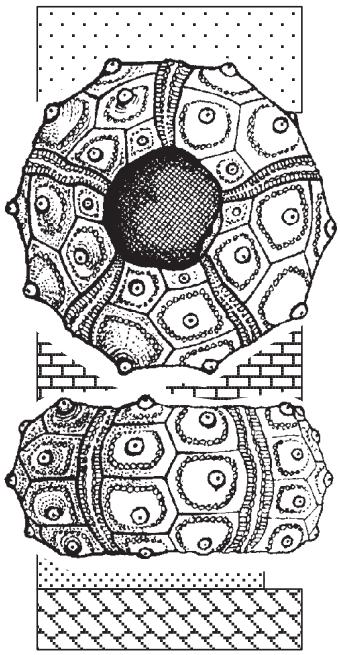

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CRANIAL REMAINS OF *CHEIROGASTER* BERGOUNIOUX 1935 (TESTUDINES: TESTUDINIDAE) FROM THE LATE MIOCENE OF ECOPARC DE CAN MATA (VALLÈS-PENEDÈS BASIN, CATALONIA, SPAIN)

RESTOS CRANEALES DE *CHEIROGASTER* BERGOUNIOUX 1935 (TESTUDINES: TESTUDINIDAE) DEL MIOCENO SUPERIOR DEL ECOPARC DE CAN MATA (CUENCA DEL VALLÈS-PENEDÈS, CATALUÑA, ESPAÑA)

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ABSTRACT

Two news skulls of the giant tortoise *Cheirogaster* (Testudines: Testudinidae) from the early Vallesian (MN 9, late Miocene) of Ecoparc de Can Mata (els Hostalets de Pierola, Vallès-Penedès Basin, Catalonia, Spain) are preliminarily described. The cranial features of the specimens confirm an attribution to the genus *Cheirogaster* and suggest that they may represent a new species of this genus. The correct taxonomic attribution should be confirmed by the study of associated postcranial elements, not prepared ye*T.* When described in further detail, these specimens will probably enable the redescription of the genus with greater accuracy, further helping to clarify the phylogenenetic relationships of the genus *Cheirogaster* among the Testudinidae, as well as to confirm or refute the purported synonymy between *Cheirogaster bolivari* and *Cheirogaster richardi.*

Keywords: Giant tortoises, testudinids, *Cheirogaster richardi*, *Cheirogaster bolivari,* Ecoparc 4.

RESUMEN

Se describen preliminarmente dos cráneos de tortuga gigante del genero *Cheirogaster* (Testudines: Testudinidae) procedentes del Vallesiense inferior (MN 9, Mioceno superior) del Ecoparc de Can Mata (els Hostalets de Pierola, cuenca del Vallès-Penedès, Cataluña, España). Las características craneales de estos especímenes confirman su atribución al género *Cheirogaster*, y sugieren que podrían representar una nueva especie de este género. La correcta atribución taxonómica debería ser confirmada mediante el estudio de elementos postcraneales asociados, aún no preparados. Cuando se describan con mayor detalle, estos especímenes probablemente permitirán redescribir el género con mayor detalle, ayudando además a clarificar las relaciones filogenéticas del género *Cheirogaster* dentro de la familia Testudinidae, así como confirmar o refutar la sinonimia propuesta entre *Cheirogaster bolivari* y *Cheirogaster richardi.*

Palabras clave: Tortugas gigantes, testudínidos, *Cheirogaster richardi, Cheirogaster bolivari*, Ecoparc 4.

1. INTRODUCTION

1.1. THE GENUS *CHEIROGASTER*

The genus *Cheirogaster* Bergounioux 1935, endemic from the Mediterranean region, includes about eleven species of medium to large-sized terrestrial testudinids (Lapparent de Broin, 2002). The first species described of this genus of large tortoises in the Iberian Peninsula corresponds to *Cheirogaster bolivari* (Hernández-Pacheco, 1917), which was erected on the basis of remains from the Miocene of Alcalá de Henares (Hernández-Pacheco, 1917). The latter publication was followed by additional citations from Aragonian and Vallesian (Middle to Late Miocene) localities of the inner Iberian Peninsula (Hernández-Pacheco, 1921; García and Alberdi, 1968; Jiménez Fuentes, 1971, 1984, 1986, 2000; Jiménez Fuentes and

Carbajosa Tamargo, 1982; Cuesta *et al*., 1983; Jiménez Fuentes *et al*., 1986, 1988a, b, 1989, 1990) and the Vallès-Penedès Basin (Bergounioux, 1938, 1958; Bataller, 1956; Alba *et al*., 2006). Following the work by Jiménez Fuentes (2000), customarily a single species of large testudinid, *Cheirogaster bolivari*, has been recognized in the Iberian Miocene, with *Cheirogaster richardi* (Bergounioux 1938) being considered its junior subjective synonym. Royo y Gómez (1935) first reported cranial material of this species, but currently these specimens are los*T.* However, cranial specimens of other *Cheirogaster* species are available: *Cheirogaster perpiniana* (Depéret 1885) from the early Pliocene (MN 15) of Perpignan (France), *Cheirogaster schafferi* (Szalai 1931) from the late Miocene (MN 12-13) of Samos (Greece) and cf. *Cheirogaster* sp. (Arambourg and Piveteau, 1929) from the late Miocene (MN12) of Thessaloniki (Greece). In this work, we report the recent discovery of two new skulls of *Cheirogaster*, further providing a preliminary description of them.

1.2. PALEONTOLOGICAL WORKS AT THE ECOPARC DE CAN MATA

The *Cheirogaster* remains reported here were recovered during the paleontological intervention carried out during the construction works of the Ecoparc de Can Mata (also known as Ecoparc 4), a recycling plant situated very close to the Abocador de Can Mata (Can Mata's rubbish dump, ACM), in the municipal term of els Hostalets de Pierola (Figure 1). Given the fossiliferous richeness of the Miocene sequences of els Hostalets de Pierola (Bataller, 1938; Crusafont and Truyols, 1954), recently highlighted by the paleontological works carried out at the ACM (Alba *et al*., 2006, 2009), a paleontological intervention of preventive control, excavation and microvertebrate sampling was carried out by PALAEOTHERIA, S.C.P. (2007-2008) and FOSSILIA Serveis Paleontològics i Geològics, S.L. (2008-2010), in order to recover the paleontological heritage that might be affected during the works with heavy machinery. During the first campaign in 2007, the removal of Miocene sediment involved the construction of a bypass of the road B-231 from Esparreguera to Piera, further continuing during 2008 to 2010 with the construction of the plant facilities themselves. To date, more than 5,300 macrovertebrate fossil remains have been recovered, including abundant remains of large testudinids. Complete and partial shells, found isolated or constituting accumulations up to ten individuals and frequently associated to other postcranial remains, are provisionally referred to *Cheirogaster* sp. The find of *Cheirogaster* skulls is however exceptional, the two specimens reported here being the only ones found during the intervention to date.

1.3. AGE AND GEOLOGICAL BACKGROUND

The area of els Hostalets de Pierola is situated in the Penedès sector of the Vallès-Penedès Basin (NE Iberian Peninsula), a NNE-SSW-oriented, asymmetric half-graben, situated between the two Catalan Coastal Ranges (Bartrina *et al*., 1992; Cabrera and Calvet, 1990; Roca and Guimerà, 1992). The sedimentary sequences of the basin record from the early to the late Miocene, mainly corresponding to proximal to distal-marginal alluvial fan sediments (Cabrera and Calvet, 1990). The thick middle to late Miocene sedimentary sequences of this area consist of red to brown mudstones, sandstones, breccias and conglomerates, which were deposited in the distal-to-marginal, inter-fan zones of two major coalescing alluvial fan systems (Moyà-Solà *et al*., 2009). The composite stratigraphic series of the Abocador de Can Mata and Riera de Claret (Moyà-Solà *et al*., 2009; Alba *et al*., 2009) corresponds to the late Aragonian and early Vallesian, therefore recording the MN 8 / MN 9 (i.e., middle to late Miocene) transition. The local stratigraphic series of the ACM is exclusively Aragonian in age, ranging approximately from 12.5 to 11.3 Ma on the basis of magnetostratigraphic data (Moyà-Solà *et al*., 2009). The local series of the Ecoparc de Can Mata is stratigraphically situated above the ACM series, and also above the classical localities of Can Mata I (latest Aragonian) and Can Mata III (earliest Vallesian) (Fig. 1), further laterally overlapping with the Vallesian levels of the Riera de Claret Claret (authors' unpublished data). Thefore, in spite of the fact that the equid Hippotherium Kaup, 1833 has not been thus far recorded from the Ecoparc de Can Mata series, an early Vallesian age must be attributed to the whole series. This is further confirmed by preliminary paleomagnetic data, which suggest a correlation with the characteristic long normal chron C5n that corresponds to the early Vallesian (Miguel Garcés, pers. com.).

1.4. HISTORICAL BACKGROUND

Testudo bolivari was erected by Hernández-Pacheco (1917) on the basis of shell material from the middle Miocene of Alcalá de Henares and other localities from the inner Iberian basins. A more complete description of the carapace, plastron and cranium of this species was reported by Royo y Gómez (1935) on the basis of specimens from the Miocene of Arévalo (Ávila) and Ciudad Universitaria (Madrid). Simultaneously, Bergounioux (1935) erected the genus *Cheirogaster* for two French species, *Cheirogaster maurini* (Bergounioux 1935) and *Cheirogaster phoshoritarum* (Bergounioux 1935). However, when the same author erected a new species of giant tortoise, on the basis of a plastron that he incorrectly attributed to the Oligocene of Tàrrega, he maintained it in the genus *Testudo* Linnaeus, 1758 i.e. *T. richardi* Bergounioux, 1938. The latter author justified the erection of the new taxon on the supposedly different geological age, and further failed to provide clear diagnostic criteria for this species as compared to *T. bolivari*. In fact, the holotype of the former species came from Aragonian levels of els Hostalets de Pierola (Bataller, 1956; Bergounioux, 1958), but unfortunately the specimen was lost during the Spanish Civil War. Posteriorly, Loveridge and Williams (1957) suggested that all European land tortoises should be included into the genus *Geochelone* Fitzinger, 1835 a proposal that, regarding the two Iberan taxa, was subsequently followed by several authors during the next decades (Auffenberg,

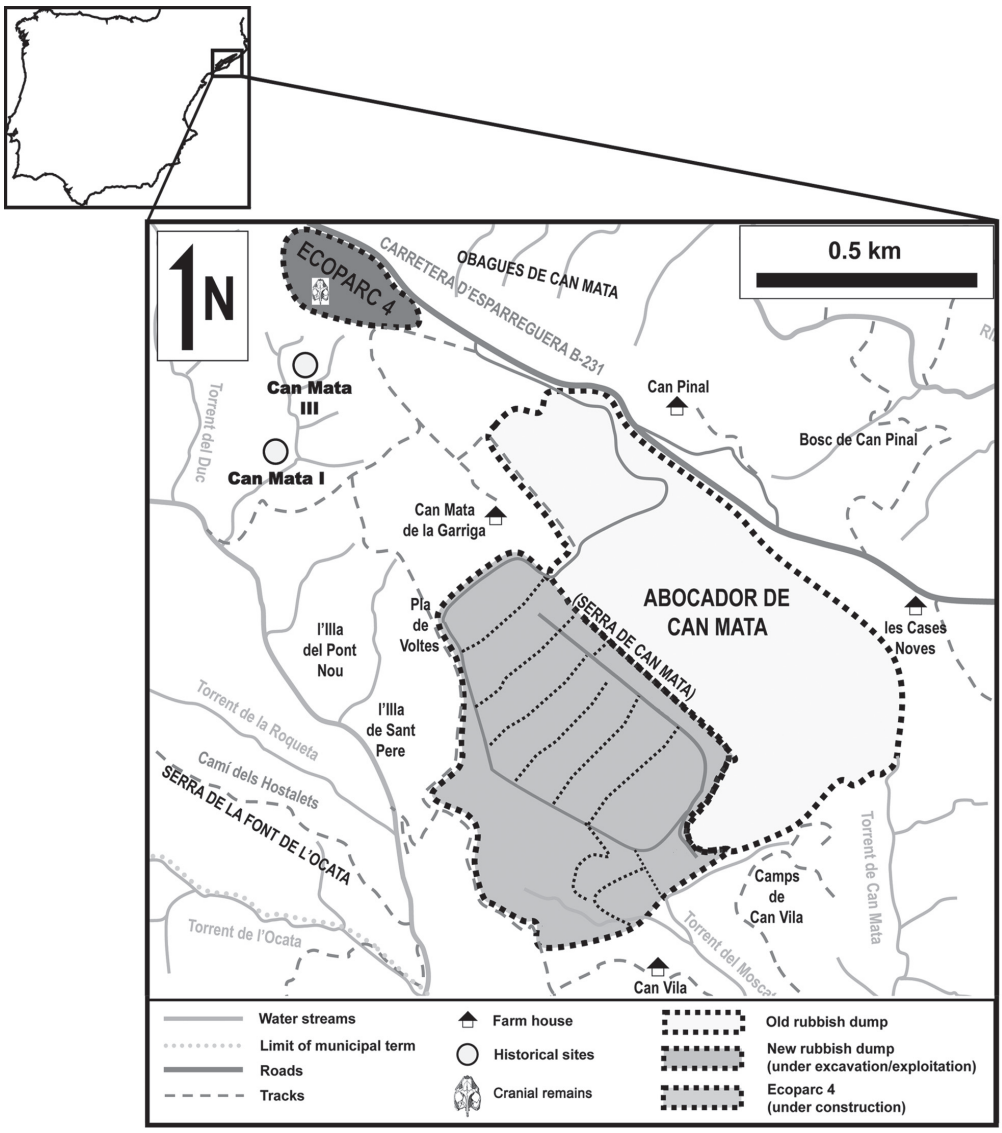

Figure 1. Map of situation of Abocador de Can Mata and Ecoparc de Can Mata. The extension of the old dump is indicated in white, whereas the area currently under exploitation and/or excavation is indicated in light gray and the area under construction in darker gray. The location of the two skulls of *Cheirogaster* mentioned in the text, together with the two classical Can Mata localities, are indicated.

1974; Jiménez Fuentes and Carbajosa, 1982; Cuesta *et al*., 1983; Jiménez Fuentes, 1984). Some years later, Bourgat and Bour (1983) suggested that these species, together with *T. perpiniana*, should be transferred to the genus *Cheirogaster* s.l., but failed to formally propose the new combination. Jiménez Fuentes (1984) justified on morphological grounds the distinction between the two Iberian species, still included within the genus *Geochelone*, although they were soon transferred to *Cheirogaster* s.l. (Jiménez Fuentes *et al*., 1986, 1988a,b, 2000). Given that type material of both taxa had been lost or destroyed, Jiménez Fuentes *et al*. (1988b) designed the corresponding neotypes on the basis of remains from supposedly male individuals: a shell from Arévalo (Ávila) for *Cheirogaster richardi* and a shell from Coca (Segovia) for *Cheirogaster bolivari*.

Most recently, however, Jiménez Fuentes (2000) concluded that the neotype of *Cheirogaster bolivari* belonged indeed to a female individual, so that most of the purportedly diagnostic features between both species were indeed attributable to sexual dimorphism. As such, Jiménez Fuentes (2000) considered that *Cheirogaster richardi* (originally erected on the basis of material from els Hostalets de Pierola) is a junior subjective synonym of *Cheirogaster bolivari*.

2. MATERIAL AND METHODS

Most of the morphological features reported here were observed with the aid of a stereomicroscope, although several details of cranial morphology were observed with the aid of computed tomography, performed with a medical CT-scan at the Hospital Mútua de Terrassa. The comparative sample employed for this study included 4 extinct species of Testudinidae: *Cheirogaster bolivari*, *Cheirogaster perpiniana*, *Cheirogaster schafferi* and cf. *Cheirogaster* sp. IPS43809a corresponds to the skull and associated lower jaw of a young specimen, which was found associated with shell fragments and other postcranials elements (not yet prepared) presumably from the same individual (Fig. 2A). IPS43810a is a complete and well-preserved skull and lower jaw of an adult individual,

which was found associated to an ulna and several vertebral remains (Fig. 2B). Although no phylogenetic analysis is reported here, the significance of the several features employed in the descriptions were determined on the basis of data published by previous authors (Crumly, 1984; Meylan and Sterrer, 2000; Takahashi *et al*., 2003). Cranial anatomical nomenclature follows Gaffney (1972).

3. SYSTEMATIC PALEONTOLOGY

Order Testudines Linnaeus 1758

Suborder Cryptodira Cope 1868

Superfamily Testudinoidea Batsch 1788

Family Testudinidae Batsch 1788

Subfamily Testunidinae Batsch 1788

Genus *Cheirogaster* Bergounioux 1935

Studied material: IPS43809a is a complete and well-preserved skull with lower jaw (Fig. 2A). IPS43810a is a complete skull and lower jaws (Fig. 2B). Both specimens are currently housed at the Institut Català de Paleontologia.

Locality and age: Ecoparc de Can Mata, sector VCE-B (Fig. 1) (els Hostalets de Pierola, Vallès-Penedès Basin, Catalonia, Spain), corresponding to the early Vallesian (MN 9, Late Miocene).

4. DESCRIPTION

Due to space limitations, only the most relevant morphological features are reported here. The premaxillae and maxillae are particularly well preserved in IPS43809a. The prepalatine foramen is situated on the posterior portion of the premaxilla, which further shows well-developed transverse ridges on the maxilla-premaxilla suture (Fig. A1 and A3). On the triturating surface of the maxillae, there are three paired distinct ridges. The median maxillary ones are restricted to the maxilla and display a very marked denticulate ornamentation. The lingual ridges run in anteroposterior direction from the premaxilla to mid-length of the palate, where they turn back to form an inverted C-shape, delimiting a depression (Fig. A1). This 'maxillary pit', delimited by the denticulate and sinuous lingual ridges, is unknown in *Cheirogaster* and other Testudines. The posterior maxillary process is well developed in both available specimens, as in *Cheirogaster bolivari* (Fig. B1). In anterior view, there is a wide fissura ethmoidalis, as in most testudinids (Meylan and Sterrer, 2000). The frontals display a triangular shape but do not constitute the largest portion of the dorsal orbital margin, unlike in most other testudinids. The parietals are well preserved, except by the eroded descending processes, which do not overlap with the prootics and do not contact the squamosal, as in *Testudo* (Gaffney, 1972).

Regarding the palatal complex, the vomer, which is not well preserved, divides the palatines but not the pterygoids, and there is no vomer-basisphenoid contact (Fig. A1 and A3). In both specimens, the palatines have been partially eroded away. The foramen palatinum posterius is small and elongated, being completely enclosed by the palatine. The quadrates are neither well-preserved in any of the two specimens. The incisura columellae auris is enclosed by the quadrates, as in most testudinids (Meylan and Sterrer, 2000). The anterior portion of the quadrate and a small portion of the prootic jointly constitute a relatively large trochlear process. The pterygoids have been partially preserved in both specimens. Ventrally, the interfenestral process is covered by the pterygoid.

With regard to the braincase elements, the prootic is only well-preserved in the left side of IPS43810a (Fig. B2). The dorsal exposure of the prootic is narrow, approximately half its length. The exoccipital, which is well preserved in IPS43810a, displays two openings on its posterior surface, a larger and more lateral (foramen jugulare posterius), and a smaller and more medial one (foramen nervi hypoglossi). The supraoccipitals are well preserved in both specimens, where they constitute the dorsal wall of the foramen magnum and a portion of the cavum labyrinthicum. The supraoccipital spine is long, extending posteriorly beyond the quadrates.

Finally, the mandible is best preserved in IPS43809a, although some characters cannot be recognized because it is attached to the base of the skull. On the trituration surface, the lingual and labial ridges are equally developed. The greater dentofacial foramen is located on the buccal side of the dentary, together with several nutritive foramina. A marked symphyseal suture can be recognized in IPS43809a. The surangular, only well preserved on the right side of IPS43809a, interdigitates with the dentary.

5. DISCUSSION

The cranial features and the morphology of the specimens reported in this contribution confirm an attribution to the genus *Cheirogaster*, which is characterized by the following features; presence of a foramen praepalatinum; three triturating ridges on the maxilla; transverses ridges restricted on the maxilla-premaxilla suture; median maxillary and lingual ridges restricted to the maxilla; a broad ethmoidal fissure; the vomer dividing the palatines but not pterygoids; the quadrate enclosing the stapes; the posterior extension of the pterygoid not covering the processus interfenestralis; a narrow dorsal exposure of the prootic; and the presence of a surangular process. Among others, our results show that the new skulls differ from the four other species of this genus for which cranial material is available (*Cheirogaster bolivari*, *Cheirogaster perpiniana*, *Cheirogaster schafferi* and cf. *Cheirogaster* sp.) by several morphological features. The latter include a marked symphyseal suture in the mandible, as well as the presence of three paired crests on the palate: the lingual ones, which are sinuous and denticulate, and generate a new "maxillary pit" on the palate; the maxillary median ones, which are also denticulate; and the transverse ones,

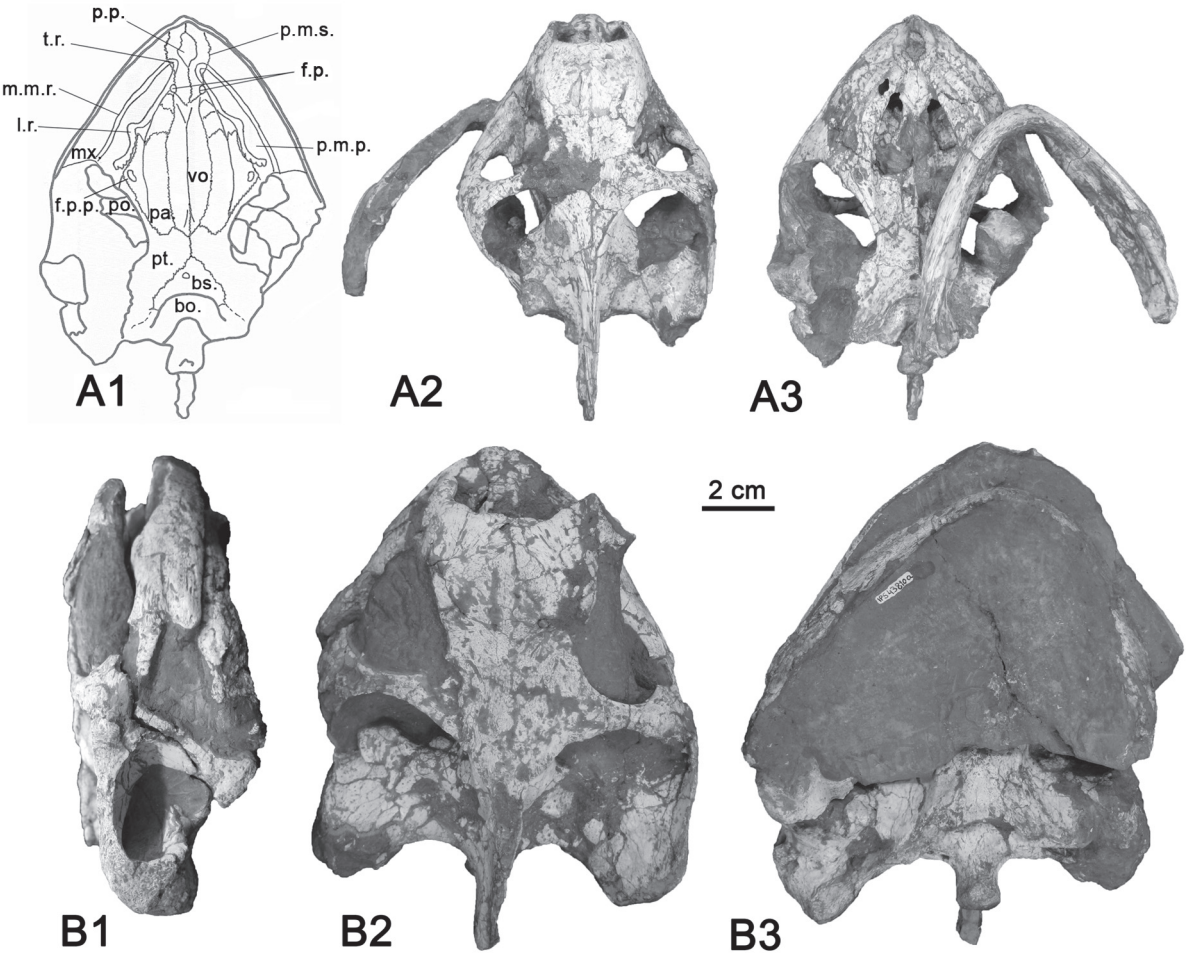

Figure 2. *Cheirogaster* skulls from Ecoparc de Can Mata: A. IPS43809a in palatal (schematic drawing showing the most important features) (A1), dorsal (A2) and palatal (A3) views; B. IPS43810a, in right lateral (B1), dorsal (B2) and palatal (B3) views. Abbreviations: bo, basioccipital; bs, basiesfenoides; f.p., foramen praepalatinum; f.p.p., foramen palatinum posterius; l.r., labial ridge; m.m.r., median maxillary ridge; mx, maxilla; pa, palatine; p.d., premaxillary pit; p.m.p., "posterior maxillary pit"; p.m.s., maxilla-premaxilla suture; po, postorbital; pt, pterygoid; *T*.r., transverse ridge; vo, vomer.

which join the above-mentioned ones on the maxilla-premaxilla suture.

6. CONCLUSIONS

To sum up, the two skulls of *Cheirogaster* from the early Vallesian of Ecoparc de Can Mata reported here provide a wealth of phylogenetically-informative data on the cranial anatomy of the genus *Cheirogaster*, which was previously very partially known for the Miocene representatives from the Iberian Peninsula. When described in detail, these specimens may enable the description of a new species of *Cheirogaster*, further helping to clarify the phylogenetic relationships among the several species of the genus and in relation to other testudinids. Furthermore, it is expected that these data, coupled with those provided by shells and other postcranial elements from the same area, will also contribute to more definitively settling the issue of the purported synonymy between *Cheirogaster bolivari* and *Cheirogaster richardi*.

7. AKNOWLEDGEMENTS

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