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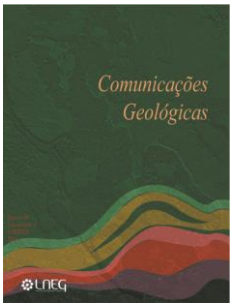
Redefinition of *Amphiope neuparthi* de Loriol, 1905 (Echinoidea, Astriclypeidae) from the early-middle Miocene of Angola



Redefinição de *Amphiope neuparthi* de Loriol, 1905 (Echinoidea, Astriclypeidae) do Miocénico inferior-médio de Angola

P. Pereira[1*], P. Stara[2]

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Abstract: Pending a full revision of the genus *Amphiope*, necessary as result of several recent findings in various peri-Mediterranean localities by a network of research groups, here are redefined, by an analytical approach combining morphometric and structural (analysis of plate patterns and X-ray images) data, the specific characters of the fossil species *Amphiope neuparthi* de Loriol, 1905, from the upper Burdigalian-Langhian of Angola (Central-West Africa). *A. neuparthi* is characterized by large, subcircular to wide ovoidal lunules, and a peculiar posterior deep marginal notch. Moreover, it is characterized by an internal structure with a wide central hollow and peripheral ballast system, which becomes denser towards the margin.

Keywords: Echinoidea; *Amphiope*; Miocene; Angola; Atlantic Ocean.

Resumo: Na sequência da revisão em curso do género *Amphiope*, necessária devido a novos achados em diversas localidades peri-mediterrânicas, por uma rede de grupos de pesquisa, são redefinidas, com base na combinação de dados morfométricos e estruturais (análise de padrões de placas esqueléticas e imagens de raio-X), as características particulares da espécie fóssil *Amphiope neuparthi* de Loriol, 1905, do Burdigaliano superior-Langhiano de Angola. *A. neuparthi* distingue-se por apresentar grandes lúnulas, de contorno subcircular a oval, característico entalhe profundo na margem posterior e estrutura interna com larga cavidade central e sistema de lastro periférico que se torna mais denso em direção à margem.

Palavras-chave: Echinoidea; *Amphiope*; Miocénico; Angola; Oceano Atlântico.

[1] Departamento de Ciências e Tecnologia, Universidade Aberta, Rua da Escola Politécnica, 147, 1269-001 Lisboa, Portugal; Instituto D. Luiz, Universidade de Lisboa.
[2] Centro Studi di Storia Naturale del Mediterraneo, Museo di Storia Naturale Aquilegia, and Geomuseo Monte Arci, Masullas, Oristano, Sardinia, Italy.
*Autor correspondente/Corresponding author: pedro.pereira@uab.pt

1. Introduction

Amphiope Agassiz, 1840 is a genus belonging to the family Astriclypeidae (Echinoidea, Clypeasteroida) that spread especially in the Miocene sedimentary succession of the European and North African seas. Its complex taxonomy has been recently reviewed by Stara and Borghi (2017) based on current methods of analysis, using both morphometric and structural data.

Several authors (e.g. Cottreau, 1914; Lambert, 1915, 1928) presented detailed descriptions of this genus, yet their diagnoses were based only on test external morphologies, supported mainly on adjectivities, causing too subjective interpretations. On this basis, Philippe (1998), who revised the *Amphiope* species reported earlier from the Rhône Basin (France), based on biometric data, included nine previously established species into the synonymy of *A. bioculata* (Des Moulins, 1837).

Some authors utilised other methods of study. Dartevelle (1953) used radiographic methods in the description of fossil echinoids from Congo and Angola (e.g. *A. neuparthi* in Dartevelle, 1953, p. 74 and pl. 7, fig. 3), while Durham (1955, fig. 32B) applied both radiographic and structural analysis on clypeasteroid echinoids, systematically explaining the schemas of arrangement of the test plating.

More recently, Mooi (1989) provided a further contribution to clarify the differences between various genera of clypeasteroids, while Kroh (2005) and Pereira (2010) illustrated a partial oral plating, describing respectively Austrian and Portuguese forms of *Amphiope*.

To conclude this brief summary, Stara and Sanciu (2014) analysed external shapes, schemes and internal structures of many species within the family Astryclipeidae and Stara and Borghi (2014) proposed and illustrated test schemes and internal structures of many *Amphiope* species from Sardinia, demonstrating the importance of using the combination of morphometric and structural data in generic and specific distinction. Finally, Stara and Borghi (2017) redefined the genus and revised many species based on a omni-comprehensive approach of the methods mentioned above.

In this paper, the species *Amphiope neuparthi* de Loriol, 1905 from the Miocene of Angola (Central-West Africa), the most southern species of its genus, is revised by the methods used by Stara and Sanciu (2014). This revision was made possible by the recent rediscovery of most of the type material and several unstudied test fragments assigned to this species. These specimens were found in the geological collections of the old Portuguese overseas provinces archived in the warehouse ("Litoteca") of the *Laboratório Nacional de Energia e Geologia* (National Laboratory of Energy and Geology, Lisbon, Portugal) (Silva and Pereira, 2014) and presently are housed at *Museu Geológico* (MG, Geologic Museum, Lisbon, Portugal).

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2. Geological setting

A. neuparthi has been reported to occur in the early-middle Miocene of the Angolan Kwanza and Namibe basins (Fig. 1) (de Loriol, 1905; Choffat, 1905; Caster, 1938; Dartevelle, 1952; 1953; Dartevelle and Roger, 1954; Antunes, 1964; Silva and Pereira, 2014).

Figure 1. Simplified map of *A. neuparthi*'s localities cited in this study.

Figura 1. Mapa simplificado com identificação das localidades, citadas neste estudo, onde ocorre *A. neuparthi*.

In the Kwanza basin, test fragments of this species have been collected in Bom Jesus (type locality), located on the right bank of the Kwanza river, about 45 km SE of Luanda (de Loriol, 1905; Choffat, 1905; Caster, 1938; Dartevelle, 1952; 1953; Dartevelle and Roger, 1954; Antunes, 1964), Luanda and its surroundings (unidentified outcrops) (Dartevelle, 1952; 1953; Dartevelle and Roger, 1954; Silva and Pereira, 2014) and in the sea cliff 20 km north of Porto Amboim (Dartevelle, 1952; 1953; Dartevelle and Roger, 1954) (Fig. 1).

In Bom Jesus locality, *A. neuparthi* occurs in a whitish sandy limestone, slightly clayey, containing an accumulation of bryozoans, *A. neuparthi* test fragments, rare *Ostrea* shells and fish teeth (Choffat, 1905; Dartevelle, 1952; Antunes, 1964).

Near Porto Amboim, *A. neuparthi* test fragments occur in a yellowish, vacuolar and coarse sandstone with small pebbles and small bivalve moulds, associated with the regular echinoids "*Cidaris vafellus*" and "*Psammechinus* cf. *dubius*" (Dartevelle, 1952; Dartevelle and Roger, 1954).

These deposits were formed in the second (of three) period of the Kwanza basins' Neogene sedimentation (Antunes, 1964) which occurred during the upper Burdigalian-Langhian (Jackson *et al.*, 2005; Guiraud *et al.*, 2010).

In the Namibe Basin, Dartevelle (1952) assigned to *A. neuparthi* a single test fragment with a lunule collected in the banks of a tributary of the Curoca river (right bank), about 20 km ENE of Tombwa (formerly known as Porto Alexandre) (Fig. 1). This author did not present the description of the layer where the test fragment was collected but he described the geology of the area as being composed of layers of fossiliferous limestones with abundant mollusc moulds, conglomerate levels with very large pebbles sometimes bearing perforations of bioeroding animals, layers of cross-bedded sandy limestones and rather fine limestones with fish teeth (Dartevelle, 1952). Based on the occurrence of *A. neuparthi*, Dartevelle (1952) attributed these deposits, as he did with the strata of the Kwanza basin with fossil remains of this species, to the upper Burdigalian and this age attribution has been in use ever since (Carvalho, 1961; Máquina *et al.*, 2012).

3. Materials and methods

The studied material, presently housed at MG, includes most of de Loriol's type material (16 test fragments from Bom Jesus, Luanda; MG 30238-30242) and eight unstudied test fragments from Luanda (MG 30243-30245) (Silva and Pereira, 2014). It does not include the specimens figured by de Loriol (1905), Caster (1938) and Dartevelle (1953). However, that was overcomed thanks to good illustrations and detailed descriptions provided by the three authors, in particular a good X-ray image of the specimen figured by de Loriol (1905) published by Dartevelle (1953, pl. 7, fig. 3).

Specimens of other species used for comparison or discussion are housed at MNHN-F (*Muséum national d'Histoire naturelle*, Paris) and MAC (*Museo di Storia Naturale Aquilegia*, Masullas, OR), as detailed in Stara and Borghi (2014; 2017).

The illustrations of de Loriol (1905) and photos of Caster (1938) and Dartevelle (1953) were used for morphometric measurements. Being amphiope essentially a flat scutelliform echinoid, measures were taken in plan view, as a percentage of Test Length using graphics programs (Autodesk Graphic 3.1); the measures of the fragments were detected using a digital calliper (0.01 mm precision). The measures of the test antero-posterior length are those provided by the mentioned authors. Morphological abbreviations (Fig. 2, *pro parte*): TL = test length; TW = test width; TH = test height; PL = antero-posterior length of the petalodium; L1 an L2 = lunule length and width, respectively; L3 = distance from the posterior petal tip to the corresponding lunule; L4 = distance from apical system to posterior margin; L5 and L6 = length and width of the frontal petal, respectively; L7 and L8 = length and width of the anterior paired petal, respectively; L9 and L10 = length and width of the posterior paired petal, respectively; L11 = distance between the posterior border of the periproct and the posterior margin; L12 = distance between the posterior border of the peristome and the posterior margin; L13 = antero-posterior diameter of the basicoronal circlet; ø pc = periproct diameter; ø ps = peristome diameter. Measures of L1 to L10 were taken from the left side of the test, where possible (Fig. 2).

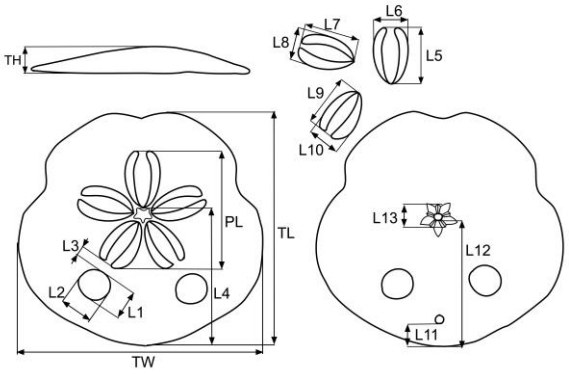

Figure 2. Scheme of biometric parameters measured in the studied *A. neuparthi* specimens.

Figura 2. Desenho esquemático dos parâmetros biométricos medidos nos exemplares de *A. neuparthi* estudados.

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In the description of the lunules two variables are considered: the "shape index" (SI), represented by the ratio L2/L1, and the "width index" (WI) which equals the area of the rectangle inscribing the lunule (L1xL2). In the case of WI, to standardize the measures, L1 and L2 are considered as percentages of TL. Given the size of the fragments, it was considered that the length of the perradial suture of the two posterior ambulacra, is about 50% of the TL; in the case of test fragments, the WI of lunules was calculated on this assumption. Numbering in plate drawings follows Lovén's (1874) system and interambulacra are shaded in grey. The higher classification used herein follows that of Kroh and Smith (2010).

With the aim of simplifying the comparisons between the numerous species of *Amphiope* to date recognized, these were divided into two informal groups based on the two main morphotypes (sensu Stara *et al.*, 2015): *A. bioculata* and *A. nuragica*. The "*nuragica*" group is characterized by narrow transversely elongate lunules with SI > 1.6, and the "*bioculata*" group is characterised by roundish to broad ovoid lunules and SI ≤ 1.6 (calculated on the population's average). The "*bioculata*" group includes: *A. bioculata* (Des Moulins, 1837), *A. bioculata* var. *drunensis* Lambert, 1915, *A. elliptica* Desor in Agassiz and Desor, 1847, *A. lovisatoi* Cotteau, 1895, *A. ovalifora* Des Moulins in Fallot, 1903, *A. neuparthi*, *A. lorioli* Lambert, 1907, *A. montezemoloi* Lovisato, 1911, *A. ludovici* Lambert, 1912, *A. romani* Stara and Borghi, 2017 and *A. romani turonensis* (Lambert, 1915) (after Stara and Borghi, 2017). The *A. nuragica* group includes: *A. sarasini* Lambert, 1907; *A. deydieri* Lambert, 1912; *A. transversifora* Lambert, 1910; *A. nuragica* (Comaschi Caria, 1955); *A. pallavicinoi* Lovisato, 1914; *A. depressa* Pomel, 1887; *A. palpebrata* Pomel, 1887; *A. tipasensis* (Aymé and Roman, 1954); *A. hollandei* Cotteau, 1877.

4. Results

The availability of several *A. neuparthi* test fragments at MG and the good X-ray image of the lost specimen illustrated by de Loriol (1905) published by Dartevelle (1953) made possible to reconstruct the fundamental specific characters necessary for an adequate redefinition of the species. The number of plates that compose the interambulacrum 5 and its oral plating, the number of plates of the ambulacra I and V and their relations with the adjacent interambulacra and the SI and WI values, calculated both in test fragments and in accurate figures provided by Loriol (1905), Caster (1938) and Dartevelle (1953), were essential for a proper and specific definition that allows the differentiation between species.

According to Stara and Borghi (2017), *A. bioculata* and other species collected in the Rhône and Bordeaux Basins (France) have relatively small lunules (WI range from a minimum of about 56 in *A. bioculata*, to a mean of 82 in *A. elliptica* and up to a maximum of about 205 in *A. ovalifora*). Only two species from the sedimentary successions of the Miocene of Sardinia show larger lunules, like those of *A. neuparthi*: *A. montezemoloi* Lovisato, 1911 and *A. lovisatoi* Cotteau, 1895 (see Stara and Borghi, 2014).

The comparison between the WI values of all species mentioned before of the *A. bioculata* group (*sensu* Stara *et al.*, 2015) shows that the only species comparable to *A. neuparthi*, from this point of view, is *A. montezemoloi* (Fig. 3) (see also the discussion chapter). Moreover, the comparison between the SI vales, the X-ray images (Fig. 5) and the presence/absence of a deep posterior interambulacral notches [see Plate 1 Figs. A, B and C and figs. 2/1 and 2/2 in Stara and Borghi (2017)] has definitively clarified that *A. neuparthi* is a distinct and valid species.

The characteristics that allow the differentiation between *A. neuparthi* and the other *Amphiope* species known to date are described in the Discussion and Systematic Palaeontology Chapters. Furthermore, the spread of *A. montezemoloi* is poorly documented, being reported sporadically (and tentatively) from the Burdigalian of Barcelona, Spain (Lambert, 1928) and from the Burdigalian of the Soummam Valley, Bejaia, Algeria (specimen MNHN-F R67289). There is no evidence of a possible spread of this species to the African Atlantic coast.

5. Discussion

The large amount of morphometric and structural data of *Amphiope* species established during the 19th century and first half of the 20th century, presented by Stara and Borghi (2017) in their systematic review of the genus *Amphiope*, provided a dataset that enables the necessary comparisons between all those species and *A. neuparthi*.

Based on those data, and according to what was mentioned above, in the Results Chapter, it was immediately noticed that, among the many fossil species belonging to the *A. bioculata* group (*sensu* Stara *et al.*, 2015) from the French Atlantic basin of Bordeaux (Lambert, 1927; Chavanon, 1974) and the Atlantic coast of northern Morocco (Lecointre, 1952; Néraudeau and Masrour, 2008), none of them presents rather large lunules, one of the *A. neuparthi* distinguishing features. Only two species from the sedimentary successions of the Miocene of Sardinia show large lunules, similar to those of *A. neuparthi*: *A. montezemoloi* Lovisato, 1911 and *A. lovisatoi* Cotteau, 1895 (see Stara and Borghi, 2014). The comparison between the WI values of all species of the *A. bioculata* group mentioned above (Fig. 3) shows that the only species comparable to *A. neuparthi*, from this point of view, is *A. montezemoloi*. The large deviation above the mean value in *A. lovisatoi* (Fig. 3) is due to one single anomalous (with five gonopores) specimen among 200 collected (personal communication of P.S.). For this reason, it was considered logical to limit the comparison of the WI values to *A. montezemoloi*. It should be noted that the average SI of *A. lovisatoi* (1.56) is very high within the group and differs considerably from those of *A. montezemoloi* (1.2) and *A. neuparthi* (1.24). The internal structure of *A. lovisatoi* is also completely different from the one of *A. neuparthi* (Fig. 5).

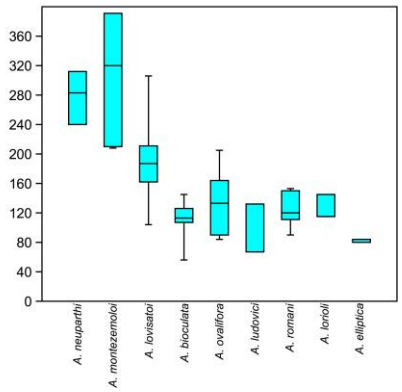

Figure 3. WI comparison between *A. neuparthi* and all other species included in the informal Bioculata group.

Figura 3. Comparação dos valores de WI entre *A. neuparthi* e todas as outras espécies incluídas no grupo informal Bioculata.

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In detail, in *A. montezemoloi* WI ranges from 200 to 400 (mean = 330, N=10), while according to the size measured in the figures of three almost complete specimens published by de Loriol (1905) and Dartevelle (1953) and numerous fragments with lunules observed during this study, in *A. neuparthi* the WI varies from 240 to 312 (mean = 278). The PL value also differs between these two species (Fig. 4), even though the sample is not very consistent: N=3 for *A. neuparthi* and N=8 for *A. montezemoloi*.

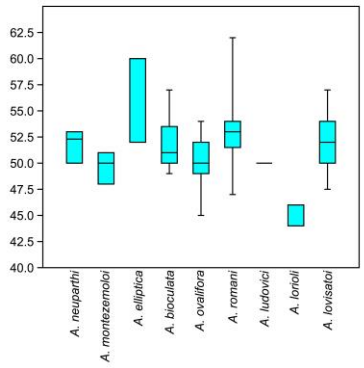

Figure 4. PL comparison between *A. neuparthi* and all other species included in the informal Bioculata group.

Figura 4. Comparação dos valores de PL entre *A. neuparthi* e todas as outras espécies incluídas no grupo informal Bioculata.

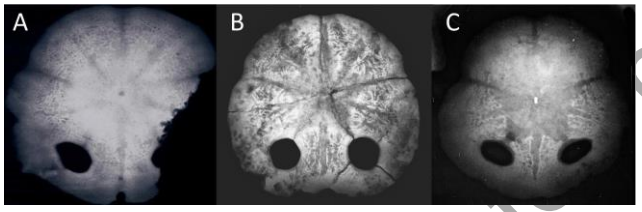

Figure 5. Internal structure (X-ray photographs) comparison between *A. neuparthi* and *A. montezemoloi* and *A. lovisatoi*. A – *A. neuparthi*; specimen illustrated by de Loriol (1905) (whereabouts unknown) from Bom Jesus, Luanda, Angola (Dartevelle, 1953, pl. 7, fig. 3); B – *A. montezemoloi*; specimen MAC PL1677 from Ardara, Sardinia, Italy (Stara and Borghi, 2017); C – *A. lovisatoi*; specimen MAC PL1702 from Chiaramonti, Sardinia, Italy (Stara and Borghi, 2017).

Figura 5. Comparação da estrutura interna (imagens de raio-X) entre *A. neuparthi* e *A. montezemoloi* e *A. lovisatoi*. A – *A. neuparthi*; exemplar ilustrado por de Loriol (1905) (localização desconhecida), Bom Jesus, Luanda, Angola (Dartevelle, 1953, pl. 7, fig. 3); B – *A. montezemoloi*; exemplar MAC PL1677, Ardara, Sardenha, Itália (Stara e Borghi, 2017); C – *A. lovisatoi*; exemplar MAC PL1702, Chiaramonti, Sardenha, Itália (Stara e Borghi, 2017).

Due to the many *A. neuparthi* test fragments available, it is possible to obtain both the plating of the post-basicoronals plates in the interambulacrum 5 and both the number of plates that compose the same interambulacrum and adjacent ambulacra, I and V. The plates in the column "a" are two while in column "b" are three (test fragments MG 30240 and MG 30243 – Plate 1, figs C-D), such as those seen in two specimens of *A. montezemoloi* (MAC PL1675, MAC PL1676). However, the length of the group of post-basiconal plates in *A. neuparthi*, corresponds to about 26% TL, whereas in *A. montezemoloi* it reaches 30% TL.

In just one specimen of *A. montezemoloi*, it is possible to count the plates of the two columns of the ambulacrum I (14-15), that corresponds to what was observed in *A. neuparthi* test fragments. Therefore, *A. neuparthi* has some morphometric features similar to those of *A. montezemoloi*, but differs from it by the presence of a rear notch and, particularly, by a different internal structure. In fact, while *A. montezemoloi* shows a much lighter structure throughout the internal support system (Fig. 5B), which extends equal from the central hollow up to almost the outer edge, with large vacuoles between the pillars, *A. neuparthi* has a dense internal structure, made of small vacuoles, which thickens more towards the outer margin. Also, while *A. montezemoloi* shows a defined pentagonal central hollow, *A. neuparthi* has it wide and sub-round.

SYSTEMATIC PALAEONTOLOGY

Family Astriclypeidae Stefanini, 1912
Genus *Amphiope* L. Agassiz, 1840

Amphiope neuparthi de Loriol, 1905

Plate 1, Figures A-D

v 1905 *Amphiope Neuparthi*, P. de Loriol 1905; de Loriol, p. 133-134, pl. 3, fig. 1.

v 1905 *A. Neuparthi*; Choffat, p. 13, note 1.

v 1914 *A. Neuparthi* de Lor.; Cottreau, p. 99, fig. 23(1).

v 1921 *A. Neuparthi* de Loriol; Lambert and Thiéry, p. 323.

v 1923 *Amphiope Neuparthi* de Loriol; Fleury, p. 236.

1938 *Amphiope* cf. *neuparthi* Loriol; Caster, p. 92-93, pl. 10.

1940 *Amphiope Neuparthi*: Dartevelle, p. 180, note 7.

1953 *Echinodiscus (Amphiope) neuparthi* (de Loriol); Dartevelle, p. 75, figs 15-16; pl. 8, figs 4, 6; pl. 15, fig. 3.

1954 *Echinodiscus (Amphiope) neuparthi* (de Loriol); Dartevelle and Roger, p. 241.

v 2014 *Amphiope neuparthi* Loriol, 1905; Silva and Pereira, p. 1380-1381, fig. 3.

Types:

Sintypes: 16 test fragments (MG 30238-30242). The whereabouts of the specimen figured by de Loriol (1905) is unknown.

Locus typicus: Bom Jesus, Luanda, Angola.

Age: Upper Burdigalian-Langhian.

Revised diagnosis: Middle to large-sized species of *Amphiope* with low test, rather deep rear marginal notch, sharp margin, and broad, subcircular to transversely elongated lunules. Only two post-basicoronal plates occur in the interambulacral column 5.a adorally. Periproct bounded by plates 5.b.2/5.a.2, rather close to the posterior test margin. Internal structure dense and becoming denser to the margin, with roundish central cavity.

Material: In addition to the type material, eight small test fragments (MG 30243-30245) from the Miocene of Luanda (Angola).

Description:

Size and shape: Test size medium to large; test length ranges from 87 to 95 mm in known material (de Loriol, 1905; Caster, 1938; Dartevelle, 1953). Outline subcircular to slightly transversely elongated. Maximal width located subcentrally. Test low (Mean TH=12% TL; N=2); maximum height coincident

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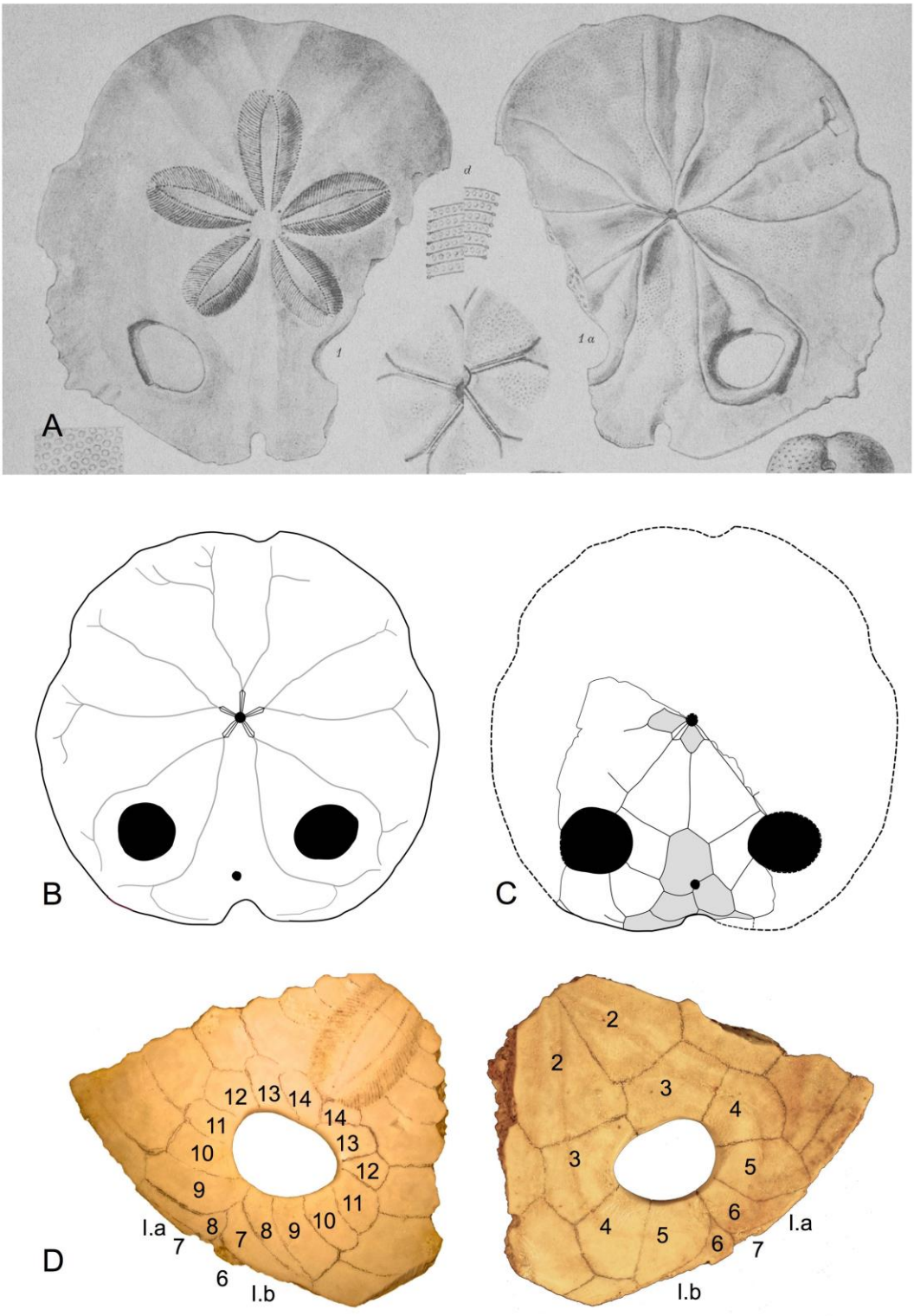

Plate I. Amphiope neuparthi, Bom Jesus and Luanda, Angola. Fig. A – Sintype (whereabouts unknown), Bom Jesus; original illustration (de Loriol, 1905: pl. III, figs 1, 1a-e). Fig. B – A. neuparthi food groove pattern. Fig. C – Oral plating structure of test fragment MG 30243, Luanda. Fig. D – Aboral (left) and oral (right) plating scheme of test fragment MG 30240 (sintype) showing the Lovén's (1874) numbering in ambulacrum V, Bom Jesus.

Estampa I. *Amphiope neuparthi*, Bom Jesus e Luanda, Angola. Fig. A – Sintipo (localização desconhecida), Bom Jesus; ilustração original (de Loriol, 1905: pl. III, figs 1, 1a-e). Fig. B – Morfologia dos sulcos alimentares de *A. neuparthi*. Fig. C – Padrão de placas esqueléticas da face oral do fragmento de carapaça MG 30243, Luanda. Fig. D – Padrão de placas esqueléticas (face aboral, à esquerda, e face oral, à direita) do fragmento de carapaça MG 30240 (sintipo), com numeração de Lovén (1874) no ambulacro V, Bom Jesus.

with the apical disc. Slight marginal sinuosities in ambulacra II, III and IV; a rather deep marginal notch is also present in interambulacrum 5. The ambitus is thin and sharp.

Apical system: The apical disc is slightly anterior of centre (mean L4=56% TL; N=2).

Ambulacra: Adapically, the ambulacra are petaloid. Petals are straight, closed distally, with a lanceolate shape.

Petalodium: The petalodium is large (mean PL=54% TL; N=3). The petals are about 20 to 30% TL long; anterior paired petals are consistently slightly shorter than the frontal petal and slightly longer than the posterior paired petals. Posterior paired petals length ranges from 78 to 87% (Mean = 81%; N=4) of frontal petal length. Maximum petal width is about one-half to two-thirds of petal length. The angle between the axis of posterior petals is large (mean α=77°; N=3). The poriferous zones are very slightly depressed; the interporiferous zones are slightly inflated and slightly wider than a single poriferous zone. The pores within the petals are closely spaced conjugate anisopores.

Tuberculation: Aboral tuberculation is dense and homogeneous, consisting of very small perforate, crenulate tubercles. The typical tubercle differentiation in locomotor and geniculate spine fields (compare Mooi, 1989: fig. 33b) can be observed. Tubercles are larger on the oral surface than adapically.

Lunules: The lunules are large (WI ranges from 240 to 312; Mean=278; N=3), sub-circular to transversely elongated (SI ranges from 1.04 to 1.44; Mean=1.24; N=6). They are separated from posterior petal by up to 8% TL; distance to posterior margin is up to about three times the distance to posterior petals. The margin on these lunules is roundish and corresponds to Fig. 3D of Stara and Borghi (2017).

Food grooves: Food grooves are well developed, bifurcating at the edge of basicoronal plates, about 15% of the corresponding test radius from peristome; secondary branching occurs in the outer third of the corresponding test radius. The posterior pair of food grooves runs around the lunules. The food grooves do not reach the margin of the test.

Interambulacra: Adapically, each interambulacrum bears two faint ridges running along each interambulacral column. They are densely covered with very small perforate, crenulate tubercles. On the oral surface, the interambulacra are very slightly inflated except adorally where they are slightly depressed along the interradial suture. As in the ambulacra, the typical sand-dollar tubercle differentiation can be observed. Only 14-15 plates in each column of interambulacra 1, 4 and 5 and ambulacra I and V; 12-13 plates in interambulacra 2 and 3, as well as in ambulacra II, III and IV. Adorally, only two post-basicoronal plates occur in the interambulacral column 5a; three in column 5b. At the most indented part of the anal notch, test margin is defined by plates 3b and 3a.

Peristome: The peristome lies slightly anterior of centre, in the oral surface. It is rather small, about 1% TL, and circular in outline.

Periproct: The periproct is rather small, about 1% TL, and circular in outline. It is separated from peristome by about 40% TL and from posterior margin by about three times its diameter (L11 about 12% of TL). Located in the distal half of the suture 5.a.2/5.b.2.

Internal structure: The central hollow is broad and vaguely roundish in shape (Fig. 5A). A large cavity extends from the central hollow through the interambulacrum 2 (containing the *caecum*?), another one longer leads to the periproct. The peripheral ballast system is dense and becomes almost massive and crossed by micro-canals towards the margin. On the test ceiling, the interporiferous areas of the petals are convex.

Remarks: *Amphiope neuparthi* differs from all the species comprised in the *A. nuragica* group (*sensu* Stara *et al.*, 2015), mainly by the lower SI. *A. neuparthi* differs from *A. bioculata, A. elliptica, A. ovalifora, A. ludovici, A. lorioli* and *A. romani*, by its higher WI, ranging from 240 to 312 (Mean=278) against the maximum of 200 reached by *A. ovalifora* (Fig. 3). Compared to *A. neuparthi*, *A. lovisatoi* also has a lower WI; although some rare specimens of this species show very large lunules, the average is about 180, and most does not exceed 200. The closest species to *A. neuparthi* are, therefore, *A. montezemoloi*, which, however, have a different internal structure from that of *A. neuparthi* (Fig. 5).

Distribution: Early-middle Miocene of Angola.

Kwanza basin: Upper Burdigalian-Langhian of Bom Jesus, near Luanda (de Loriol, 1905; Choffat, 1905; Caster, 1938; Dartevelle, 1952, 1953; Dartevelle and Roger, 1954; Antunes, 1964), Luanda and its surroundings (Dartevelle, 1952, 1953; Dartevelle and Roger, 1954; Silva and Pereira, 2014) and Porto Amboim (Dartevelle, 1952, 1953; Dartevelle and Roger, 1954).

Namibe Basin: Upper Burdigalian of Tombwa (Dartevelle, 1952, 1953; Dartevelle and Roger, 1954).

6. Conclusion

With this study, it is possible to conclude that *A. neuparthi* is distinct from any other *Amphiope* species. The morphologically closest species is *A. montezemoloi*, but, for now, it is very unlikely that they derive from the same ancestor species, due to distinct geographic distributions and structural differences.

To completely solve this problem, it is necessary, through new field campaigns or old museum collections, to deepen the knowledge about the *Amphiope* forms present in peri-Mediterranean and Atlantic-Mediterranean regions.

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