSKA 2000; VAN CLEEF-RODERS & VAN DEN HOEK OSTENDE 2001; AGUILAR et al. 2002; FURIÓ 2007). Looking for details of *T. minor* from other localities to compare with, we found in the material from Hundsheim (RABEDER 1972: tab. 2; Fig. 2c) a less accentuated compression between p1 and p4, but indeed present. This trait could reinforce our ascription to the same species, but due to the lack of any other unequivocal/diagnostical one, we have preferred to leave the specific identification of the Capo Mannu D1 talpid teeth as *Talpa* cf. *minor*.

Finally, we must notice that we are conscious of the existing reservations about the validity of *T. minor* by considering it as a possible junior synonym of *T. caeca* (see VAN CLEEF-RODERS & VAN DEN HOEK OSTENDE 2001 and HUTTERER 2005 for details), but accepting or refusing this supposed equivalence is beyond the scope of this work.

4. Discussion

4.1. Advances in systematics and palaeobiodiversity

In the preliminary report of the Capo Mannu D1 fauna PECORINI et al. (1974) identified a talpid and an erinaceid (this latter in their opinion, pertaining to a genus unknown in Europe). Such systematic attribution was reported in all the following overviews about Sardinian Neogene vertebrates (PALOMBO 2006, and references therein). The present revision allowed to identify at the species level the talpid and the erinaceid (*Talpa* cf. *minor* and *Parasorex depereti*), noticing that the identified taxa are almost identical to European ones (contradicting PECORINI et al. 1974).

Moreover, two additional taxa have been recognized in the present revision (*Asoriculus gibberodon* and cf. *Soricini* indet.), that represent the oldest record of Pliocene soricids in Sardinia.

4.2. Relationships with other Sardinian insectivores

Capo Mannu D1 insectivores are completely different from, and have no relationship with the Early Miocene taxa from Oschiri (DE BRUIJN & RÜMKE 1974; VAN DER MADE 2008). On the other hand, it is quite likely that two of them (*Talpa* cf. *minor* and *Asoriculus gibberodon*) could be the ancestors of later Sardinian insectivore taxa as those from the Middle Pliocene locality Nuraghe su Casteddu (*Talpa* sp. and “*Episoriculus* aff. *gibberodon*”; ESU & KOTSAKIS 1979), and the Corso-Sardinian *Talpa tyrrhenica* and “*Nesiotites*” spp. (Late Pliocene-Quaternary; PALOMBO 2006, and references therein). However, morpho-dimensional evidences are not sufficient to demonstrate such hypothesis, as the literature on the subject is too lacunose and in the case of “*Nesiotites*” there are unsolved taxonomic questions (ABBAZZI et al. 2004).

Parasorex depereti and cf. *Soricini* indet. seem to have disappeared from younger Sardinian assemblages. The disappearance of *Parasorex* is interesting as in another Mediterranean insular environment a member of the Galericiini – probably a descendant of *Parasorex* according to VAN DEN HOEK OSTENDE (2001), but see MAZZA & RUSTIONI (2008) – became the largest insectivore ever lived (*Deinogalerix* spp., Abruzzo-Apulian palaeobioprovince, namely Early Tortonian of Scontrone and ?MN13-14 of Gargano palaeoarchipelago, SE Italy; FREUDENTHAL 1972; BUTLER 1980; VAN DEN HOEK OSTENDE 2001 and references therein; MAZZA & RUSTIONI 2008).

4.3. Insularity

The species identified in Capo Mannu D1 do not show any of the expected morpho-dimensional modifications as result of the permanence under insular environments, which indeed are still to be modeled in insectivores. Other micromammals of Capo Mannu D1 show morpho-dimensional modifications due to “insularity effect” at different stages: incipient as in *Rhagapodemus azzarolii*, more marked as in *Apodemus mannu* (ANGELONE & KOTSAKIS 2001).

The absence of morphological and dimensional modifications due to insular conditions in the insectivores from Capo Mannu D1 allow formulating the following hypotheses:

1) For some unknown reason the insectivores from Capo Mannu D1 (that may have colonized the island in one single migrational event or in several not coeval

migrational events) did not undergo the “island rule”;

2) Such taxa arrived to the island in one colonization event, slightly before the accumulation of Capo Mannu D1 sediments and did not have the time to undergo the “destiny” of insular endemic micromammals.

As there is no evidence of taphonomic mixing, the last hypothesis is the most parsimonious explanation of the peculiar characteristics of the Capo Mannu D1 insectivores, also fitting with the framework suggested by *R. azzarolii* (ANGELONE & KOTSAKIS 2001). A similar case study is reported for the Oschiri fauna (DE BRUIJN & RÜMKE 1974): some taxa were practically unchanged compared to mainland species (see VAN DER MADE 2008 for further details).

4.4. Temporal range and source of the Capo Mannu D1 insectivore assemblage

The temporal distribution in continental Europe and Italy of the species present in Capo Mannu D1 is summarized in the following lines (see also Fig. 5).

According to VAN DEN HOEK OSTENDE (2001) *Parasorex depereti* is temporally restricted to the Early Pliocene (MN14-MN15, Ruscianian) of southern France and Spain. However, the species was also quoted in the faunal list of the evaporitic Messinian locality of Brisighella (central Italy; FANFANI 2000). The only other record of *P. depereti* in continental Italy is in the earliest Pliocene (MN14) of Borro Strolla (central western Italy; ABBAZZI et al. 2008).

The oldest European record of *A. gibberodon* is at the Mio/Pliocene boundary (Maramena, Greece; DOUKAS et al. 1995). The fossil record of *Asoriculus* in Italy is sparse and uncertain. The original quotation of *A. aff. gibberodon* for Brisighella in DE GIULI (1989) was refused by FANFANI (2000) who changed the ascription of such remains to *Neomysorex*. The oldest record of continental Italy thus corresponds to cf. *A. gibberodon* from the Middle Pliocene (MN16a) of Arondelli (NW Italy), but the taxonomic ascription was not adequately supported by pictures or detailed descriptions in the original paper (BERZI et al. 1967). Thus, the oldest doubtless report of *A. gibberodon* in continental Italy comes from the Late Pliocene (MN17) of Rivoli Veronese (FANFANI & MASINI 1998).

Talpa minor is known since MN14 to the beginning of the Middle Pleistocene of Europe (RZEBIK-KOWALSKA 2000; FURIÓ 2007). In continental Italy the oldest known record of *Talpa* is from Arondelli (NW

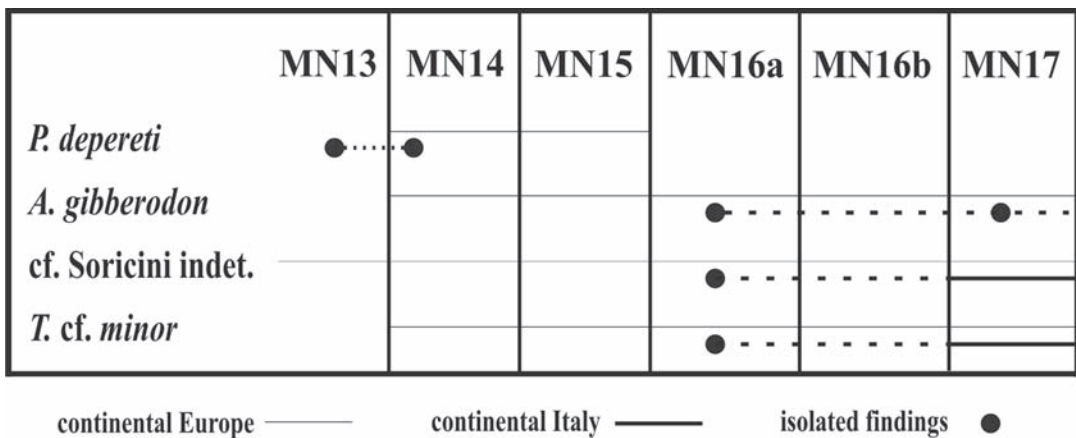


Fig. 5. Messinian-Pliocene distribution in continental Europe and Italy of the insectivore species present in Capo Mannu D1 (in the case of *T. cf. minor* and cf. *Soricini* indet., the continental data correspond to *T. minor* and tribe *Soricini*). The Italian record is biased by the extreme scantiness of Early and Middle Pliocene fossil sites.

Italy, Middle Pliocene, MN16a; BERZI et al. 1967) where it was classified as *T. minor* or *T. fossilis*. Unfortunately, as in the case of *Asoriculus*, there is no iconographic section and the description is missing in the original paper. No other presence of *Talpa* is recorded in continental Italy until Late Pliocene, again in Rivoli Veronese where *Talpa* sp. and *T. minor-caeca* coexist (FANFANI 2000).

In Arondelli may be also recorded the first occurrence of tribe *Soricini* in continental Italy, with a probable new species of *Sorex* (BERZI et al. 1967; KOTSAKIS et al. 2003 and references therein). Also in this case iconography and morphological descriptions are missing, and the following continental Italian record of a *Soricini* is in Rivoli Veronese (KOTSAKIS et al. 2003 and references therein).

Then, the age of the Capo Mannu D1 assemblage can not be older than MN13-MN14 boundary (first appearance of *A. gibberodon*) and younger than MN15-MN16 boundary (last report of *P. depereti*) (Fig. 5). As the arrival of the insectivores of Capo Mannu D1 is very likely to have been a single event (see previous section “Insularity”), we do not agree with VAN DER MADE (1999) who considers the Messinian as the moment in which the lineage of *T. tyrrhenica* entered in Corso-Sardinia. A more suitable moment for this colonization could be the Early/Middle Pliocene regression. In this case the studied insectivores entered Sardinia together with *Rhagapodemus azzarolii*. Actually *R. azzarolii* shows only minor modifications if compared to its continental

ancestor (ANGELONE & KOTSAKIS 2001), and considering that murids are supposed to be a quite tachytelic group if compared to insectivores, it is quite likely that they could have migrated at the same time.

As for the continental source area of the Capo Mannu D1 insectivores, it has to be sought in SW Europe. Indeed, continental Italy could be a very probable source area as, in case of sea level low stands, a land- or filterbridge is likely to connect the Italian and Corso-Sardinia bioprovinces. An emerged connection with mainland (filterbridge or landbridge) should be invoked to justify at least the presence of *Talpa*.

5. Conclusions

The locality of Capo Mannu D1 (formerly known as Mandriola) is a key site for the reconstruction of Sardinian Neogene faunas and palaeobiogeography. The insectivore assemblage from Capo Mannu D1 include *Asoriculus gibberodon*, *Talpa* cf. *minor*, *Parasorex depereti*, and cf. *Soricini* indet. The former two, *Asoriculus gibberodon* and *Talpa* cf. *minor*, may be possible ancestors of the ?Late Pliocene-Pleistocene Sardinian endemic “*Nesiotites*” spp. and *Talpa tyrrhenica*. The latter two, *Parasorex depereti* and cf. *Soricini* indet. (probably related to the genus *Sorex*), are for the first time recorded in Sardinia and are not present in younger assemblages. The degree of endemization of the insectivores from Capo Mannu

D1 is null. This probably means that the deposition of the Capo Mannu D1 sediments occurred shortly after the arrival in Sardinia of the insectivores here analyzed.

Such arrival may have occurred from SW Europe (very likely peninsular Italy) in a single event during the Early/Middle Pliocene regression, probably by a filter- or a landbrige, together with one of the murids of the Capo Mannu D1 assemblage, *Rhagapodemus azzarolii*.

Acknowledgements

We wish to thank Prof. T. KOTSAKIS (Università Roma Tre) and the researching staff from IVAU (Utrecht University) for kindly letting us to study the fossil material from Capo Mannu D1. We are indebted to Profs. J. VAN DAM, T. KOTSAKIS for the fruitful discussions and the critical revision of the manuscript, as well as to J. REUMER and an anonymous reviewer for their improvements of the first submitted version. B. VILLIER provided some useful bibliographical references. S. LO MASTRO (Università Roma Tre) performed the SEM images of DSG/URT material. This paper has been supported by the National Science Foundation through the project, "Revealing Hominid Origin Initiative" (RHOI-Hominid-NSF-BCS-0321893) and by Generalitat de Catalunya (Grup de Recerca Consolidat 2009 SGR 754), which covered the expenses derived from the lab work and the SEM photographs taken in the Servei de Microscopia de la Universitat Autònoma de Barcelona. C. ANGELONE benefits from a post-doc grant by the Dipartimento di Scienze della Terra, Torino University.

References

- ABBAZZI, L., ANGELONE, C., ARCA, M., BARISONE, G., BEDETTI, C., DELFINO, M., KOTSAKIS, T., MARCOLINI, F., PALOMBO, M. R., PAVIA, M., PIRAS, P., ROOK, L., TORRE, D., TUVERI, N., VALLI, A. & WILKENS, B. (2004): Plio-Pleistocene fossil vertebrates of Monte Tuttavista (Orosei, E. Sardinia, Italy): an overview. – *Rivista Italiana di Paleontologia e Stratigrafia*, **110**: 681-706.
- ABBAZZI, L., BENVENUTI, M., CECI, M. E., ESU, D., FARANDA, C. & TANGOCCI, F. (2008): The end of the Lago-Mare time in the SE Valdelsa Basin (Central Italy): interference between local tectonism and regional sea-level rise. – *Geodiversitas*, **30**: 611-639.
- ABBAZZI, L., CARBONI, S., DELFINO, M., GALLAI, G., LECCA, L. & ROOK, L. (2008): Fossil vertebrates (Mammalia and Reptilia) from Capo Mannu Formation (Late Pliocene, Sardinia, Italy) with description of a new Testudo (Chelonii, Testudinidae) species. – *Rivista Italiana di Paleontologia e Stratigrafia*, **114**: 119-132.
- AGUILAR, J.-P., CROCHET, J.-Y., HEBRARD, O., LE STRAT, P., MICHAUX, J., PEDRA, S. & SIGÉ, B. (2002): Les micromammifères de Mas Rambault 2, gisement karstique du Pliocène supérieur du Sud de la France: âge, paléoclimat, géodynamique. – *Géologie de la France*, **4**: 17-37.
- ANGELONE, C. & KOTSAKIS, T. (2001): *Rhagapodemus azzarolii* n. sp. (Muridae, Rodentia) from the Pliocene of Mandriola (Western Sardinia, Italy). – *Bollettino della Società Paleontologica Italiana*, **40**: 127-132.
- BATE, D. M. A. (1944): Pleistocene shrews from the larger Western Mediterranean Islands. – *Annals and Magazine of Natural History series*, **11**: 738-769.
- (1945): The Pleistocene mole of Sardinia. – *Annals and Magazine of Natural History series*, **12**: 448-471.
- BERZI, A., MICHAUX, J., HUTSCHISON, J. H. & LINDSAY, E. (1967): The Arondelli local fauna, an assemblage of small vertebrates from the Villafranchian stage near Villafranca d'Asti, Italy. – *Giornale di Geologia*, **35**: 1-4.
- BUTLER, P. M. (1980): The giant erinaceid insectivore, *Deinogalerix FREUDENTHAL*, from the upper Miocene of Gargano, Italy. – *Scripta Geologica*, **57**: 1-72.
- CARBONI, S. & LECCA, L. (1995): Le Pliocène de Capo Mannu (Sardaigne occidentale): transition marin littoral – continental dunaire. – *Comptes Rendues de l'Académie des Sciences Paris, série 2a*, **320**: 1203-1210.
- CROCHET, P. Y. (1986): Insectivores Pliocènes du sud de la France (Languedoc-Roussillon) et du nord-est de l'Espagne. – *Palaeovertebrata*, **16**: 145-171.
- DE BRUIJN, H. & RÜMKE, C. (1974): On a peculiar mammalian association from the Miocene of Oschiri (Sardinia). II. – *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen (B)*, **77**: 60-79.
- DE GIULI, C. (1989): The rodents of the Brisighella latest Miocene fauna. – *Bollettino della Società Paleontologica Italiana*, **28**: 197-212.
- DOUKAS, C. S., VAN DEN HOEK OSTENDE, L. W., THEOCHAROPOULOS, C. D. & REUMER, J. W. F. (1995): The Vertebrate locality Maramena (Macedonia, Greece) at the Turolian-Ruscian Boundary (Neogene). – *Münchner Geowissenschaftliche Abhandlungen, (A)*, **28**: 43-64.
- ESU, D. (1986): La malacofauna continentale pliocenica di Mandriola (Sardegna occidentale): sistematica e paleobiogeografia. – *Geologica Romana*, **23**: 23-50.
- ESU, D. & KOTSAKIS, T. (1979): Restes de Vertébrés et de Mollusques continentaux dans le Villafranchien de la Sardaigne. – *Géobios*, **12**: 101-106.
- FANFANI, F. (2000): *Revisiione degli insettivori (Mammalia) tardo neogenici e quaternari dell'Italia peninsulare* – Unpublished PhD Thesis, Università di Bologna-Firenze-Modena-Roma "La Sapienza". – 282 pp.
- FANFANI, F. & MASINI, F. (1998): Insectivores (Mammalia) from Rivoli Veronese, a Late Villanyian site in North-eastern Italy. – *Bollettino della Società Paleontologica Italiana*, **36**: 367-380.
- FREUDENTHAL, M. (1972): *Deinogalerix koenigswaldi* nov. gen., nov. spec., a giant insectivore from the Neogene of Italy. – *Scripta Geologica*, **14**: 1-19.
- FURIÓ, M. (2003): The Late Miocene Insectivora (Mammalia) in Spain: biogeographical and biostratigraphical patterns of distribution. – Abstracts EEDEN Meeting "Birth of the New World", Stará Lesná (Slovakia), 20-21.
- (2007): Los Insectívoros (Soricomorpha, Erinaceomorpha, Mammalia) del Neógeno Superior del Levante Ibérico. – Unpublished PhD. Thesis, Universitat Autònoma de Barcelona. – 299 pp.

- GERAADS, D. (1995): Rongeurs et insectivores (Mammalia) du Pliocène final de Ahl Al Oughlam (Casablanca, Maroc). – *Géobios*, **28**: 99-115.
- GLIOZZI, E., MALATESTA, A. & PALOMBO, M. R. (1984): Upper Pleistocene small mammal association in the Is Oreris area (Iglesiente, SW Sardinia). – *Geologica Romana*, **23**: 121-129.
- HUTTERER, R. (2005): Order Soricomorpha. – In: WILSON, D. E. & REEDER, D. M. (Eds.): *Mammal Species of the World: A Taxonomic and Geographic Reference* 3rd edition, 220-311; Baltimore (John Hopkins University Press).
- KOTSAKIS, T. (1980): Osservazioni sui vertebrati Quaternari della Sardegna. – *Bollettino della Società Geologica Italiana*, **99**: 151-165.
- KOTSAKIS, T., ABBAZZI, L., ANGELONE, C., ARGENTI, P., BARISONE, G., FANFANI, F., MARCOLINI, F. & MASINI, F. (2003): Plio-Pleistocene biogeography of Italian mainland micromammals. – *Deinsea*, **10**: 313-342.
- KOWALSKI, K. (1956): Insectivores, bats and rodents from the early Pleistocene bone breccia of Podlesice near Krolzyce (Poland). – *Acta Palaeontologica Polonica*, **1**: 331-394.
- LYDEKKER, R. (1887): Catalogue of the Fossil Mammalia in the British Museum (Natural History), **5**: 1-345.
- MASINI, F. & SARÀ, M. (1998): *Asoriculus burgioi* sp. nov. (Soricidae, Mammalia) from the Monte Pellegrino faunal complex (Sicily). – *Acta Zoologica Cracoviensia*, **41**: 111-124.
- MAZZA, P. P. A. & RUSTIONI, M. (2008): Processes of island colonization by Oligo-Miocene land mammals in the central Mediterranean: New data from Scontrone (Abruzzo, Central Italy) and Gargano (Apulia, Southern Italy). – *Palaeogeography, Palaeoclimatology, Palaeoecology*, **267**: 208-215.
- MEIN, P. & MARTÍN-SUÁREZ, E. (1994): *Galerix iberica* sp. nov. (Erinaceidae, Insectivora, Mammalia) from the Late Miocene and Early Pliocene of the Iberian Peninsula. – *Géobios*, **26**: 723-730.
- MEIN, P., MOISSENET, E. & ADROVER, R. (1990): Biostratigraphie du Néogène Supérieur du bassin de Teruel. – *Paleontologia i Evolució*, **23**: 121-139.
- PALOMBO, M. R. (2006): Biochronology of the Plio-Pleistocene terrestrial mammals of Sardinia: The state of the art. – *Hellenic Journal of Geosciences*, **41**: 47-66.
- PASSEMARD, E. (1925): Une brèche osseuse à petits mammifères des environs de Corte (Corse). – *Bulletin de la Société Géologique de France*, **25**: 347-350.
- PECORINI, G., RAGE, J.-C. & THALER, L. (1974): La formation continentale de Capo Mannu, sa faune de vertébrés pliocènes et la question du Messinien en Sardaigne. – *Rendiconti del Seminario della Facoltà di Scienze dell'Università di Cagliari*, **43** (1973) (suppl.): 305-319.
- PONS-MOYÀ, J. & MOYÀ-SOLÀ, S. (1980): Nuevo representante del género *Nesiotites* BATE 1944; *Nesiotites meloussae* nov. sp. (Insectivora, Soricidae) de los relleños cársticos del Barranc de Binigaus (Es Mercadal, Menorca). – *Endins*, **7**: 53-56.
- RABEDER, G. (1972): Die Insectivoren und Chiropteren (Mammalia) aus dem Altpleistozän von Hundsheim (Niederösterreich). – *Annalen des Naturhistorischen Museums Wien*, **76**: 375-474.
- REUMER, J. W. F. (1980): On the Pleistocene shrew *Nesiotites hidalgo* BATE, 1944 from Majorca (Soricidae, Insectivora). – *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, (B)*, **83**: 39-68.
- (1984): Ruscinian and early Pleistocene Soricidae (Insectivora, Mammalia) from Tegelen (The Netherlands) and Hungary. – *Scripta Geologica*, **73**: 1-173.
- (1995): Insectivora (Mammalia: Soricidae, Talpidae) from the Late Pliocene of Frenchen, Germany. – *Deinsea*, **2**: 9-15.
- (1996): Quaternary Insectivora (Mammalia) from southwestern France. – *Acta Zoologica Cracoviensia*, **39**: 413-426.
- REUMER, J. W. F. & HORDIJK, L. W. (1999): Pleistocene Insectivora (Mammalia) from the Zuurland boreholes near Rotterdam, The Netherlands. – *Deinsea*, **7**: 253-281.
- ROFES, J. & CUENCA-BESCÓS, G. (2006): First evidence of the Soricidae (Mammalia) *Asoriculus gibberodon* (PETÉNYI, 1864) in the Pleistocene of North Iberia. – *Rivista Italiana di Paleontologia e Stratigrafia*, **112**: 301-315.
- RZEBIK-KOWALSKA, B. (1988): Soricidae (Mammalia, Insectivora) from the Plio-Pleistocene and Middle Quaternary of Morocco and Algeria. – *Folia Quaternaria*, **57**: 51-90.
- (1998): Fossil history of shrews in Europe. – In: WÓJCIK, J. M. & WOLSAN, M. (Eds.): *Evolution of Shrews*, 23-92; Białowieża (Mammal Research Institute; Polish Academy of Sciences).
- (2000): Insectivora (Mammalia) from the Early and early Middle Pleistocene of Betfia in Romania. II. Erinaceidae BONAPARTE, 1838 and Talpidae GRAY, 1825. – *Acta Zoologica Cracoviensia*, **43**: 55-77.
- TOBIEN, H. (1935): Über die pleistozänen und postpleistozänen *Prolagusformen* Korsikas und Sardinien. – *Berichte der Naturforschenden Gesellschaft zu Freiburg im Breisgau*, **34**: 17-344.
- VAN CLEEF-RODERS, J. T. & VAN DEN HOEK OSTENDE, L. W. (2001): Dental morphology of *Talpa europaea* and *Talpa occidentalis* (Mammalia: Insectivora) with a discussion of fossil *Talpa* in the Pleistocene of Europe. – *Zoologische Mededelingen*, **75**: 51-68.
- VAN DEN HOEK OSTENDE, L. W. (2001): A revised generic classification of the Galericiini (Insectivora, Mammalia) with some remarks on their palaeobiogeography and phylogeny. – *Géobios*, **34**: 681-695.
- VAN DER MADE, J. (1999): Biogeography and stratigraphy of the Mio-Pleistocene mammals of Sardinia and the description of some fossils. – *Deinsea*, **7**: 337-360.
- (2008): New endemic large mammals from the Lower Miocene of Oschiri (Sardinia): Observations on evolution in insular environment. – *Quaternary international*, **182**: 116-134.
- VAZFREY, R. (1929): Les Eléphants nains des Iles Méditerranéennes et la question des Isthmes Pleistocènes. – *Archiv für Naturgeschichte Leipzig*, **7**: 514-588.

- ZAMMIT MAEMPEL, G. & DE BRUIJN, H. (1982): The Plio-Pleistocene Gliridae from the Mediterranean Islands Reconsidered. – Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen, (B), **85**: 113-128.
- ZIEGLER, R. (1999): Order Insectivora. – In: RÖSSNER, G. E. & HEISSIG, K. (Eds.): The Miocene land mammals of Europe, 53-74; München (Pfeil).

Manuscript received: August 10th, 2009.

Revised version accepted by the Stuttgart editor: November 2nd, 2009.

Addresses of the authors:

MARC FURIÓ, Institut Català de Paleontologia, Edifici ICP, Campus UAB Bellaterra, 08193 Barcelona (Spain);
e-mail: marc.furio@icp.cat

CHIARA ANGELONE, Dipartimento di Scienze della Terra, Università di Torino, via Valperga Caluso 35 – 10125 Torino (Italy); Dipartimento di Scienze Geologiche, Università Roma Tre, Largo San Leonardo Murialdo 1, 00146 Roma (Italy)