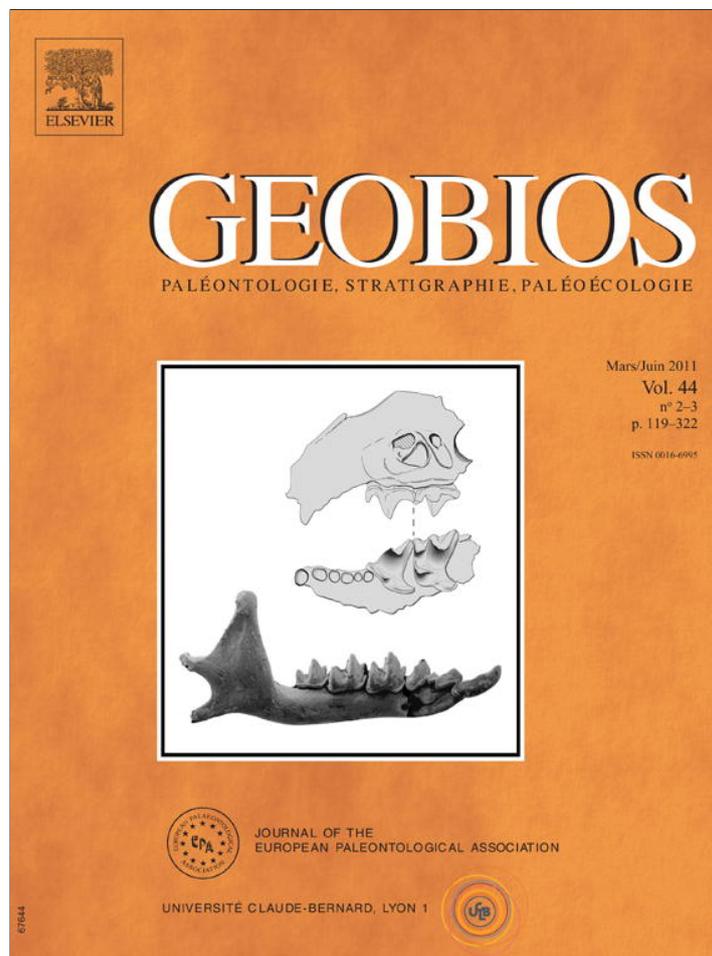


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Original article

A new short-snouted shrew from the Miocene of Spain[☆]

Une nouvelle musaraigne à museau court du Miocène d'Espagne

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Abstract

A new Miocene shrew from east Central Spain is described. The new form, named *Turiasorex pierremeini* nov. gen., nov. sp., was found in 13–10–Ma old sediments of the Calatayud-Daroca and Teruel basins. It is characterized by an extreme dental morphology consisting of elements with low length-width ratios, implying a relatively short snout. Such an adaptation could point to a hypogean life style – using burrows made by other mammals – with a non-standard shrew diet consisting not only of insects, but also of earthworms and possibly small vertebrates such as lizards. © 2011 Elsevier Masson SAS. All rights reserved.

Keywords: Miocene; Spain; Mammalia; Soricidae; *Turiasorex* nov. gen.; Dentition

Résumé

Une nouvelle musaraigne miocène du centre-est de l'Espagne est décrite : *Turiasorex pierremeini* nov. gen., nov. sp., trouvée dans des sédiments âgés de 13–10 Ma des bassins de Calatayud-Daroca et de Teruel. Cette nouvelle forme est caractérisée par une morphologie dentaire extrême consistant en des éléments à faible rapport longueur-largeur, impliquant un museau relativement court. Une telle adaptation suggère un mode de vie hypogé – utilisant des terriers d'autres mammifères – ainsi qu'un régime alimentaire non standard chez les musaraignes, comprenant non seulement des insectes, mais également des vers de terre et possiblement des petits vertébrés comme des lézards.

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Mots clés : Miocène ; Espagne ; Mammalia ; Soricidae ; *Turiasorex* nov. gen. ; Dentition

1. Introduction

The knowledge of Miocene shrew assemblages on the Iberian Peninsula has significantly increased during the last ten years (e.g., Van Dam et al., 2001; Van den Hoek Ostende, 2003; Van den Hoek Ostende and Furió, 2005; Furió et al., in press). It has also been observed that certain episodes stand out because of a higher than average lineage turnover and/or change in relative abundances. The early Late Miocene (Vallesian) represents such an interval, not only for the Iberian Peninsula, but also for Europe as a whole (Reumer, 1994, 1999). From 10–9 Ma onwards, lineages such as *Paenlimnoecus*, *Blarinella*, *Crusafontina* and

Amblycoptus dominate the Spanish shrew record. By contrast, the late middle Miocene record is characterized by a very low shrew diversity, with *Miosorex* being the dominant and often sole shrew element in well-sampled micromammal localities (Van den Hoek Ostende and Furió, 2005).

In this paper, a new late Middle to early late Miocene crocidosoricine genus from the Teruel and Calatayud-Daroca basins, east Central Spain is described. The new form, which has a remarkably derived morphology, co-occurred with the similarly-sized *Miosorex*, but was less common and had a shorter temporal range.

2. Systematic paleontology

Order SORICOMORPHA Gregory, 1910
 Family SORICIDAE Fischer, 1814

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Subfamily CROCIDOSORICINAE Reumer, 1987

Genus *Turiasorex* nov.

Fig. 1

Derivation of name: Genus named after the river Turia, close to which the type material was found (Casas Altas).

Type species: *Turiasorex pierremeini* nov. gen., nov. sp.

Occurrence: As for the type species.

Diagnosis: As for the type species.

Turiasorex pierremeini nov. gen., nov. sp.

1988. *Miosorex* aff. *grivensis* (de Jong) - pro parte (several specimens from Borjas, La Solera, Carrilanga 1, Pedregueras 2A).

1997. Gen. and sp. 1 (Van Dam).

2001. Gen. and sp. 1 (Van Dam et al.).

Derivation of name: In honor of Dr Pierre Mein.

Holotype: Mandible fragment with m1-2, no. CASAL 1454-1455, stored in the Department of Earth Sciences, Utrecht University, the Netherlands (Fig. 1(2, 3)). L(m1) = 1.33, AW(m1) = 0.81, PW(m1) = 0.94; L(m2) = 1.30, AW(m2) = 0.83, PW(m2) = 0.86.

Paratypes: 1 a1 (CASAL 1443), 2 p4 (CASAL 1218-19), 15 m1 (CASAL 1454-64, 1467-70, 1478), 7 m2 (CASAL 1455, 1465-66, 1472, 1476-77), 11 m3 (CASAL 1450, 1481-90), 8 I1 (CASAL 1346, 1381-85, 1388-89), 1 A1 (CASAL 1284), 6 P4 (CASAL 1297-98, 1308, 1316-17, 1320), 15 M1 (CASAL 1302, 1312, 1315, 1328, 1401-05, 1411-15, 1427), 14 M2 (CASAL 1313, 1421-1426, 1428, 1431-1436). Material from Casas Altas stored in the Department of Earth Sciences, Utrecht University (UU).

Remaining material: Nombrevilla (=Nombrevilla 1): 1 m3, 3 I1, 1 P4, 3 M2; Pedregueras 2C: 1 a1, 3 m1, 5 m2, 3 m3, 4 I1, 2 M1, 3 M2; Peralejos 5: 3 m1, 5 m2, 2 m3, 5 I1, 8 M1, 5 M2, 1 M3 (PER5 415), Borjas: 1 m1, 1 M1; Carrilanga 1: 1 I1; Pedregueras 2A: 1 p4, 1 m1, 1 m2; La Solera: 3 m1, 2 m2; Paje 1: 1 I1, 4 M2; Paje 2: 1 I1; Nombrevilla 2: 1 m1, 2 m2, 1 I1, 1 M2; Cascante 4: 1 m1, 1 m2, 1 m3, 1 P4. The material is housed in the Department of Earth Sciences, Utrecht University (UU), NCB Naturalis Leiden (RGM), Museo Nacional de Ciencias Naturales Madrid (MA), and Fundación Conjunto Paleontológico Teruel (Dinópolis). See Table S1 for a full list of collection specimen numbers, locality ages and bio-units. Faunal and chronological information can be found in the literature (Daams et al., 1988, 1999a, 1999b; Van Dam et al., 2001, 2006; Garcés et al., 2003; Abdul Aziz et al., 2004).

Type locality and biostratigraphy: Casas Altas, Comunidad Valenciana; Local Biozone: H; Mammal Neogene Unit: MN9; Age: between 11 and 10.5 Ma (Besems and van de Weerd, 1983). The temporal range of the species is confined to the interval 13-10 Ma, i.e., to local Zones G2 (Borjas) and G3 (Paje 1-2, Solera, Nombrevilla 2), which correlate to MN7-8, and local Zones H (Carrilanga, Nombrevilla, Casas Altas) and I (Cascante 4, Pedregueras 2A, Pedregueras 2C, Peralejos 5), which correlate to MN9. Its geographical range is currently restricted to the Teruel and Calatayud-Daroca basins, east Central Spain.

Measurements: See Table S2, Figs. 2 and 3.

Diagnosis: Small- to middle-sized shrew (mean m1 length ~ 1.2 mm), dentition with strongly pointed cusps, length small compared to width in most elements. Foramen mentale positioned below the anterior root of m1. Antemolar a1 short. Broad and asymmetric p4 with posteriorly extending buccal part and V-shaped wear surface. Lower molars with very short talonids, entoconid of m1 cone-shaped, m3 with broad anterior cingulum and with talonid consisting of a single cusp in unworn condition and a tiny basin when worn. I1 with flattened root, narrow and long anterior main hook and concave postero-buccal border. A1 relatively symmetric lingual-buccally. P4 short, with anteriorly protruding protocone. M1 strongly asymmetric due to a buccally protruding metastyle, a lingually protruding hypoconal flange, and strong posterior emargination. Hypoconal flange of M1-2 inclined downward towards posterior emargination with hypocone standing out as a cusp from the posterolingual cingulum.

Differential diagnosis: Differs from *Miosorex* Kretzoi, 1959 by a foramen mentale positioned below the anterior root of m1 instead of at (posterior) root of p4, by a more asymmetric p4, by the stronger reduction of the talonids and the absence of the middle and posterior part of the lingual cingulum in the lower molars, by absent (m1) or almost reduced (m2) entoconid crests, by the condition of the m3 talonid, which is reduced to a single cusp in unworn condition, by an I1 with a flatter root, narrower and longer anterior main hook, and concave postero-buccal border, by a shorter P4, by higher width-length ratios of the upper molars, by a lingually protruding hypoconal part in M1, by stronger emarginations of the posterior borders, presence of a distinct hypocone and more inclined hypoconal flanges in M1-2, and by the posterior arm of the protocone in M3 connecting to the metacone along the edge, instead of ending freely in the trigon basin. Differs from "*Oligosorex*" *bruijni* by the more reduced talonids and shorter cingula in the lower molars. The cingula end just around the antero-lingual corner, whereas in "*O.*" *bruijni* they run all around the tooth in m1 or reach a position halfway the lingual border in m2-3. The general shape of the M1 is similar to *T. pierremeini*, but the latter species shows a slightly better developed, more elongated hypocone and a more pronounced W-shape at the buccal border. The size of "*O.*" *bruijni* is at the lower part of the variation of *T. pierremeini*. Comparison to the Late Pliocene *Myosorex meini* from Spain shows the following differences: in *M. meini* the foramen mentale resides under the p4 and not under the m1, the posterior emargination in p4 is less deep, the buccal reentrant in m1-2 is higher and the hypolophid in m1-2 is closer to the entoconid. Furthermore, the buccal emargination of the I1 is less deep, and the hypocone on the P4 and M1-2 of *M. meini* is larger and extending farther backward. *Florinia stehlini* differs from *T. pierremeini* in its M1, which has a more squared shape, in its m2 being shorter than its m1, and in the smaller relative width of m1-2. The three species of *Lartetium* (*Lartetium prevostianum*, *Lartetium petersbuchense* and *Lartetium dehmi*) differ from *T. pierremeini* by the more anterior position (at the level of p4) of their foramen mentale, by their more symmetric p4 that is clearly two-rooted and contains small cusps at the ends of the anterior buccal and lingual crests, by their longer

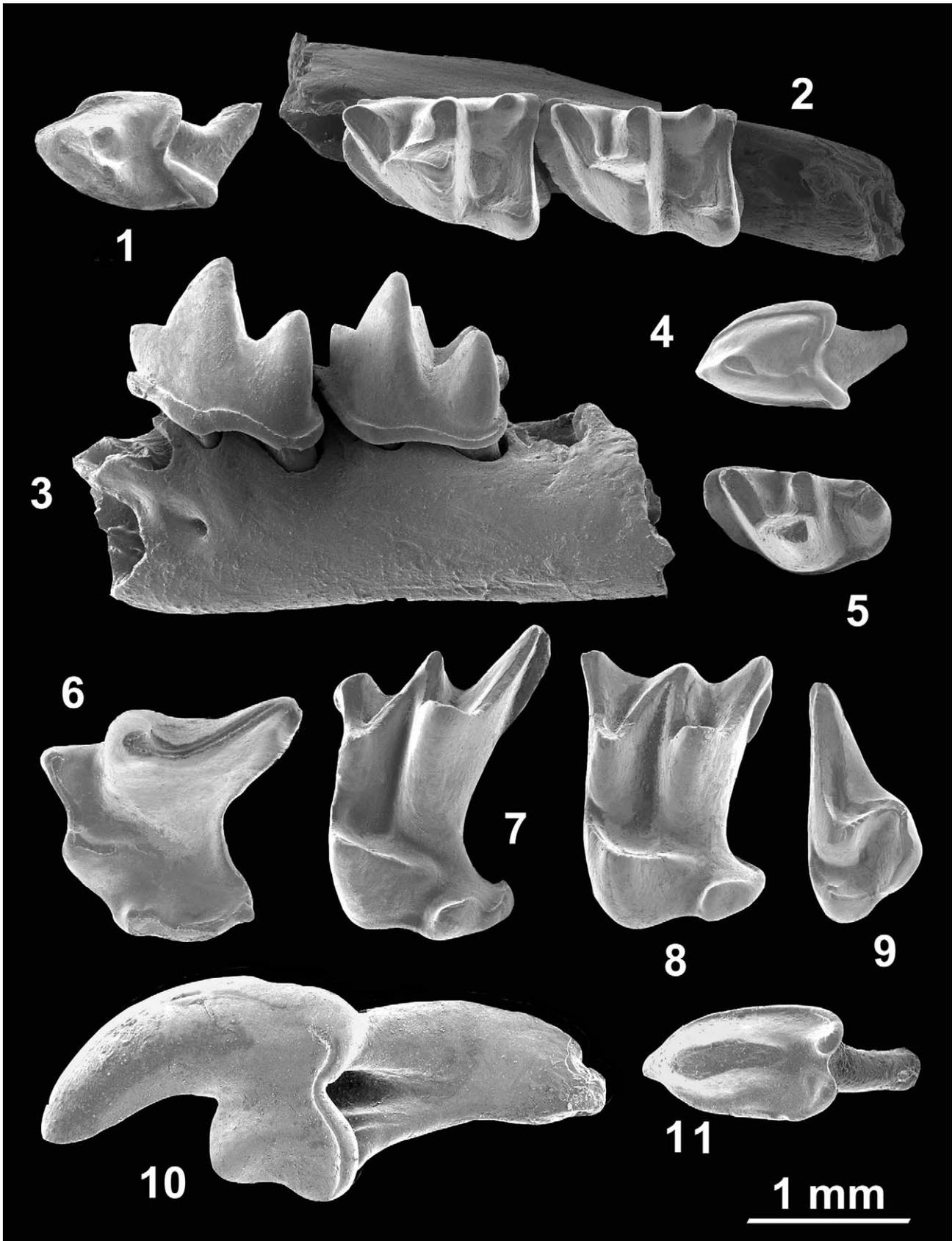


Fig. 1. Dental elements and mandible fragment of *Turiasorex pierremeini* nov. gen., nov. sp. from Casas Altas, Peralejos 5 and Pedregueras 2C. 1: right p4 (CASAL-1218, mirror image); 2: left mandible fragment with m1-2 (CASAL-1454-1455, holotype); 3: left mandible fragment with m1-2 (CASAL-1454-1455, holotype, buccal view); 4: right a1 (PED2C-2763, mirror image); 5: left m3 (CASAL-1483); 6: left P4 (CASAL-1298); 7: left M1 (CASAL-1404); 8: right M2 (CASAL-1434, mirror image); 9: Right M3 (PER5-415, mirror image); 10: right I1 (PER5-378, mirror image); 11: left A1 (CASAL-1284). All figures except 3 in occlusal view.

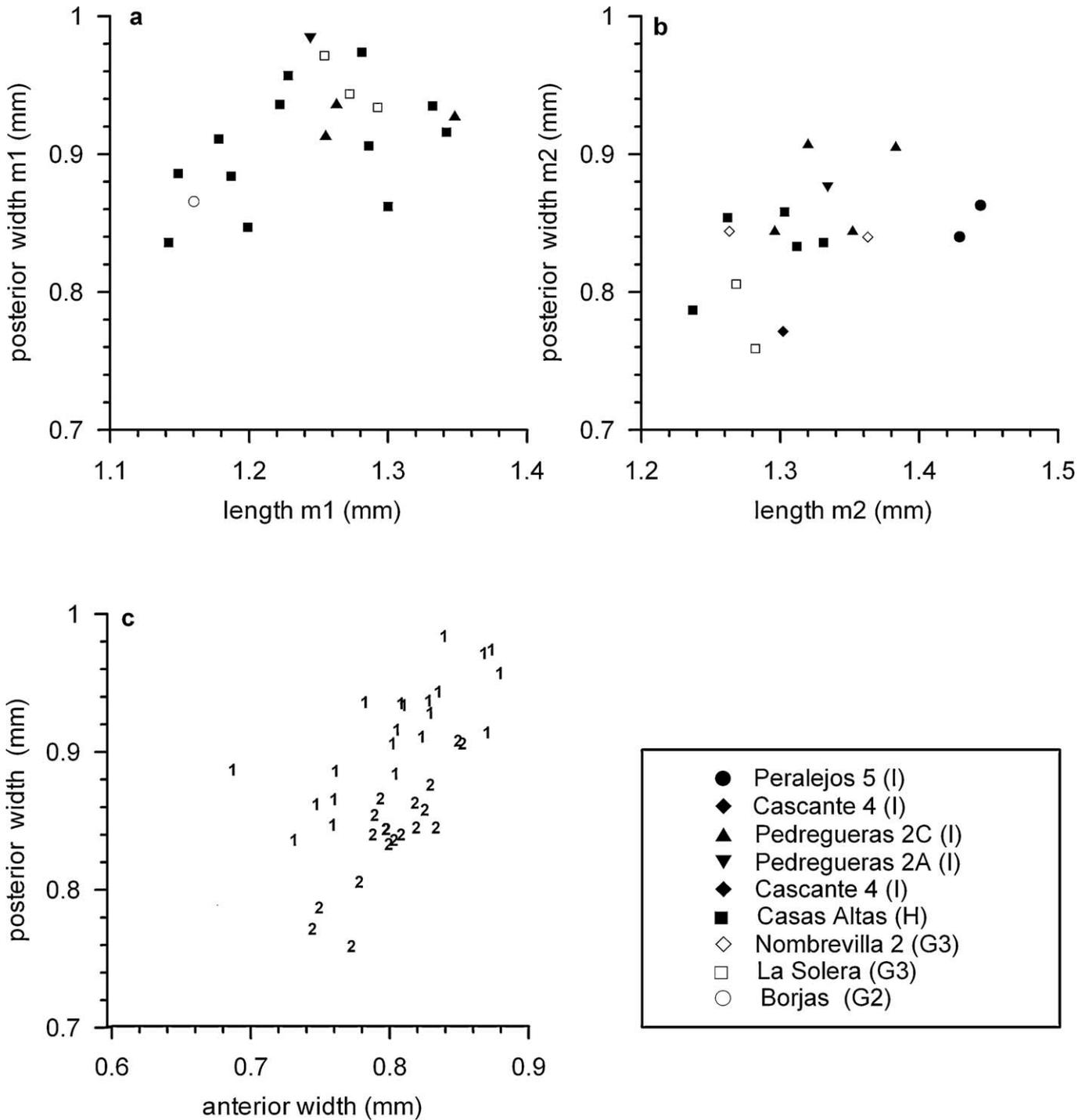


Fig. 2. Scatter plots of m1-2 of *Turiasorex pierremeini* nov. gen., nov. sp. a: m1 posterior width against length; b: m2 posterior width against length; c: m1-2 posterior width against anterior width. Open symbols: pre-*Hipparion* localities = Local Zones G2-G3 = MN7-8; closed symbols = localities with or correlative to *Hipparion* = Local Zones H-I = MN9.

m1-2 having interrupted buccal cingula and relatively less wide talonids, in their m2 being shorter than m1, in their m3 containing a small talonid basin, in their M1-2 having a smaller width/length ratio and shallower posterior emargination, and in their M1 showing a buccally less pronounced W-shape.

Description: Descriptions are based on material from the type locality, unless stated otherwise.

Lower jaw (Fig. 1(2, 3), holotype) with foramen mentale at the level of the anterior part of the anterior root of m1. The

first lower antemolar (a1, Fig. 1(4)) is smaller and more symmetric buccal-lingually than in *Miosorex grivensis*, is relatively short, unicuspidate and has a large paracone. The p4 (Fig. 1(1)) is unicuspidate. Only one root was observed in the two specimens from Casas Altas, but a trace of a small anterior root is present in the specimen from Pedregueras 2A. Crown relatively wide and asymmetric with the posterobuccal part extending farther posteriorly. Strong posterior emargination and strong posterior cingulum

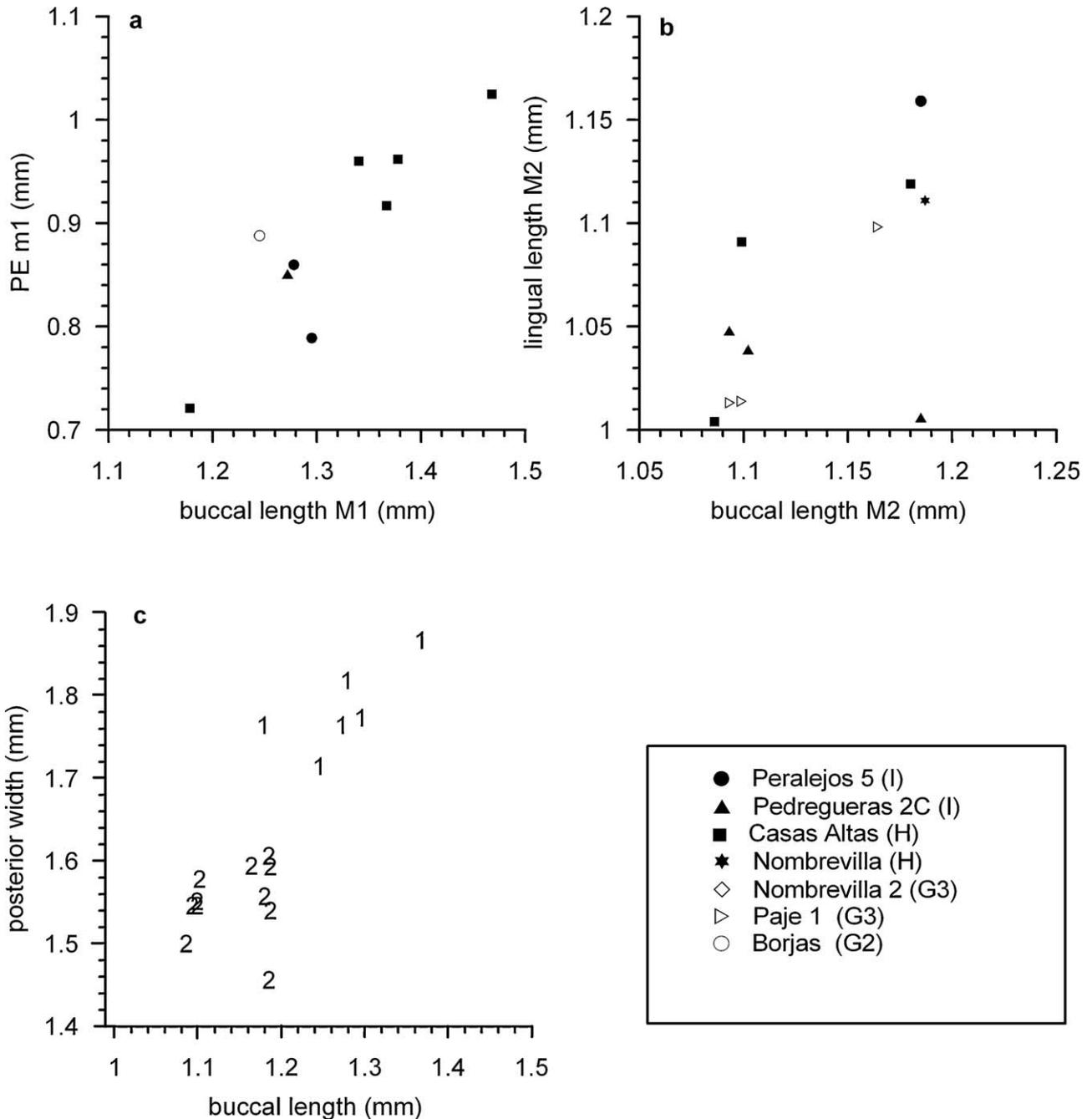


Fig. 3. Scatter plots of M1-2 of *Turiasorex pierremeini* nov. gen., nov. sp. a: M1 length up to posterior emargination (PE) against buccal length; b: M2 lingual length against buccal length; c: M1-2 posterior width against buccal length. Symbols: see Fig. 2.

present, especially at the buccal side. Central wear surface V-shaped. Cingulum all around, very thick posteriorly and thin at apex. The holotype (Fig. 1(2, 3)) shows an alveolus corresponding to the (posterior) root of p4. The damaged depression anteriorly of it probably partly corresponds to the alveolus of the root of a1.

First lower molar (Fig. 1(2, 3)) with exceptionally short talonid containing cone-shaped entoconid and lacking entocoid crest. Hypolophid relatively straight, ending postero-buccally of entoconid. Cingulum present at posterior, buccal

and anterior border and continuing to a position just around the antero-lingual corner, but almost interrupted under parastyle. Broadest part of cingulum anterobuccally. Cingulum below protoconid and hypoconid curving upward and shallow re-entrant present between these two cusps. Second lower molar (Fig. 1(2, 3)) with relatively short talonid, and with a small entoconid crest next to well delineated entoconid. Presence of cingulum as in m1, but continuous at parastyle and ending slightly more posteriorly at lingual border. Cingulum between protoconid and hypoconid with very weak curvature, and re-

entrant between these cusps well developed. Talonid of the third lower molar (m3, Fig. 1(5)) reduced to a single cusp in unworn condition and tiny cusp when worn. Cingulum presence as in m2; anterior cingulum very broad.

Upper incisor (Fig. 1(10)) not fissident. Main hook relatively long and narrow. Buccal cingulum concave. Postero-lingual border almost straight until anterior border of main cusp. Root flattened, with deep and elongated buccal cavity. One first antemolar (A1, Fig. 1(11)) from the type locality (CASAL-1284) is assigned to the new species, because of its symmetric posterior part, thereby differing from a more asymmetrically shaped A1 attributed to the more common *M. grivensis* from the same assemblages. Both posterior lobes with small cusp positioned on cingulum. Lingual part of cingulum higher at a position one third from posterior end, building an incipient cusp homologous to hypocone. Cingulum continuous except at anterior apex. P4 (Fig. 1(6)) strongly compressed antero-posteriorly compared to *M. grivensis*. Parastyle-protocone line oriented with an angle less than ninety degrees with regard to buccal border. Parastyle not connected to paracone as in *M. grivensis*, and protocone protruding anteriorly from border.

First upper molar (M1, Fig. 1(7)) characterized by large width-length ratio, and strongly asymmetric antero-posteriorly because of lingually extending hypocone and buccally extending metastyle. Very strong posterior emargination, as indicated by PE-index values (Reumer, 1984) of 0.47 and 0.51 for the two specimens for which all three measures LL, BL and PE could be measured. Lingual crests form sharp W-shape. Parastyle standing out anteriorly. Posterior arm of protocone (metaloph) directed longitudinally or bended towards hypocone. Hypoconal flange sharply inclined downward towards posterior emargination and hypocone standing out as cusp from posterolingual cingulum. M2 (Fig. 1(8)) with large width-length ratio, but lacking protruding metastyle of M1. Mean PE-index on three measurable specimens relatively high (0.24, 0.29, 0.32). Posterior arm of protocone (metaloph) directed longitudinally or bending towards hypocone, as in M1. The single third upper molar (M3, Fig. 1(10), PER5-415) is strongly compressed antero-posteriorly, showing long and thin parastyle. Posterior arm of the protocone connecting to metacone along tooth border.

Remarks: A weak size trend can be observed within the interval 13–10 Ma (Table S2, Figs. 2 and 3). Generally, the youngest localities (Pedregueras 2C and Peralejos 5; 10–9.9 Ma) have the largest m1–2. The much older locality Nombrevilla 2 (11.7 Ma) also has relatively large m1, but the m2 are relatively small. The smallest m1 is from the oldest locality (Borjas). Morphologically, all cusps seem to become somewhat higher and sharper in time. The hypoconal part of M2 is more reduced in earlier forms. Some M2 morphotypes of smaller size and with small hypoconal flange are present in Peralejos 5, one of the younger sites. The PE-index (Reumer, 1984) of the oldest M1 from Borjas is the lowest of all measured specimens, but more specimens are necessary before any conclusion on a trend in posterior emargination deepness can be ascertained.

3. Discussion

3.1. Systematic relationships

Turiasorex pierremeini nov. gen., nov. sp. represents a lineage with a range of at least 3 million years crossing the Middle to Late Miocene boundary (13–10 Ma, MN7–8 and MN9, Local Zones G2–3, H and I). Up to now, it is only known from basins in east Central Spain. A series of specimens from the karstic locality Escobosa de Calatañazor in Soria, which is situated more northeasterly and correlates to zone G3, fit the description for *Turiasorex* nov. gen. fairly well (indicated as ‘Soricidae II’ and ‘Crocodurinae gen. and sp. indet.’ by Lopez-Martinez et al., 1977 and Sesé, 1980, respectively). A detailed study of this rich assemblage is foreseen to separate the different soricid morphotypes present and confirms the presence of *Turiasorex* nov. gen. Engesser (1972) described a similarly-sized soricid with short talonids from the late Middle Miocene of Anwil called ‘Soricidae 1’. The entoconid in m1 is distinct as in *Turiasorex* nov. gen., although it is of lower height. Both forms show a relatively slender anterior hook of the I1. However, the foramen mentale of the Anwil form (age 13–12 Ma) is situated even more backward – under the middle of m1 – than in the more recent *Turiasorex* nov. gen. from Casas Altas (11–10.5 Ma), in which it is positioned at the level of the anterior root of m1. Another difference pertains to the height of the cusps, which is lower in the form from Anwil, and the corresponding low position of the re-entrant between proto- and hypoconid (Engesser, 1972: fig. 10). Despite these differences, both forms might well share a Middle Miocene common ancestor.

The p4 have a V-shaped wear surface, excluding a classification within Soricinae. This inference is supported by the absence of any sign of pigmentation, and the strongly reduced talonid basin of m3. Assignment to either Crocidurinae or Crocidosoricinae is a matter of systematic philosophy. The Crocidosoricinae were erected as a stem group (Reumer, 1987) of mainly pre-Late Miocene shrews, from which both Crocidurinae and Soricinae are supposed to have evolved. On the other hand, other workers (McKenna and Bell, 1997) assigned these older lineages to either Soricinae or Crocidurinae. In this they followed previous studies (Repenning, 1967), who noted that, morphologically, living Crocidurinae differ more amongst each other than from several Miocene forms. Differences with those older forms include the reduction of upper antemolars between I1 and P4 from 5 to 2–4, of lower antemolars between i1 and p4 from 2–3 to 1–2, the reduction of the talonid basin of the m3, and larger posterior emarginations in the P4 and M1–2 (Repenning, 1967: p. 60). Another characteristic of the Miocene forms is their shorter i1, and its root, of which the direction of its ventral side is often not parallel to the ventral border of the slightly up-curving tooth (Reumer, 1987, 1994). Also the main wear surface on the p4 tends to be smaller and more triangular in Crocidurinae, not possessing long arms extending from it.

Like *Miosorex* and *Soricella*, *Turiasorex* nov. gen. can be placed in the group that shows distinct crocidurine features. The

number of antemolars cannot be determined, but the extreme reduction of the m3 talonid and the strong emargination in P4 and M1-2 are reminiscent of modern Crocidurinae. Furió et al. (2007) acknowledged these resemblances of *Miosorex* with Crocidurinae, but preferred to expand the Crocidosoricinae with the Myosoricini, including both the extinct *Miosorex* as well as the living African *Myosorex*, *Surdisorex* and *Congosorex*, forms that also differ molecularly from other Crocidurinae. In a recent classification of living shrews (Hutterer, 2005), this latter group of living genera has even been raised to the subfamily rank (Myosoricinae), based on both morphological and molecular grounds. Despite the superficial resemblance of *Turiasorex* nov. gen. to *Myosorex* (see below), we refrain from an assignment to Myosoricini/inae, because the absence of sufficiently complete jaw and antemolar material of *Turiasorex* nov. gen. and because of several morphological differences. Some features in *M. meini* (see differential diagnosis) could be explained by straightforward evolution from *Turiasorex* nov. gen., such as the larger hypocone in P4 and M1-2 and the lingual end of hypolophid being thinner and closer to entoconid in m1, but other features such as the position of the foramen mentale and the weaker emarginations of p4 and I1 would imply reversed evolution, which is not very probable.

In contrast to Soricinae, in which several fossil lineages have been traced back to the Middle Miocene (e.g., Harris, 1998; Ziegler, 2003; Van Dam, 2010), the record of Crocidurinae or Crocidurinae-like Crocidosoricinae (depending on the use of these terms) shows a conspicuous Late Miocene–Early Pliocene gap. It is assumed that the bulk of evolution during these times took place in Africa, where the fossil record is poor (Butler, 1998). In practice, this temporal gap also functions as a taxonomic boundary, because the links between the fossil forms before and after it are far from evident. Nevertheless, the morphology of *Turiasorex* nov. gen. does fit several typical characters of the Crocidurinae, such as the lack or extreme reduction of entoconid crests in the m1-2 (Dannelid, 1998), the supposed absence of pigmentation, the strongly reduced talonid basin in m3, and the position of the foramen mentale located below the anterior root of m1. However, here we choose not to include *Turiasorex* nov. gen. into the Crocidurinae, because no direct descendents in this subfamily can be inferred, and because there are some resemblances with other Miocene forms included into the Crocidosoricinae.

Direct ancestors of *Turiasorex* nov. gen. are unknown. This could well be due to the low diversity of shrews during the warm early Middle Miocene, during which Spain was dry (Van der Meulen and Daams, 1992; Van Dam et al., 2006: suppl. fig. 7), leading soricid lineages to extinction or forcing them to migrate to more northern regions (Van Dam, 2010). Alternatively, small populations might have stayed in wetter patches, and their rarity might have prevented their recovery as fossils. Before this time, during the Early Miocene (Ramblian, early Aragonian, MN3-4), insectivore diversity on the Iberian Peninsula was higher (Van den Hoek Ostende, 2003; Van den Hoek Ostende and Furió, 2005; Van Dam et al., 2006; Furió et al., 2011, in press).

One candidate ancestor of *Turiasorex* nov. gen. is “*Oligosorex*” *bruijni* (Gibert, 1975, 1976). This form has been found in the same area 4–5.5 million years earlier (Ateca 1, 3, and Villafeliche 2A, zones A, A and B, respectively; 18–16.5 Ma; Gibert, 1975, 1976). M1 and m1 are similarly-sized (m2-3 are somewhat smaller) as *Turiasorex* nov. gen. The M1 of “*O.*” *bruijni* (Gibert, 1975: pl. 2, fig. 3) also shows a large width-length ratio, a strong antero-posterior asymmetry due to buccally protruding metastyle and lingually protruding hypoconal flange, a distinct hypocone (although smaller), and a significant posterior emargination.

Also the central European form *Florinia stehlini* Doben-Florin, 1964 with age MN3-5 (late Early Miocene to early Middle Miocene), shares some features with *Turiasorex* nov. gen.: the foramen mentale resides at the level of the anterior root of m1, the p4 wear pattern has the typical V-shape, the m1-2 have hardly or no entoconid crests, and the talonid of the m3 is reduced to one cusp (Ziegler, 1989). On the other hand, in the German form the m2 is shorter than the m1, i.e., a configuration opposite to *Turiasorex* nov. gen. (but not to that in “*Oligosorex*” *bruijni*). Also the relative width of m1-2 is smaller in *Florinia stehlini*. Moreover, the M1 (Ziegler, 1989) is very different from that of *Turiasorex* nov. gen. Nevertheless, *Florinia* seems to be phylogenetically more distant from *Turiasorex* nov. gen. than “*Oligosorex*” *bruijni*. Also *Lartetium* (MN4 to MN7-8) is more distant: in contrast to *T. pierremeini* nov. gen., nov. sp., *Lartetium* retains a number of plesiomorphic features throughout its range, such as the position of the foramen mentale at the level of p4, the presence of small cuspules at the end of ridges on p4, and a basined m3. Even the earliest representative of this genus (*L. petersbuchense*) does not seem to be a good candidate for the ancestry of *Turiasorex* nov. gen. because of a marked difference in upper molar shape (especially M1; see the differential diagnosis).

3.2. Functional morphology and diet

The anterior-posterior “compression” of upper and lower teeth as observed in *T. pierremeini* nov. gen., nov. sp. is not unique within soricids. It is shared by several extant Crocidurinae such as *Diplomesodon* and various *Crocidura* and *Suncus* species (e.g., *S. lixus*), and (as mentioned before) by *Myosorex*. E.g., differences with *S. lixus* are small and relate to the shape of the P4, showing a more lingually positioned protocone and to the p4, showing shorter crests. *Diplomesodon pulchellum* from Asia (Turkmenistan Kazakhstan, Uzbekistan) has been regarded as an early (latest Miocene?) offshoot in the radiation of *Crocidura* (Butler, 1998; Ruedi, 1998). Our inspection of *D. pulchellum* material shows that again the p4 is differently shaped, with the buccal crest virtually lacking and the lingual crest taking a central position (see also Repenning, 1967), and that the hypolophid in m1-2 have the same configuration close to the entoconid as in *Myosorex meini*. Hypocones in M1-2 appear to be smaller than in *Turiasorex* nov. gen. and the buccal emargination of the I1 is less deep.

The long snout of most shrews serves to probe for and pick small insects, grubs, worms from the vegetation floor or litter

layer. A shorter than average snout length in *Turiasorex* nov. gen. could point to other additional types of preferred prey. *D. pulchellum* mostly consumes both lizards and insects, with the lizards being killed by biting the head and ingesting bones of skull and skeleton (Nowak, 1999). Dannelid (1998) suggested that a short snout might be an adaptation to handling and eating lizards. *Myosorex* mainly eats insects and earthworms, but also small birds, frogs or mammals when available (Kingdon, 1997; Nowak, 1999). *Myosorex polulus* and *M. norae* feed mainly on earth worms. The *Myosorex* group as a whole shows hypogeal adaptations such as well-clawed toes and reduced or absent (*Surdisorex*) eyes and ears (Kingdon, 1997). Hypogeal activity does not imply fossorial (burrowing) action in the true sense, but involves use of tunnels made by other mammals. Hypogeal shrews, which include *Myosorex*, *Diplomesodon* and *Anour-osorex*, tend to be robust, using their snout, teeth and forefeet when necessary (Churchfield, 1990). A similar hypogeal life style with earthworms as an important diet item could be hypothesized for *Turiasorex* nov. gen. Apart from insects and grubs, it could have consumed both earthworms and small vertebrates such as lizards. The presence of earthworms and other soil-dwelling small prey would have required a relatively wet climate. According to micromammal species richness-based estimations (Van Dam, 2006; Van Dam et al., 2006), the interval 13–10 Ma (Zone G2-I, correlating to MN7–8 and 9) was a relatively wet period, with mean annual precipitations between 500 and 650 mm/year. A return to lower precipitation levels at the base of Zone J (e.g., locality Masía de la Roma 4C, 9.85 Ma: estimated rainfall 350 mm/year) in combination with a strong warming (~10.5–9.8 Ma; Van Dam and Reichart, 2009) causing additional evaporation may have caused the local (and global?) extinction of *Turiasorex* nov. gen.

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Appendix A. Supplementary data

Supplementary data associated Tables S1–S2 with this article can be found, in the online version, at doi:10.1016/j.geobios.2010.11.007.

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