Journal of South American Earth Sciences 86 (2018) 23–37

Contents lists available at ScienceDirect

Journal of South American Earth Sciences

journal homepage: www.elsevier.com/locate/jsames

Western Gondwana non-marine ostracods from Early Cretaceous low-latitude ephemeral lake, Northeastern Brazil

Ariany de Jesus e Sousa[a,b,*], Ismar de Souza Carvalho[b], Elizabete Pedrão Ferreira[a]

[a] Petrobras/Cenpes, Horácio Macedo, 950, Ilha do Fundão, 21941-915, Rio de Janeiro, Brazil
[b] Universidade Federal do Rio de Janeiro, Instituto de Geologia, Avenida Athos da Silveira Ramos, 274, Ilha do Fundão, 21910-200, Rio de Janeiro, Brazil

ARTICLE INFO

Keywords:
Sousa formation
Taxonomy
Lower Cretaceous
Berriasian-Hauterivian
Podocopina

ABSTRACT

In the beginning of Gondwana's break up, small rift lakes were formed in the area that is nowadays located in Northeastern Brazil. These lakes captured the drainage systems and were subjected to hot and arid climatic conditions in a low-latitude area. These conditions are evidenced by the Lower Cretaceous fluvio-lacustrine deposits that filled the Sousa Basin, which integrates a complex of basins along the Rio do Peixe (State of Paraíba). The Sousa Formation is the most representative unit in the Sousa Basin, being predominantly composed of siltstones and shales deposited in shallow lacustrine environments with fluvial influence. The sedimentation occurred under a semi-arid climate with alternating rainy and dry seasons, indicating the presence of ephemeral lakes. This is also supported by the lithology, the sedimentary structures (mud cracks) and the evaporites (gypsum). The lacustrine environment is favorable to the proliferation of non-marine ostracods, which are microcrustaceans of great importance for the study of current and paleolake deposits. Non-marine ostracod assemblages recovered from the Sousa Formation, sampled from core 2-FC-1-PB, revealed undescribed species. In this work, these ostracods were studied taxonomically, with the new species *Cypridea paraibensis* sp. nov., *Cypridea vianai* sp. nov. and *Alicenula sousaensis* sp. nov., as well as the already described *Alicenula leguminella* (Forbes, 1855) Martens, Rossetti and Horne 2003, *Brasacypris ovum* Krömmelbein 1965, *Cypridea ambigua* Krömmelbein 1962, and *Reconcavona swaini* Krömmelbein 1962 being identified. Another set of taxa remained in open nomenclature, since the morphological descriptions did not fit existing species. Thus, the descriptions referring to the described groups take into consideration criteria such as similarity and variability of morphological factors (*Alicenula* ex gr. *leguminella* and *Alicenula* sp. 1), degree of preservation, and quantity of recovered carapaces.

1. Introduction

The Cretaceous period was marked by important geological and paleoclimatic global events, such as the South American Event, which includes the break-up of Gondwana and the formation of the South Atlantic (Ponte, 1992; Silva et al., 1997). In the Early Cretaceous, the Gondwana rifting process made small rifts in Northeastern Brazil, capturing the drainage system waters and forming lakes (Carvalho and Melo, 2012). These lakes occupied regions of low latitude and were subjected to arid conditions during the transition from a moderate icehouse to greenhouse condition (Anderson et al., 2007, 1999; Frakes et al., 1992; Scotese et al., 1999), which are documented in siliciclastic rocks (Françolin and Szatmari, 1987; Rocha and Amaral, 2006) in the Sousa Basin, located in the State of Paraíba (Fig. 1). The basin was filled with sediments deposited in fluvio-lacustrine environments, successively represented by the Antenor Navarro (sandstones and conglomerates), Sousa (mudstones) and Rio Piranhas (sandstone and conglomerates) formations included in the Rio do Peixe Group (Albuquerque, 1986). The Sousa Formation possesses dinosaur footprints (Carvalho, 2000; Leonardi and Carvalho, 2002), conchostracans (Carvalho and Carvalho, 1990; Tinoco and Katoo, 1975), ostracods (Braun, 1969; Mabesoone and Campanha, 1974), palynomorphs (Lima, 1983; Lima and Coelho, 1987; Regali, 1990), fish scales and crocodilian bones (Maisey, 2000).

This paper presents the first detailed taxanomic description and Scanning Electronic Microscope (SEM) photomicrographs of non-marine ostracods from Lower Cretaceous assemblages of the Sousa Formation. In addition, it includes proposals for three new species.

2. Sousa Formation

The Sousa Formation is composed predominantly of siltstones and

* Corresponding author. Petrobras/Cenpes, Avenida Horácio Macedo, 950, Ilha do Fundão, 21941-915, Rio de Janeiro, Brazil.
E-mail addresses: ariany@petrobras.com.br (A.J. Sousa), ismar@geologia.ufrj.br (I.S. Carvalho), elizabete@petrobras.com.br (E.P. Ferreira).

https://doi.org/10.1016/j.jsames.2018.06.001
Received 16 March 2018; Received in revised form 4 June 2018; Accepted 5 June 2018
Available online 08 June 2018
0895-9811/

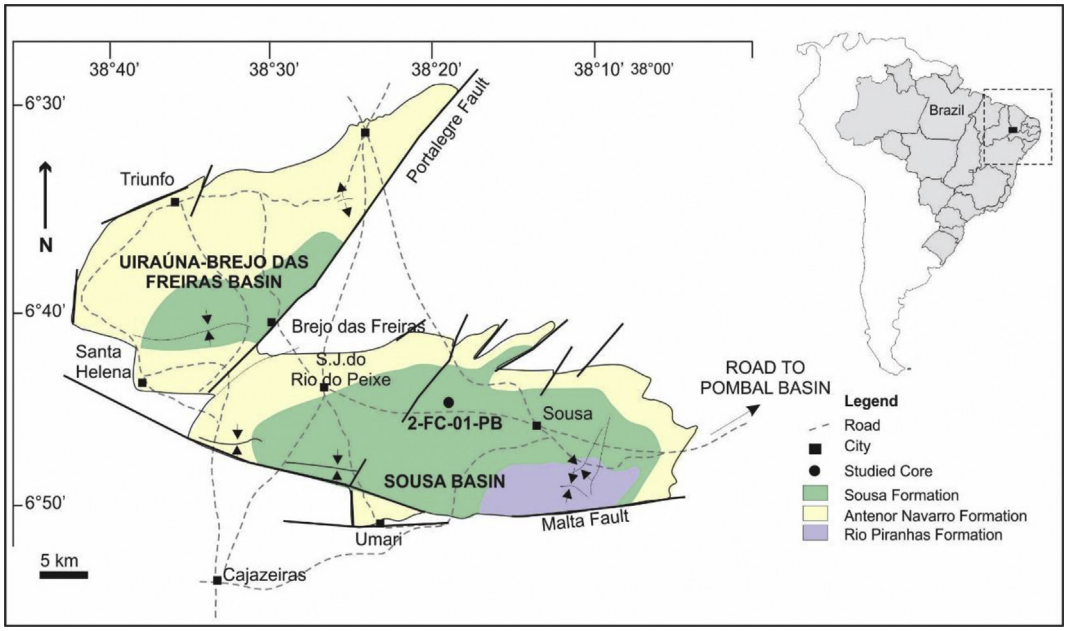

Fig. 1. Geological setting of the Sousa Basin (modified from Srivastava and Carvalho (2004)).

reddish brown shales, interbedded with fine to medium calciferous sandstones, as well as marl and limestone (Nogueira et al., 2004). The deposits show flat-parallel laminations, wavy marks, mud cracks, and diverse fossil content (Tinoco and Mabesoone, 1975). The sediments were deposited in meandering fluvial, with occasional floods of their plains, and lacustrine environments, under a semi-arid climate with alternating rainy and dry seasons (Lima-Filho, 1991).

3. Material and methods

3.1. Sample, laboratory procedures and image acquisition

Non-marine ostracods were recovered from forty of 189 samples collected from well 2-FC-01-PB (Fazenda Carnaúba: 6°44′ 47,4″S and 38°18′ 52,6″W), with about 200 m in length (Fig. 1). The core was drilled by Universidade Federal do Rio de Janeiro and comprises the main fine-grained siliciclastic section of the Sousa Formation (Fig. 2). Based on the lithology (mudstones, shales, muddy sandstones and silty sandstones) and the sedimentary structures (planar lamination, ripple cross-lamination), these rocks were interpreted as deposits of shallow lakes influenced by rivers. Periods of lake dryness are indicated by erosion levels, mud cracks and gypsum. Brackish water conditions and high evaporation rate are evidenced by the predominance of calcareous shales and evaporites. The presence of pyrite was recorded at various levels indicating periods of water-column stratification and low oxygen at the bottom of the lake.

The chemical treatment follows the steps established by Wanderley (2004). All ostracod carapaces found in each sample were picked. The taxonomic analyses were performed with a Zeiss Discovery V8 stereoscopic microscope with reflected light. Specimen photomicrographs were obtained with a Scanning Electron Microscope (SEM). All the above steps were performed in the Petrobras/Gerência de Bioestratigrafia e Paleoecologia (Rio de Janeiro, RJ). The ostracod specimens are housed in the repository of the Laboratório de Micropaleontologia/Instituto de Geociências, Universidade Federal do Rio de Janeiro (Rio de Janeiro, RJ, Brazil).

3.2. Abbreviations and parameters used in text and figures

Ostracod parameters used for the descriptions followed the premises discussed in Sames (2011). The abbreviations used to describe the valves are: LV (left valve), RV (right valve), L (length), H (height), L/H (length/height-coefficient), W (width), ACA (anterior cardinal angle), PCA (posterior cardinal angle), IHM (inclination of hinge margin in relation to base line), RLV (right lateral view), LLV (left lateral view) and DV (dorsal view). Ostracod size parameters used here were presented in Ayress and Whatley (2014): Very small: < 0.4 mm; Small: 0.40–0.50 mm; Medium: 0.51–0.70 mm; Large: 0.71–1.0 mm, Very Large: 1.10–2.0 mm, Gigantic: > 2.0 mm. Measurements were obtained using Zeiss' program AxioVision SE64 version 4.9.1.

4. Results

The non-marine ostracods recorded in this study were attributed to the Cypridoidea and Darwinuloidea superfamilies of the order Podocopida. The families Cyprideidae, Cyprididae, Darwinulidae and Ilyocyprididae were identified.

Three new species of the genera *Cypridea and Alicenula* are described. Eight other species remain in open nomenclature, assigned to the genera *Alicenula*, *Cypridea*, *Ilyocypris, Mantelliana* and *Reconcavona?*.

4.1. Systematic paleontology

The suprageneric taxonomy is based on the revised study of the Ostracoda lead by Horne (2005). The generic taxonomy adopted in this work follows Sames (2011), for genus *Cypridea*; Smith (2000) for the genus *Reconcavona*; Rossetti and Martens (1998) for the genus *Alicenula*; Anderson (1966) for the genus *Mantelliana*; and Brady and Norman (1889) for the genus *Ilyocypris*.

Class OSTRACODA Latreille 1802
Order PODOCOPIDA Sars 1866
Suborder CYPRIDOCOPINA Jones 1901
Superfamily Cypridoidea Baird 1845
Family Cyprideidae Martin 1940 (emended by Sames, 2011)
Genus *Cypridea* Bosquet 1852 (emended by Sames, 2011)

Type species: *Cypris granulosa* Sowerby 1836
Stratigraphic range: Late Jurassic to Paleogene (Sames, 2011)

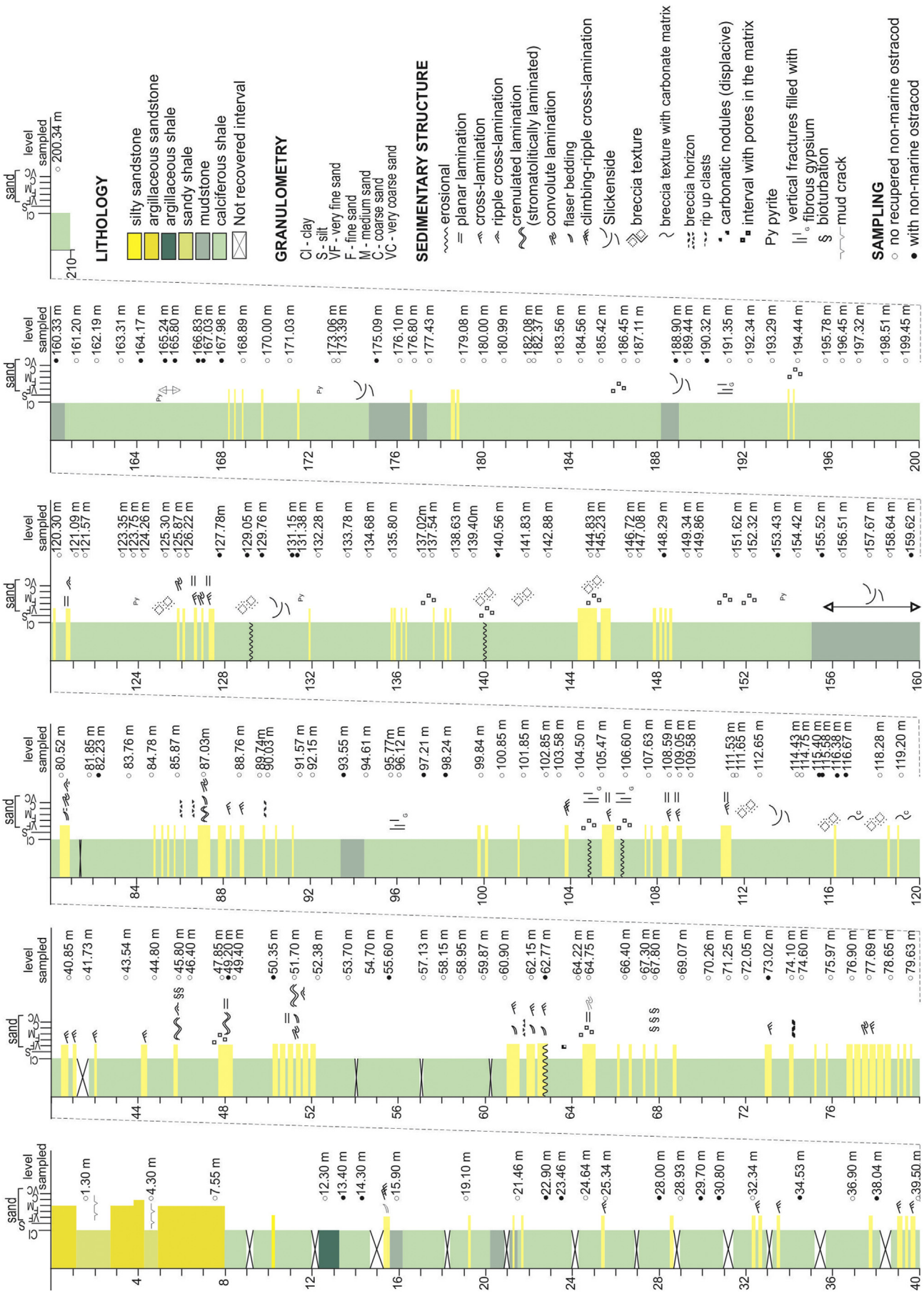

Fig. 2. Lithologic section of core 2-FC-01-PB (mod. Silva-Filho, 2009) with depth sampled for non-marine ostracods indicated.

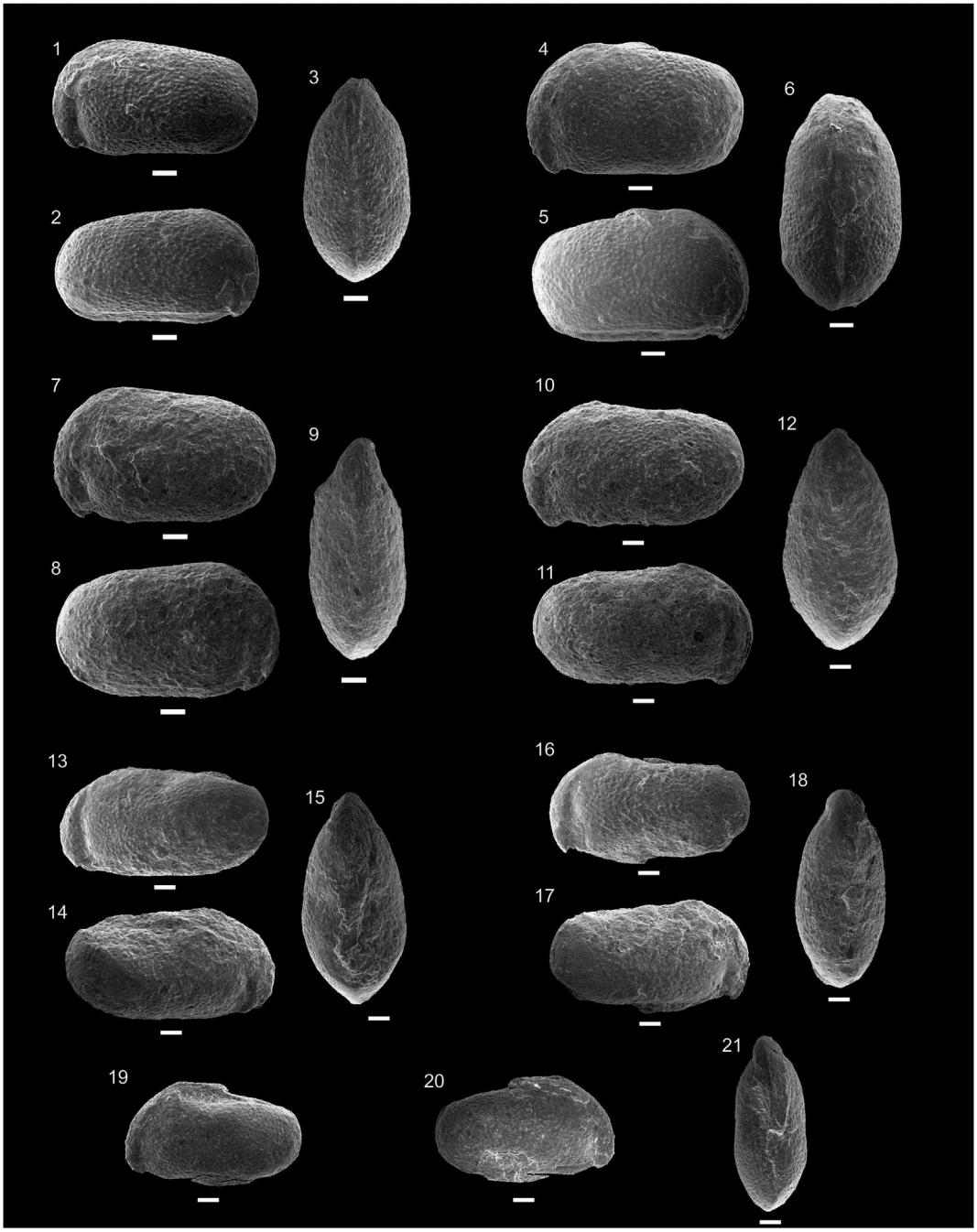

Fig. 3. 1–9 *Cypridea ambigua*, Sousa Basin, Core 2-FC-1-PB. **1–3** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0001: 1-LLV, 2-RLV, 3-DV; **4–6** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0002: 4-LLV, 5-RLV, 6-DV; **7–9** sample UFRJ-DG-LM180053, depth 165.80 m, UFRJ-DG-LMOS0003: 7-LLV, 8-RLV, 9-DV; **10–21** *Cypridea paraibensis* sp. nov., Sousa Basin, Core 2-FC-1-PB. **10–12** female, sample UFRJ-DG-LM180053, depth 165.80 m, UFRJ-DG-LMOS0004: 10-LLV, 11-RLV, 12-DV; **13–15** male, sample UFRJ-DG-LM180042, depth 148.29 m, UFRJ-DG-LMOS0006: 13-LLV, 14-RLV, 15-DV; **16–18** male, sample UFRJ-DG-LM180043, depth 153.43 m, UFRJ-DG-LMOS0007: 16-LLV, 17-RLV, 18-DV; **19–21** juvenile, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0008: 19-LLV, 20-RLV, 21-DV; Scale bar = 100 μm.

*Cypridea ambigua*Krömmelbein 1962
Fig. 3, 1-9

1962 *Cypridea ambigua* Krömmelbein (1962), p. 511, taf. 57, fig. 28a–c.

Figured specimens: Fig. 3, 1–3, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0001, L: 0.84 mm; H: 0.47 mm; W: 0.44 mm 4–6, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0002, L: 0.89 mm; H: 0.53 mm; W: 0.38 mm 7–9, sample UFRJ-DG-LM180053, depth 165.80 m, UFRJ-DG-LMOS0003, L: 0.91 mm; H: 0.55 mm; W: 0.38 mm.

Material: 26 carapaces of adults and juveniles.

Dimensions (in mm): L: 0.82–0.94; H: 0.44–0.56; W: 0.36–0.50.

Type locality and horizon: DJ-2-BA core, depth 99.4–101.5 m, lower portion of the Candeias Formation.

Holotype: Deposited in the collection of the Senckenberg Naturmuseum, Frankfurt-am-Main, holotype no. Xe 4189, and paratype Xe 4190.

Description: Large-sized carapace, with coarse punctation. Rectangular in lateral outline with equicurvate anterior and posterior

margins. The margins' curvature are similar, but the posterior margin is slightly thinner than the anterior. Maximum length slightly below the mid-height; maximum height at about 1/3 of length (at anterior cardinal angle); maximum width behind the mid-length. The anteroventral margin has a well-developed rostrum slightly bending backwards that is not attached to the anteroventral margin and can reach slightly the ventral margin. Broad rostrum with rounded extremity. Broad and deep alveolar groove in LV, reaching beyond mid-height. In RV, the alveolar groove is less evident than in LV and does not reach 1/3 of the height. L/H ratio 1.66–1.78. Dorsal margin straight, with hinge margin weakly inclined towards posterior (IHM around 6°). Anterior and posterior cardinal angles rounded and not always well defined (ACA = 135°–150° PCA = 118°–135°). The carapace has a normal overlap and a high level of symmetry. The greatest difference between the LV and RV is in the outline of the ventral region. In this region, the smaller valve is relatively straighter than the larger one, which is slightly concave. Valve overlap is relatively uniform, except for the ventral region, where the LV strongly overlaps the RV. The dorsal view is elongate-ovate, flattened toward the anterior margin. Both valves with dorsolateral depression better visualized in dorsal view. Small nodes ornamentation seems to develop in the anterior and posterior margin areas of some specimens (Fig. 2.8). No internal characters and sexual dimorphism were observed.

Discussion: The material presented is slightly larger than the holotype (L: 0.76 mm; H:0.46 mm), described by Krömmelbein (1962), and displays a smaller cyathus. It differs from other *Cypridea* species presented in this paper, because it is smaller, always has a cyathus, and its small valve displays a concave ventral margin (not always observed in the larger valve).

Faunal association in the Sousa Formation: *Alicenula leguminella*, *A.* ex gr. *leguminella*, *A. sousaensis* sp. nov., *A.* sp. 1, *Brasacypris ovum*, *Cypridea paraibensis* sp. nov., *C. vianai* sp. nov. and *Ilyocypris* sp. 1.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin, Paraíba State, Brazil (this work); Candeias and Itaparica formations, Recôncavo-Tucano Basin, Bahia state, Brazil (Krömmelbein, 1962; Viana, 1966a); Sergipe Basin, Sergipe state, Brazil (Cassab et al., 1994; Krömmelbein, 1966), Gabon Basin, Gabon (Viana, 1966b). All *Cypridea ambigua* occurrences in these basins were found in Berriasian sections.

Paleoecology: *Cypridea ambigua* was recorded in deep lacustrine rocks in Sergipe-Alagoas and Recôncavo-Tucano basins, Brazil (Feijó, 1994); this species is also found in deep lacustrine facies in the Gabon Basin (Smith, 1995). The occurrence of *C. ambigua* in the Sousa Formation indicates that this species can also inhabit shallow ephemeral lakes with high evaporation rate.

Cypridea paraibensis sp. nov.
Fig. 3, 10-21

Etymology: Named after the State of Paraíba, located in NE Brazil, where the species was first found.

Holotype: UFRJ-DG-LMOS 0004 (Fig. 3, 10–21), female, sample UFRJ-DG-LM180053. L: 1.03 mm; H: 0.57 mm; W: 0.53 mm.

Paratypes: Fig. 3, 13–15, male, sample UFRJ-DG-LM180042, depth 148.29 m, UFRJ-DG-LMOS0006, L: 0.97 mm; H: 0.49 mm; W: 0.48 mm 16–18, male, sample UFRJ-DG-LM180043, depth 153.43 m, UFRJ-DG-LMOS0007, L: 0.93 mm; H: 0.47 mm; 0.42 mm 19–21, juvenile, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0008, L: 0.82 mm; H: 0.45 mm; W: 0.33 mm.

Material: 23 adults and juveniles carapaces.

Dimensions (in mm): L: 0.88–1.03; H: 0.45–0.57; W: 0.35–0.53.

Type locality and horizon: Sousa Formation, Sousa Basin.

Diagnosis: Normal valve relationship (LV > RV), oblong lateral outline with supracurvate posterior region, slight sulcus in the center of the dorsolateral region visible in dorsal and lateral views. Dorsal margin weakly inclined, cyathus absent, rostrum and alveolar notch well developed.

Description: Large carapace with diffuse punctation. Oblong in lateral outline with equicurvate anterior margin and supracurvate posterior margin. The posterior region is thinner than the anterior region. Maximum length at mid-height; maximum height at anterior third; maximum width behind mid-length. L/H ratio between 1.95 and 1.79. The anteroventral margin has a well-developed rostrum, which is not attached to the anteroventral margin, bending backwards and ending together with the ventral outline. Broad rostrum with rounded to pointy extremity. Broad and deep alveolar groove. Dorsal margin straight, with hinge margin weakly inclined towards posterior (IHM around 6°). Anterior and posterior cardinal angles rounded and not always well defined (ACA = 143°–147° PCA = 139°–154°). The ventral region has a weak concavity in both valves. The carapace has a normal overlap and a high level of symmetry. The valve overlap is weak, with the exception of the posterior cardinal angle and the ventral region, where the LV clearly overlaps the RV. The dorsal view is elongate-ovate, flattened toward the anterior margin. In dorsal view, the dorsolateral depression is clear in both valves. No internal characters were observed in the recovered material.

Morphologic variations: Few variations were observed. The most prominent variation is the degree of the supracurvature in the posterior margin. In the paratypes, the alveolar groove can be more intense.

Ontogenetic variation: Not all ontogenetic stages were recovered, but it was observed that juvenile specimens are smaller and have a stronger inclination of the dorsal margin.

Dimorphism: The holotype (Fig. 3, 10–12) is a female in which the posterior margin is broadly curved and the supracurvate degree is weaker than in the males, which are represented by paratypes UFRJ-DG-LMOS0006 (Fig. 3, 13–15) and UFRJ-DG-LMOS0007 (Fig. 3, 16–18).

Discussion: *Cypridea paraibensis* sp. nov. is a new ostracod species easily identified by its elongate oblong outline. It is more elongate in lateral view than *Cypridea vianai* sp. nov. and other Lower Cretaceous *Cypridea*, such as *Cypridea vulgaris* Krömmelbein 1962 and *Cypridea ambigua* Krömmelbein 1962.

Differential diagnosis: Differs from the other *Cypridea* described in this paper by being the most elongated. Besides that, the cyathus is always absent, and the posterior region is supracurvate and presents a low dorsal margin inclination, which provides a rectangular appearance to the fossil.

Faunal association: *Alicenula leguminella*, *A.* ex gr. *leguminella*, *A. sousaensis* sp. nov., *A.* sp. 1, *Brasacypris ovum*, *Cypridea ambigua*, *C. vianai* sp. nov. and *Ilyocypris* sp. 1.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin, the Berriasian-Hauterivian age.

Paleoecology: The Cypridea genus prefers freshwater, but tolerates non-marine saline waters (Horne, 2002). An environmental preference for non-marine saline waters has been attributed to C. paraibensis sp. nov. The Sousa Formation's sedimentation occurred in shallow ephemeral lakes with gypsum levels, indicating non-marine saline water conditions in the studied core.

Cypridea vianai sp. nov.
Fig. 4, 1-12

Etymology: Named after the geologist and paleontologist Cleantho Fialho Viana, in recognition of his important contribution to micropaleontology and biostratigraphy in Brazil.

Holotype: UFRJ-DG-LMOS 0009 (Fig. 4, 1–3), sample UFRJ-DG-LM180050. L: 1.12 mm; H: 0.63 mm; W: 0.57 mm.

Paratypes: Fig. 4, 4–6, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0010, L: 0.95 mm; L: 0.58 mm; W: 0.36 mm 7–9, sample UFRJ-DG-LM180053, depth 165.80 m, UFRJ-DG-LMOS0011, L: 0.95 mm; H: 0.58 mm; W: 0.36 mm; 10–12, sample UFRJ-DG-LM180001, depth 13.40 m, UFRJ-DG-LMOS0012, L:

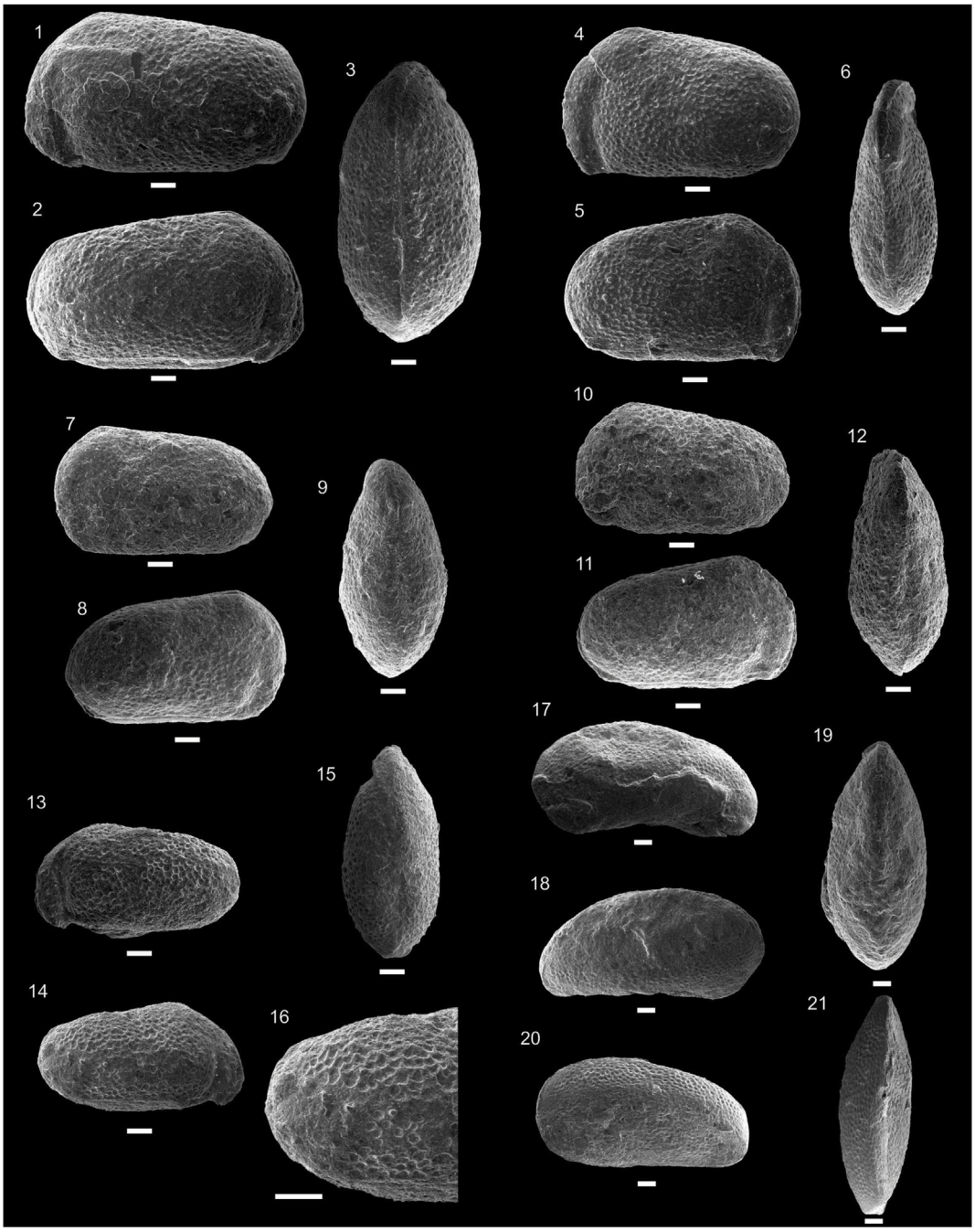

Fig. 4. 1–12 *Cypridea vianai* sp. nov., Sousa Basin, Core 2-FC-1-PB. **1–3** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0009: 1-LLV, 2-RLV, 3-DV; **4–6** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0010: 4-LLV, 5-RLV, 6-DV; **7–9** juvenile, sample UFRJ-DG-LM180053, depth 165.80 m, UFRJ-DG-LMOS0011: 7-LLV, 8-RLV, 9-DV; **10–12** juvenile, sample UFRJ-DG-LM180001, depth 13.40 m, UFRJ-DG-LMOS0012: 10-LLV, 11-RLV, 12-DV; **13–16** *Cypridea* sp. 1, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180004, depth 22.90 m, UFRJ-DG-LMOS0015: 13-LLV, 14-RLV, 15-DV, 16-Detail of RV nodes of 4.14; **17–21** *Mantelliana* sp. Sousa Basin, Core 2-FC-1-PB. **17–19** sample UFRJ-DG-LM180019, depth 62.77 m, UFRJ-DG-LMOS0016: 17-LLV, 18-RLV, 19-DV; **20–21** sample UFRJ-DG-LM180018, depth 55.60 m, UFRJ-DG-LMOS0017: 20-LLV, 21-DV; Scale bar = 100 μm.

0.84 mm; H: 0.52 mm; W: 0.40 mm.

Material: 50 complete adult and juvenile carapaces.

Dimensions (in mm): L: 0.78–1.12; H: 0.5–0.63; W: 0.31–0.57.

Type locality and horizon: Sousa Formation, Sousa Basin.

Diagnosis: True cyathus prominent and always present. Dorsal margin well inclined (IHM circa 10°) and straight. The ventral margin is sinuous. No dorsal sulcus. Salient anterior and posterior cardinal angle. Surface strongly punctated, small rostrum and well-developed alveolar notch.

Description: Large carapace, with coarse and deep punctation grading to a weak reticulation. Truncated pentangular lateral outline, with equicurvate anterior and posterior margins. The posterior margin is narrower than the anterior and possesses a well-developed cyathus. Maximum length slightly bellow mid-height; maximum height at anterior cardinal angle (about 1/4 of length); maximum width behind mid-length. L/H ratio between 1.63 and 1.77. The carapace has a normal overlap (LV > RV) and a high level of symmetry. LV overreaches RV along the entire free margin, with a prominent overlap in the ventral, posterior region and slightly above the anteroventral region. Dorsal margin straight, with hinge margin inclined towards

posterior (IHM around 10°). Conspicuous anterior and posterior cardinal angles (ACA = 133°–141°; PCA = 130°–140°). The anteroventral margin has a small rostrum blandly bending backwards that is almost aligned with the ventral outline. Broad rostrum with rounded extremity. Broad and deep alveolar groove reaching 1/3 of the height in the RV; in the holotype, the alveolar groove is covered in the LV. No internal characters were observed in the recovered material. In dorsal view, the carapace is elongate-ovate, flattened toward the anterior margin, which gives a fusiform aspect. Small node-like ornamentation is present in anterior margin and in posterolateral region.

Morphologic variations: Minor, mostly in relation of the size of the alveolar sulcus, which is more developed in the LV (reaching up to 1/2 of height) than in the RV (1/3 of height) in some paratypes.

Ontogenetic variation: Not observed.

Dimorphism: Not observed.

Discussion: Coimbra et al. (2002) suggested that some species of the genus *Cypridea* are erroneously used to indicate the presence of *Cypridea vulgaris* Krömmelbein 1962, due to the similarity of their morphological features. These cases are usually referred to as *Cypridea* aff. *vulgaris* (Bate, 1999; Braun, 1969; Grosdidier et al., 1996; Viana, 1966b). In this paper, *Cypridea vianai* sp. nov. is indicated as related to *C. vulgaris* and *C.* aff. *vulgaris*. The specimens illustrated by Coimbra et al. (2002) and the fossil recovered in the Recôncavo-Tucano basins (Krömmelbein, 1962) are, in fact, *C. vulgaris*, which shows a more inflated carapace and possesses a rounded outline, when compared with *Cypridea vianai* sp. nov. It is important to emphasize that *C.* aff. *vulgaris* was described in the Sousa Basin by Braun (1969); however, the fossil was not photographed and only a drawing is presented in the publication. Neither description nor information about the specimens' repository are available. Therefore, the occurrence of *Cypridea vulgaris* in the basin remains uncertain.

Differential diagnosis: Differs from *Cypridea paraibensis* sp. nov. in the well-inclined dorsal margin, salient cardinal angles, straight ventral and dorsal margins, lack of dorsal depression, prominent and always present cyathus and small rostrum. The *C. vulgaris* holotype is different from the *C. paraibensis* one due to a rounded outline, not so prominent cardinal angles, slightly curved dorsal margin, and an inflated fusiform shape in dorsal view. *Cypridea vianai* sp. nov. possesses prominent cardinal angles whereas *Cypridea ambigua* has the cardinal angles with a rounded aspect. Also, the dorsal margin is straighter and inclinated more strongly (around 10°) in *C. vianai* than in *C. ambigua* (around 6°).

Faunal association: *Alicenula leguminella*, *A.* ex gr. *leguminella*, *A.* sp. 1, *Brasacypris ovum*, *Cypridea ambigua*, *C. paraibensis* sp. nov., *C.* sp. 1 and *Ilyocypris* sp. 1.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin, the Berriasian-Hauterivian age.

Paleoecology: The *Cypridea* genus usually prefers freshwater, but tolerates non-marine saline waters (Horne, 2002). *C. vianai* also tolerates saline waters, having been found in the shallow ephemeral lake deposit with gypsum levels of the Sousa Formation.

Cypridea sp. 1
Fig. 4, 13-16

Figured specimens: Fig. 4, 13–16, juvenile, sample UFRJ-DG-LM180004, depth 22.90 m, UFRJ-DG-LMOS0015, L: 0.81; H: 0.42; W: 0.39.

Material: One complete, well-preserved carapace.

Dimensions (in mm): L: 0.81; H: 0.42; W: 0.39.

Description: Large carapace with a, reticulated and sub-ovoid lateral outline. Anterior margin slightly infracurvate and posterior margin slightly supracurvate. The posterior region is thinner than the anterior region. Maximum length at mid-height; maximum height at about 1/3 of length, at anterior cardinal angle; maximum width behind the mid-length. L/H ratio 1.91. The anteroventral margin has a well-developed rostrum not attached to it and finishing together with the ventral outline. Rostrum rounded. Deep alveolar groove, reaching up to 2/3 of height in LV and 1/2 in RV. Dorsal margin slightly convex, with hinge margin inclined towards posterior (IHM around 9°). Anterior cardinal angle defined (ACA = 155°), posteriorcardinal angle rounded and not well defined (PCA = 143°). The ventral region is straight in both valves. The carapace has a normal overlap and a high level of symmetry. The valve overlap is weak in almost the entire outline, with the exception of the posterior cardinal angle, where the LV overlap is clear, and the ventral region, where the LV strongly overlaps the RV. This condition can be attributed to the preservation process. The dorsal view is elongate-ovate, flattened toward the anterior margin. Both valves with dorsolateral sulcus more easily visible in dorsal view. No internal characters were observed in the recovered material. Morphologic, ontogenetic and dimorphism variations were not observed.

Discussion: The species *Cypridea* sp. 1 remains in open nomenclature due to uncertainty regarding it being a juvenile or adult exemplar. Only one complete carapace was recovered in the studied material. More sampling in different regions is recommended, so that, with more carapaces, it might be possible to elucidate the taxonomic status.

Differential diagnosis: *Cypridea* sp. 1 can be distinguished from other *Cypridea* by its small size and ovoid outline. The other *Cypridea* found in the studied region displays an oblong to sub-oblong outline.

Faunal association: *Alicenula leguminella*, *A.* ex gr. *leguminella* and *Cypridea vianai* sp. nov.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin, the Hauterivian Age.

Paleoecology: It is assumed that *Cypridea* sp. 1 tolerated non-marine saline waters of shallow ephemeral lake deposits.

Family Cyprididae Baird 1845
Genus *Brasacypris* Krömmelbein 1965

Type species: *Brasacypris ovum* Krömmelbein 1965
Stratigraphic range: Lower Cretaceous (Krömmelbein, 1965)

Brasacypris ovum Krömmelbein 1965 emended
Fig. 5, 1-26

1965 *Brasacypris ovum* Krömmelbein (1965), p. 213, taf. 15, fig. 19.

Figured specimens: Fig. 5, 1–3, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0018, L: 2.01 mm, H: 1.37 mm, W: 0.97 mm 4–7, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0019, L: 1.64 mm; H: 1.11 mm; W: 0.84 mm 8–10, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0020, L: 1.52 mm; H: 0.98 mm; W: 0.69 mm 11–13, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0021, L: 1.35 mm; H: 0.93 mm; W: 0.69 mm 14–16, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0022, L: 1.33 mm; H: 0.85 mm; W: 0.60 mm 17–19, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0023, L: 1.01 mm; H: 0.62 mm; W: 0.34 mm 20–22, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0024, L: 0.66 mm; H: 0.46 mm; W: 0.34 mm; 23–26, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0025, L: 1.13 mm; H: 0.78 mm; W: 0.56 mm.

Material: 161 complete adult and juvenile carapaces. Recovery of ontogenetic series, shown in Fig. 5Fig. 5.

Dimensions (in mm): L: 2.01–2.09; H: 1.37–1.42; W: 0.83–0.97.

Type locality and horizon: Bahia series from Tucano Basin, Itaparica and Candeias Formation.

Holotype: Senckenberg Natural History Museum, Frankfurt, Germany; holotype nº Xe 5369; and paratypes nº Xe 5370.

Original Diagnosis: "Gehäuse groβ (um 1.2 mm Gehäuse-Länge), dickschalig. Seiten-Umriß eiförmig; Rücken-Umriß dick bikonvex. Beide Dorsalwinkel ausgeprägt, jedoch gerundet. Rückenrand gerade, ziemlich steil nach hinten geneigt. Bauchrand konvex. Linke Kappe größer als die rechte Klappe, übersteht diese allseitig, besonders

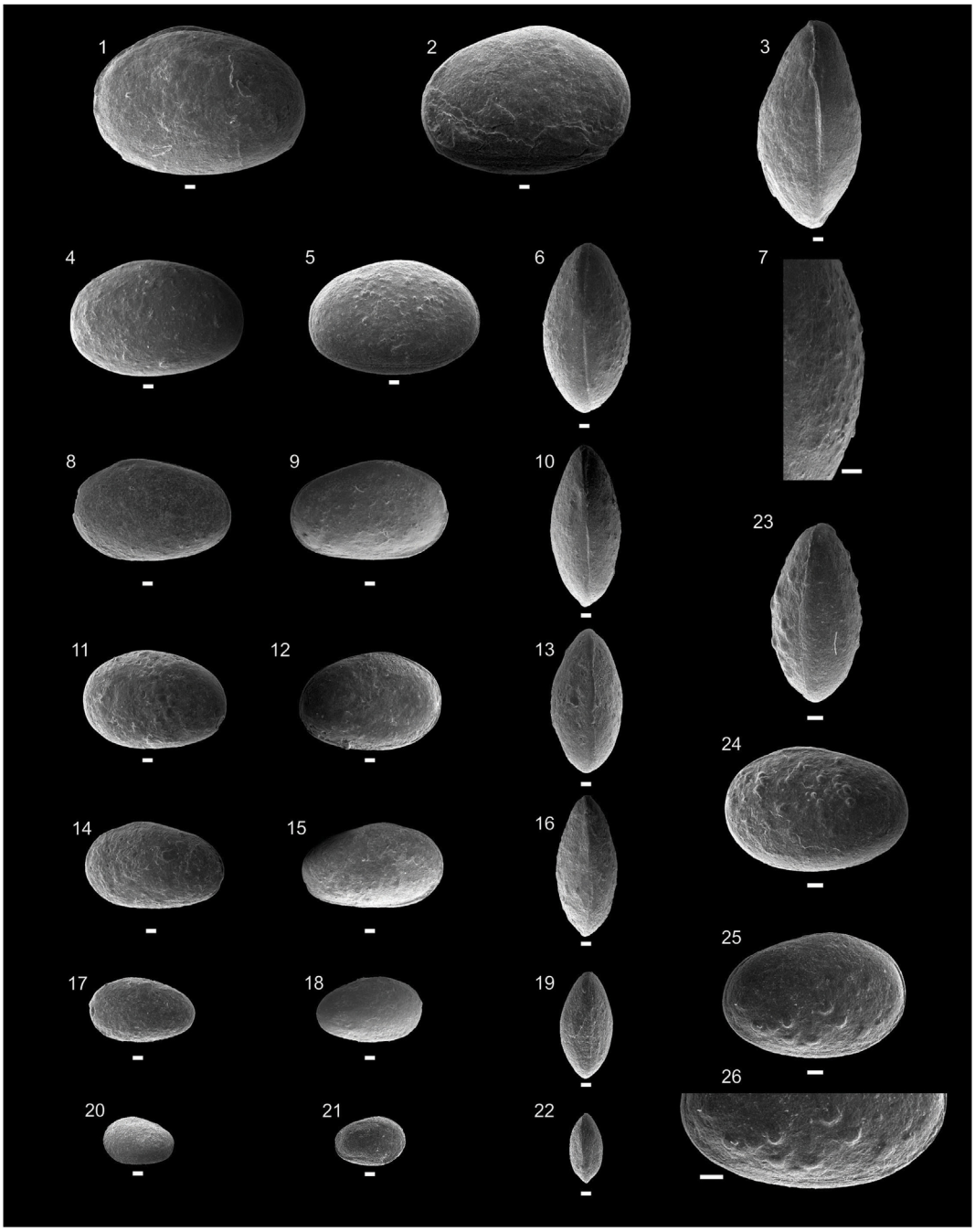

Fig. 5. 1–26 *Brasacypris ovum*, Sousa Basin, Core 2-FC-1-PB. **1–3** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0018: 1-LLV, 2-RLV, 3-DV; **4–7** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0019: 4-LLV, 5-RLV, 6-DV, 7- Detail of nodes in DV (Fig. 5.6); **8–10** sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0020: 8-LLV, 9-RLV, 10-DV; **11–13** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0021: 11-LLV, 12-RLV, 13-DV; **14–16** sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0022: 14-LLV, 15-RLV, 16-DV; **17–19** sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0023: 17-LLV, 18-RLV, 19-DV; **20–22** sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0024: 20-LLV, 21-RLV, 22-DV; **23–26** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0025: 23-DV, 24-LLV, 25-RLV, 26- Detail of RV nodes of 5.25; Scale bar = 100 μm.

deutlich und teilweise überlappend entlang dem Bauchrand und dem unteren Abschnitt des Vorder- und Hinterrandes. Gehäuse-Oberfläche glatt. (Innere Cehäuse-Merk-male nicht bekannt. Vermutlich eine Gattung der Cyprididae von noch unbekannter Unterfamilien-Zugehörigkeit.) Unter-Kreide" Translation: "Large carapace (carapace length about 1.2 mm), thick wall. Lateral outline oviform; dorsal outline strongly biconvex. Both dorsal angles pronounced, but rounded. Dorsal margin straight, steeply inclined backward. Convex ventral margin. The left valve is larger than the right one, surpassing it in all the margins, more intensely and partially overlapping it along the ventral margin and in the lower part of the anterior and posterior margins. Smooth carapace surface. (inner shell characteristics unknown. Possibly a genus of Cyprididae, subfamily affiliation still unknown.) Lower Cretaceous."

Emended diagnosis: Smooth or ornamented with nodes, gigantic well-calcified carapace. Characterized by ovoid lateral outline and greatest height almost at the mid-length (slightly forward). Anterior and posterior margins rounded, ventral margin straight at RV and convex at LV. Dorsal view strongly biconvex.

Emmended description: Gigantic carapace can be smooth or

ornamented with nodes. The outline in lateral view is ovoid. The curvature of the anterior and posterior margins varies from equicurvate to slightly supracurvate. The posterior region is a little bit lower than the anterior region, with this difference being easily noticed in juveniles. Maximum length slightly below mid-height; maximum height at anterior cardinal angle; maximum width behind mid-length. L/H ratio between 1.4 and 1.6. Dorsal margin straight, with hinge margin inclined towards posterior (IHM from 12° to 16°). Anterior and posterior cardinal angles rounded and poorly defined in most adults (ACA = 150°–158° PCA = 148°–150°). The ventral margin is straight in RV and convex in LV. The carapace has a normal overlap and a high level of symmetry. The valve overlap is homogeneous, with the exception of the ventral and anterodorsal regions, where the LV strongly overlaps the RV. In dorsal view the carapace is ovate, flattened toward the anterior margin. No internal characters were observed in the recovered material.

Morphologic variations: In rare cases, little nodes can be observed in the carapace surface.

Ontogenetic variation: The instars present a more inclined hinge margin than the adults. This variation results in a triangular aspect for the juveniles, instead of the ovoid outline observed in adult specimens. The posterior region also shows variation from acute to rounded in successional juveniles.

Dimorphism: Not observed

Discussion: *Brasacypris ovum* was described by Krömmelbein (1965) as an ovoid, large, smooth ostracod. The present study is the first to document its valve surface ornamentation and its ontogenetic series. Because of that, *Brasacypris ovum* is emended here. The variation in the ontogenetic series shows that the ovoid outline is an adult's feature, while the juveniles tend to be triangular. The triangular outline in juveniles is a common characteristic in ostracods, but, due to the big size difference between juveniles and adults, it is important to highlight the ontogenetic series and its variations.

Noding is a rare phenomenon in *Brasacypris ovum* and tends to occur in juveniles. This fact suggests that the mechanism for the appearance of nodes is similar in both *B. ovum* and *Cyprideis torosa* (Jones 1885). The noding process in *C. torosa* is an ecophenotic feature induced by the variations in water salinity and calcium content (Keyser, 2005), as in *B. ovum*. Also, in juveniles of *C. torosa* the nodes are more common than in the adults ones (Keyser and Aladin, 2004); the same is observed in *B. ovum*.

Differential diagnosis: *B. ovum* is similar to *Pattersoncypris micropapillosa* Bate 1972. It can be easily distinguished from the latter by its strongly calcified carapace, larger size, and convex ventral margin with strong LV overlap. Besides the morphological differences, the stratigraphic range is very different as well.

Faunal association: *Cypridea ambigua*, *C. paraibensis* sp. nov., *C. vianai* sp. nov., C. spp., *Alicenula leguminella*, A. ex gr. leguminella, *A. sousaensis* sp. nov., *A* sp. 1, *A.* spp. and *Ilyocypris* sp. 1.

Stratigraphic and geographic distribution: *B. ovum* is found in the Berriasian rocks of the Bahia series from Tucano Basin, Itaparica and Candeias Formation (Krömmelbein, 1965, 1966); in the Berresian sections of the Sergipe-Alagoas Basin (Cassab et al., 1994); and in the Sousa Formation, Sousa Basin (this paper).

Paleoecology: *Brasacypris ovum* was recorded in deep lacustrine rocks in Sergipe-Alagoas and Recôncavo-Tucano the basins, Brazil (Feijó, 1994); in the Sousa Formation (Sousa Basin), this species inhabited shallow ephemeral lakes, with water salinity variation suggested by the presence/absence of nodes in the carapaces.

Genus *Mantelliana* Anderson 1966

Type species: *Candona mantelli* Jones 1888

Stratigraphic range: Upper Jurassic to Lower Cretaceous (Anderson, 1966)

Mantelliana sp.
Fig. 4, 17-21

Figured specimens: Fig. 4, 17–19, sample UFRJ-DG-LM180019, depth 62.77 m, UFRJ-DG-LMOS0016, L: 1.16 mm; H: 0.58 mm; W: 0.51 mm; 20–21, sample UFRJ-DG-LM180018, depth 55.60 m, UFRJ-DG-LMOS0017, L: 1.20 mm; H: 0.62 mm; W: 0.42 mm.

Material: Four fragmented adults carapaces.

Dimensions (in mm): L: 1.16–1.2; H: 0.58–0.62; W: 0.42–0.52.

Description: Very large, elongate sub-trapezoidal carapace, coarse punctation grading to reticulate ornamentation. Anterior and posterior margins infracurvate. The anterior region is rounder and larger than the posterior region. Maximum length below mid-height; maximum height at almost the middle of the length; maximum width behind the mid-length. L/H ratio 1.93–1.99. Dorsal margin convex, with hinge margin inclined towards posterior (IHM around 17°–14°). Anterior cardinal angle rounded (ACA = 159–166°), and posterior cardinal angle distinct (PCA = 158°–149°). The ventral region varies from slight concave to strongly concave in both valves. The carapace has a normal overlap and a high level of symmetry. The valve overlap is weak along the entire outline. The dorsal view is elongate. No internal characters were observed in the recovered material.

Morphologic variations: The specimens show variation in lateral outline, dorsal view and at the end of the posterior region. These variations can be the product of the preservation process, or, maybe, there is more than one species of the *Mantelliana* genus in the Sousa Basin rocks.

Ontogenetic variation: Not observed.

Dimorphism: Not observed.

Discussion: Unfortunately, the low recovery and the poor state of preservation of these ostracods did not allow a refined taxonomy. The carapaces are identified only to the generic level. More studies are required to better investigate the distribution and the taxonomy of this group.

Faunal association: *Alicenula* ex gr. *leguminella*, *Alicenula leguminella*, *Alicenula* spp., *Alicenula* sp. 1, *Reconcavona*? spp.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin.

Genus *Reconcavona* Krömmelbein 1962

Type species: *Candona*? *striatula* Swain 1946.

Stratigraphic range: Upper Jurassic (Guzmán-González et al., 2016)? to lower Cretaceous (Smith, 2000).

Reconcavona swaini Krömmelbein 1962.
Fig. 6, 1-6

1962 *Reconcavona swaini* Krömmelbein (1962), p.519, taf. 61, fig. 60a–c.

1984 *Reconcavona swaini* Grosdidier and Bignoumba (1984), p. 95, pl. 1, fig. 10.

Figured specimens: Fig. 6, 1–3, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180038, depth 129.76 m, UFRJ-DG-LMOS0026, L: 0.86 mm; H: 0.44 mm; W: 0.25 mm 4–6, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180038, depth 129.76 m, UFRJ-DG-LMOS0027, L: 0.81 mm; H: 0.42 mm; W: 0.25.

Material: 16 complete adult carapaces.

Dimensions (in mm): L: 0.81–0.86; H: 0.42–0.44; W: 0.25–0.26.

Type locality and horizon: Lower Cretaceous, Ilhas Formation, Recôncavo Basin, Brazil.

Holotype: Deposited in the collection of the Natur-Museum Senckenberg, Frankfurt-am-Main, Holotype no. Xe 4238, and paratypes no. Xe 4239.

Description: Large, round carapace, no ornamentation observed. Anterior margin equicurvate and posterior margin infracurvate. The

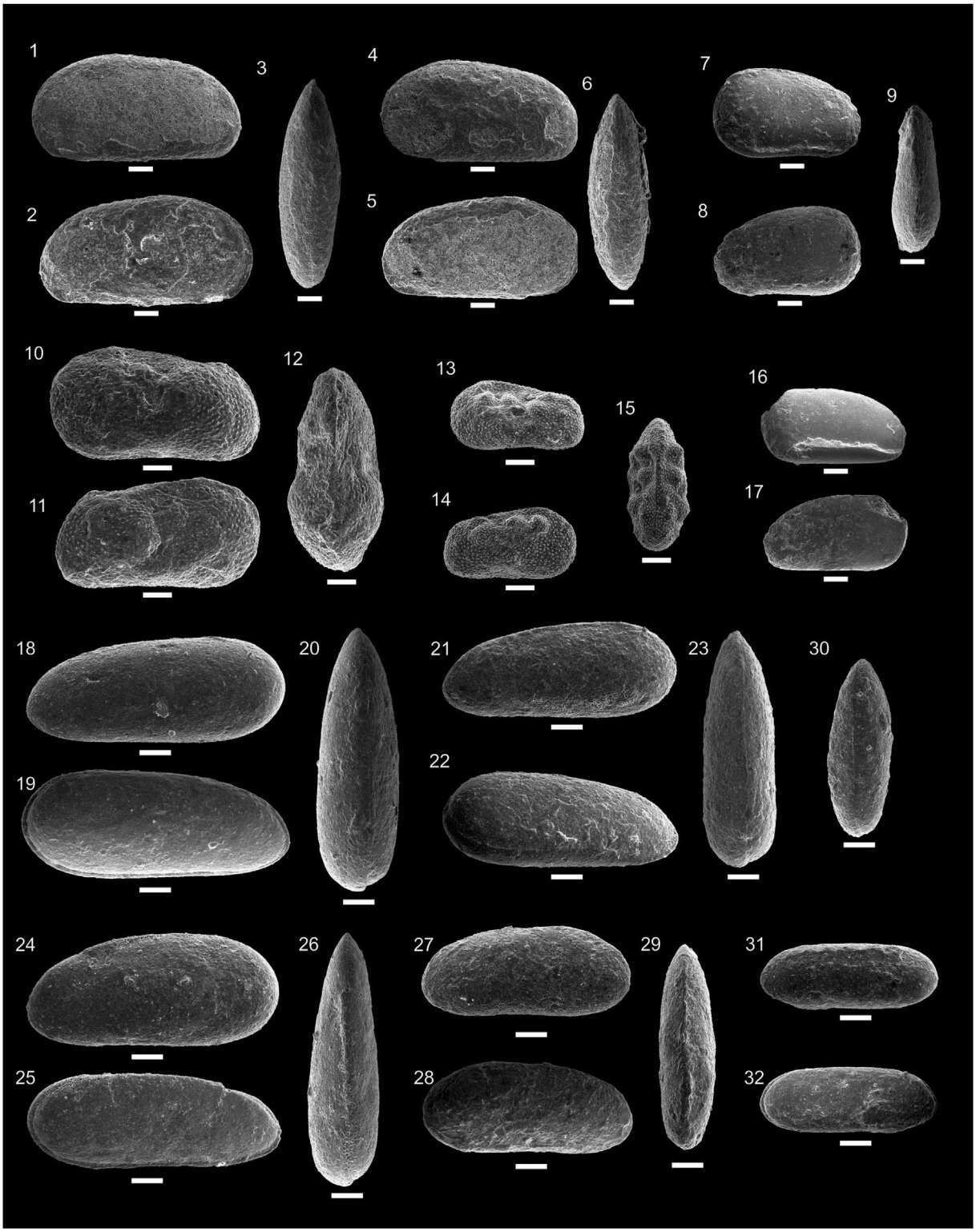

Fig. 6. 1–6 *Reconcavona swaini*, Sousa Basin, Core 2-FC-1-PB. **1–3** sample UFRJ-DG-LM180038, depth 129.76 m, UFRJ-DG-LMOS0026: 1-LLV, 2-RLV, 3-DV; **4–6** sample UFRJ-DG-LM180038, depth 129.76 m, UFRJ-DG-LMOS0027: 4-LLV, 5-RLV, 6-DV; **7–9** *Reconcavona*? spp., Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180018, depth 55.60 m, UFRJ-DG-LMOS0028: 7-LLV, 8-RLV, 9-DV; **10–15** *Ilyocypris* sp. 1, Sousa Basin, Core 2-FC-1-PB. **10–12** sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0030: 10-LLV, 11-RLV, 12-DV; **13–15** sample UFRJ-DG-LM180003, depth 14.30 m, UFRJ-DG-LMOS0031: 13-LLV, 14-RLV, 15-DV; **16–17** *Reconcavona*? spp., Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180018, depth 55.60 m, UFRJ-DG-LMOS0029: 16-LLV, 17-RLV; **18–23** *Alicenula leguminella*, Sousa Basin, Core 2-FC-1-PB. **18–20** sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0032: 18-LLV, 19-RLV, 20-DV; **21–23** sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0033: 21-LLV, 22-RLV, 23-DV; **24–26** *Alicenula* ex gr. *leguminella*, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-MOS0034: 24-LLV, 25-RLV, 26-DV; **27–29** *Alicenula* sp. 1, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180059, depth 190.32 m, UFRJ-DG-LMOS0035: 27-LLV, 28-RLV, 29-DV; **30–32** *Alicenula sousaensis* sp. nov., Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0038: 30-DV; 31-LLV, 32-RLV; Scale bar = 100 μm.

posterior region is lower than the anterior region. Maximum length at below mid-height; maximum height at about 1/3 of length; maximum width behind mid-length. L/H ratio 1.95. Dorsal margin straight, with hinge margin inclined towards posterior (around 8–10°). Anterior and posterior cardinal angle rounded (ACA = 147°–150° / PCA = 143°). Ventral region straight. The carapace has a normal overlap and a high level of symmetry. The valve overlap is from weak to absent in the entire outline. Dorsal view is elongate. No internal characters were observed in the recovered material. Morphologic, ontogenetic and dimorphism variations not observed.

Discussion: The holotype illustrated by Krömmelbein (1962) has a strong overlap in the posterior and anterior margins, which was not observed in the specimens recovered in this study, probably due to variations in carapace calcification. These variations are an environmentally controlled feature and not a determining factor for species identification.

Faunal association: *Cypridea* spp., *Alicenula* spp., *A.* ex gr. *leguminella*, *A. leguminella*, *A. sousaensis* sp. nov., *A.* sp. 1 e *Reconcavona* spp.

Stratigraphic and geographic distribution: In Brazil, *Reconcavona swaini* was reported in the Hauterivian age of the Recôncavo and Tucano basins, upper Ilhas Formation (Krömmelbein, 1962; Cunha and Moura, 1979; Moura, 1972); Sergipe-Alagoas Basin, Coruripe Group (Cassab et al., 1994); and in the Sousa Formation (Sousa Basin, this paper). Gabon Basin (Bate, 1999; Grosdidier et al., 1996; Grosdidier and Bignoumba, 1984). All these records occur in the Hauterivian age.

Paleoecology: Grosdidier and Bignoumba (1984) observed that, in several fluvial-lacustrine sections of the rift valley of the Gabon Basin, associations dominated by *Reconcavona* species (including *R. swaini*) were recovered from lake deposits with stratified waters and rich in organic matter. In the 2-FC-01-PB core, *R. swaini* is found in one level only (129.76 m) and displays pyriteous carapaces, which may indicate reducing conditions and water-column stratification for this level.

Reconcavona? spp.
Fig. 6, 7–9; 16-17

Figured specimens: Fig. 6, 7–9, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180018, depth 55.60 m, UFRJ-DG-LMOS0028, L: 0.61 mm; H: 0.37 mm; W: 0.2 mm 16–17, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180018, depth 55.60 m, UFRJ-DG-LMOS0029, L: 0.59 mm; H: 0.3 mm.

Material: Three complete, poorly preserved carapaces.

Dimensions (in mm): L: 0.59–0.61; H: 0.31–0.37; W: ~0.2.

Description: Medium, round carapace, no ornamentation observed. Anterior margin equicurvate and posterior margin infracurvate. The posterior region is thinner than the anterior region. Maximum length below mid-height; maximum height dislocated forward; maximum width in the posterior region. L/H ratio 1.65. Dorsal margin convex, with hinge margin inclined towards posterior (IHM around 8°). Anterior and posterior cardinal angles rounded, poorly defined (ACA = 155° / PCA = not measured). Ventral region varies, convex in both valves. The carapace has a normal overlap and a high level of symmetry. The valve overlap grades from weak to absent in the entire outline. The dorsal view is elongate. No internal characters were observed in the recovered material.

Discussion: These fossils are rare and poorly preserved in the studied material. The carapace margins are not complete, which makes identification uncertain. The maximum height being so dislocated towards the anterior margin is unusual in *Reconcavona* species. Nevertheless, the narrow dorsal view is characteristic of this genus. Therefore, these specimens were included in the genus *Reconcavona* with question mark. More studies in the basin are necessary to verify if the displacement of maximum height forward is a valid character or just a phenotypic variation. Variations in the ventral margin (straight or concave) and in the inclination of the hinge margin in relation to the base line were observed. These feature variations can indicate different species, but the low quantity of material and the poor preservation prevent the differentiation of the morphological characteristics.

Faunal association: *Mantelliana* spp., *Alicenula* spp., *A. leguminella* and *A.* ex gr. *leguminella*.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin, Hauterivian age.

Family Ilyocyprididae Kaufmann 1900
Subfamily Ilyocypridinae Kaufmann 1900
Genus *Ilyocypris* Brady and Norman 1889

Type species: *Ilyocypris* (*Cypris*) *gibba* Ramdohr 1808
Stratigraphic range: Triassic to Recent (Benson et al., 1961)

Ilyocypris sp. 1
Fig. 6, 10-15

Figured specimens: Fig. 6, 10–12, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180050, depth 160.33 m, UFRJ-DG-LMOS0030, L: 0.71 mm; H: 0.39 mm; W: 0.33 mm 13–15, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180003, depth 14.30 m, UFRJ-DG-LMOS0031, L: 0.45 mm; H: 0.24 mm; W: 0.22 mm.

Material: Seven complete adult and juvenile carapaces. All adult carapaces are poorly preserved.

Dimensions (in mm): L: 0.45–0.71; H: 0.24–0.39; W: 0.22–0.33.

Description: Sub-rectangular, small to medium, strongly ornamented carapace, the entire surface is grainy with three tubercles and two sulci in dorsal region. The outline in lateral view is sub-rectangular, with rounded anterior margins and equicurvate (juveniles) to supracurvate (adults) form. Posterior margin truncate and infracurvate. The posterior region is narrower than the anterior region; this difference is more accentuated in juveniles. Maximum height displaced towards anterior region; maximum width behind mid-length, dislocated towards posterior region. L/H ratio 1.8. Dorsal margin straight, with hinge margin inclined towards posterior (IHM around 10°). Anterior cardinal angle rounded (ACA = 148°–155°) and posterior cardinal angle well defined (PCA = 148°–154°). The ventral region is concave in both valves. The carapace has a normal overlap (LV > RV) and a high level of symmetry. The valve overlap is homogeneous and slightly little apparent. The dorsal view is ovate, flattened toward the anterior margin, with maximum width displaced towards the posterior region. In dorsal view, the carapace has distinct nodes and sulci in both valves. No dimorphism, internal characters or morphologic variations were observed in the recovered material.

Ontogenetic variation: Adults possess rounder cardinal angles than juveniles. In the recovered material, juveniles' tubercles are more distinct than adult ones. The difference in ornamentation between adults and juveniles may be caused by the state of preservation. More studies are necessary to confirm this hypothesis.

Discussion: In this paper, *Ilyocypris* sp. 1 is kept in open nomenclature, due to being a rare and poorly preserved ostracod in the studied samples. *Ilyocypris* sp. 1 was compared with *Ilyocypris* sp. Krömmelbein, 1962, which occurs from the Valanigian to the Berriasian in the Recôncavo Basin. Despite the similar age of occurrence, they probably are different species, since *Ilyocypris* sp. 1 possesses a more ornamented surface, more defined cardinal angles, and a more quadrate outline than *Ilyocypris* sp. Krömmelbein,1962.

Faunal association: Brasacypris ovum, Cypridea ambigua, C. paraibensis sp. nov., C. vianai sp. nov., C. spp., Alicenula sp. 1, A. leguminella, A. ex gr. leguminella and A. spp.

Stratigraphic and geographic distribution: Berriasian-Hauterivian rocks of the Sousa Formation, Sousa Basin.

Paleoecology: The genus *Ilyocypris* inhabited fresh to oligohaline water (Benson et al., 1961). Horne (2002) recorded the genus *Ilyocypris* in Puberck-Wealden semi-permanent pools. The author also argues that some Ilyocyprididae taxa may indicate flowing water, such as rivers,

springs and streams. In the studied core, *Ilyocypris* is found in ephemeral lake deposits with fluvial system input (14.30 m, 34.53 m and 188.90 m).

Suborder Darwinulocopina Sohn 1988
Superfamily Darwinuloidea Brady and Norman 1889
Family Darwinulidae Brady and Norman 1889
Alicenula Rossetti and Martens 1998

Type species: *Darwinula serricaudata* Klie 1935

Stratigraphic range: Late Jurassic (Martens et al., 2003) to Recent (Rossetti and Martens, 1998).

Remarks: In this paper, we followed the concept found in Rossetti and Martens (1998) and Martens et al. (2003). These authors suggest that species previously indicated as representatives of the genus *Darwinula* should be placed in one of the genera described in Rossetti and Martens (1998). All representatives of the Darwinulidae family recovered in the studied material possess normal overlap (LV > RV), are medium- to large-sized, and have an elongate outline. These characters indicate that they belong to the genus *Alicenula*.

Alicenula leguminella (Forbes, 1855 *in* Lyell, 1855) Martens, Rossetti and Horne 2003
Fig. 6,18-23

1855 *Cypris leguminella* Forbes *in* Lyell, 1855, p. 294, fig. 334c.
1885 *Darwinula leguminella* Jones (1885), p. 346, pl. 8, fig. 30–31.
2003 *Alicenula leguminella* Martens et al. (2003), p. 725–727, figs. 3a–u.

Figured specimens: Fig. 6, 18–20, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0032, L: 0.81 mm; H: 0,33 mm; W: 0,26 mm. 21–23, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0033, L: 0.73 mm; H: 0,3 mm; W: 0,23 mm.

Material: 160 complete adult and juvenile carapaces.

Dimensions (in mm): L: 0.67–0.8; H: 0.23–0.3; W: 0.23–0.28.

Type locality and horizon: Purbeck-Wealden, England

Holotype: Unknown

Description: Small, smooth carapace. Oblong and elongate outline, anterior margin acute and infracurvate, posterior margin round and equicurvate. The anterior region is narrower than the posterior one. Maximum height displaced towards posterior region; maximum width occurs in posterior region. L/H ratio from 2.4 to 2.9. Dorsal margin slightly convex, with hinge margin inclined towards anterior (from 13° to 16°). Anterior cardinal angle distinct (ACA = 141°–143°) and posterior cardinal angle rounded (PCA = 122°–147°). The ventral region is slightly concave in both valves, but slightly more concave in RV than in LV. The carapace has a normal overlap (LV > RV). The valve overlap is homogeneous in the entire carapace, but is sometimes difficult to visualize due to the state of preservation. When observed in dorsal view, it shows sub-parallel margins, with maximum width displaced to the posterior region. No internal characters were observed in the recovered material.

Morphologic variations: The length-height ratio (L/H) shows some variation. So does the inclination of the hinge line in relation to the base line. The variation in these features results in oblong outlines.

Ontogenetic variation: Not observed.

Dimorphism: Not observed.

Discussion: The authors follow Martens et al. (2003) in that the previously called *Darwinula leguminella* is now placed in the genus *Alicenula*. *Alicenula leguminella* is an ostracod with a wide stratigraphic range, being a poor fossil guide when compared with other species from the same age. In fact, it is improbable that the same species persisted for such a long time, when compared with other Cretaceous or Jurassic species. There is a possibility that what is called *Alicenula leguminella* comprises more than one species. However, the lack of features in the carapace prevents species identification. Internal features can help in this case, but these were not observed in the recovered material. The authors attempted to differentiate *Alicenula leguminella* from other *Alicenula* recovered in the Sousa Basin.

Differential diagnosis: *Alicenula leguminella* differs from other *Alicenula* recovered in the Sousa Basin by the acute anterior region and the well-defined anterior cardinal angle. When compared with *Alicenula leguminella*: *Alicenula* ex gr. *leguminella* possesses an ovate outline, not so acute anterior margin, and a sometimes supracurvate posterior region; *Alicenula* sp. 1 has an ovate outline and round cardinal angles, with anterior and posterior margins rounded and equicurvate; and *Alicenula sousaensis* sp. nov. possesses parallel dorsal and ventral margins, which make the fossil oblong in lateral view, its anterior and posterior regions are equicurvate.

Faunal association: *Alicenula* ex. gr. *leguminella*, *A. sousaensis* sp. nov., *A.* sp. 1, *A.* spp, *Brasacypris ovum*, *Cypridea ambigua*, *C. paraibensis* sp. nov., *C. vianai* sp. nov., *C.* spp., *Ilyocypris* sp. 1, *Mantelliana* spp., *Reconcavona swaini*, *R.* ? spp. and *R.* spp.

Stratigraphic and geographic distribution: Worldwide from Late Jurassic to Early Cretaceous. Examples can be seen in South (Carignano et al., 2017; Coimbra et al., 2002; Nascimento et al., 2017; Tomé et al., 2014) and North America (Swain, 1999), Africa (Mette, 1997; Trabelsi et al., 2015), Europe (Anderson, 1985; Néraudeau et al., 2012; Wightman, 1990) and Asia (Pei-ji, 1983).

Paleoecology: Martens et al. (2003) recorded *A. leguminella* in several environment types, being a common taxa in the Juro-Cretaceous assemblages worldwide, which suggests the species has a high ecological tolerance.

Alicenula ex gr. *leguminella*
Fig. 6, 24-26

Figured specimens: Fig. 6, 24–26, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0034, L: 0.8 mm; H: 0.35 mm; W: 0.22 mm.

Material: 111 complete adult and juvenile carapaces.

Dimensions (in mm): L: 0.61–0.8; H: 0.24–0.35; W: 0.2–0.3.

Type locality and horizon: Sousa Formation, Sousa Basin.

Description: Large, ovoid carapace. Anterior margin varies from equicurvate to infracurvate, posterior margin round and equicurvate. The anterior region is narrower than the posterior one. Maximum height displaced towards posterior region; maximum width occurs in posterior region. L/H ratio from 2.1 to 2.3. Dorsal margin convex, which provides the ovoid outline. The hinge margin is inclined towards anterior (from 12° to 24°). Anterior and posterior cardinal angles rounded (ACA = 144°–152°; PCA = 117°–147°). The ventral region can be concave or straight in both valves. The carapace has a normal overlap (LV > RV). The valve overlap is homogeneous in the entire carapace, with the exception of the dorsal margin, where the overlap is weaker. When observed in dorsal view, shows sub-parallel margins, with maximum width displaced to the posterior region. No internal characters were observed in the recovered material.

Morphologic variations: Very variable, mainly in the degree of convexity of the dorsal margin and in the curvature of the anterior region. Ontogenetic variation and dimorphism were not observed.

Discussion: These ostracods are similar to *Alicenula leguminella* (Forbes *in* Lyell, 1855) Martens, Rossetti and Horne (2003), but the authors chose to include them as an “ex. gr.” due to their ovate outline, rounder anterior region and smaller length/height ratio. We suggest a comparison between the *Alicenula leguminella* described worldwide with the one recovered in the Wealden rocks. In the material recovered from the Sousa Basin, variations in outline, hinge margin inclination in relation to the base line, and in the anterior and posterior regions can be noticed.

Sexual dimorphism is rare and difficult to identify in Darwinulidae, especially when only external carapace features are available (Smith

et al., 2006). In an attempt at interspecific differentiation of genus *Alicenula* from the Aliança Formation (Jatobá Basin, Thitonian age), sexual dimorphism and variation in the L/H ratio did not provide conclusive data, leading the authors to not differentiate the specimens down to species (Guzmán-González et al., 2016). However, the proposal for the *Alicenula* genus points out that the slow evolutionary rates in Darwinulidae cause small, but constant, morphological differences between the species (Rossetti and Martens, 1998). Additionally, Martens et al. (2003) suggest that *A. leguminella* can be the Mesozoic equivalent of *Darwinula stevensoni* Brady and Robertson 1870, whose long stratigraphical range is the result of developing a general-purpose genotype. These two views are both valid, but require a review of the occurrence of *A. leguminella* worldwide in order to ascertain if its differences to *A.* ex gr. *leguminella* are persistent and sufficient to define a new species. This is beyond the scope of this paper, so the authors chose to differentiate *A. leguminela* from *A.* ex gr. *leguminella* here and conduct this attempt in tracking their biostratigraphic distribution in a later work.

Differential diagnosis: *Alicenula* ex gr. *leguminella* possesses an ovate outline, a not so acute anterior margin, and a sometimes supracurvate posterior region, when compared with *Alicenula leguminella*.

Faunal association: *Alicenula leguminella*, *A.* sp. 1, *A. sousaensis* sp. nov., A. spp, *Brasacypris ovum*, *Cypridea ambigua*, *C. paraibensis* sp. nov., *C. vianai* sp. nov., *C.* spp., *Ilyocypris* sp. 1, *Mantelliana* spp., *Reconcavona swaini*, *R.*? spp. and *R.* spp.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin, Berriasian-Hauterevian age.

Alicenula sp. 1
Fig. 6, 27-29

Figured specimens: Fig. 6, 27–29, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180059, depth 190.32 m, UFRJ-DG-LMOS0035, L: 0.65; H: 0.28; W: 0.17.

Material: 25 complete adult and juvenile carapaces.

Dimensions (in mm): L: 0.65–0.73; H: 0.28–0.31; W: 0.17–0.25.

Type locality and horizon: Sousa Formation, Sousa Basin.

Description: Ovoid to sub-trapezoidal carapace, medium to large size. Anterior and posterior margins infracurvate. The anterior region is narrower than the posterior one. Maximum height displaced towards posterior region, at about 3/4 of the carapace; maximum length behind mid-height. L/H ratio around 2.2. Dorsal margin slightly convex. The hinge margin is inclined towards anterior (IHM around 5°). Anterior and posterior cardinal angle well defined (ACA = 138°; PCA = 154°). The ventral region is always concave in both valves. The carapace has a normal overlap (LV > RV). The valve overlap is weak and homogeneous in the entire carapace, with the exception of the anterior cardinal angle, where the overlap of the LV over the RV is stronger. Narrow in dorsal view, with the margins slightly ovate and maximum width almost at mid-length. No internal characters were observed in the recovered material.

Morphologic variations: The carapace outline can vary from ovate to sub-trapezoidal, the cardinal angles cause this variation.

Ontogenetic variation: Not observed.

Dimorphism: Not observed.

Discussion: *Alicenula* sp. 1, in comparison to *A. leguminella* and *A.* ex gr. *leguminella*, is uncommon. We chose to keep this ostracod in open nomenclature due to the poorly preserved carapaces and the few retrieved representatives. With more studies in the area, it will be possible to conclude if this ostracod is really a new species or merely a poorly preserved or juvenile representative of *A.* ex. gr. *leguminella*. Identification of Darwinulidae ostracods using only external carapace features is made complex due to little, although important, variations in the outline.

Differential diagnosis: The most important features for distinguishing between *Alicenula* sp. 1 and other *Alicenula* found in the Sousa Basin are the infracurvate anterior and posterior margins. Both infracurvate margins also make the ventral region more concave than in other *Alicenula* found in the material.

Faunal association: *Alicenula leguminella*, *A.* ex gr. *leguminella*, *A. sousaensis* sp. nov., *A.* spp, *Brasacypris ovum*, *Cypridea ambigua*, *C. paraibensis* sp. nov., *C. vianai* sp. nov., *C.* spp., *Ilyocypris* sp. 1, *Mantelliana* spp., *Reconcavona swaini* and *R.*? spp.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin. Berriasian-Hauterevian age.

Paleoecology: Horne (2002) postulates that the Family Darwinulidae prefers sediments rich in organic matter and becomes abundant in waters rich in ions (Calcium). In the Sousa Formation *Alicenula* sp. 1 was found in calciferous shales of non-marine ephemeral lake deposits.

Alicenula sousaensis sp. nov.
Fig. 6, 30-32

Etymology: Named after the Sousa Basin, where the species was originally found.

Holotype: UFRJ-DG-LMOS0038 (Fig. 6, 30–32), sample UFRJ-DG-LM180048, L: 0.56 mm; H: 0.2 mm; W: 0.19 mm.

Figured specimens: Fig. 6, 30–32, Sousa Basin, Core 2-FC-1-PB, sample UFRJ-DG-LM180048, depth 159.62 m, UFRJ-DG-LMOS0038.

Material: 32 complete adult and juvenile carapaces.

Dimensions (in mm): L: 0.56; H: 0.2; W: 0.19.

Type locality and horizon: Sousa Formation, Sousa Basin.

Diagnosis: Medium elongate ostracod with parallel ventral and dorsal margins. Rectangular in lateral view and ovate in dorsal view. Anterior and posterior margins equicurvate. Cardinal angles almost the same.

Description: Small, elongate, rectangular carapace. Anterior and posterior margins equicurvate, with almost the same length. Maximum height not distinguished; maximum length at the mid-height. L/H around 2.79, which produces an elongate outline in lateral view. Dorsal and ventral margins straight. The hinge margin possesses almost no inclination in relation to the base line (around 0°). Anterior and posterior cardinal angles well defined, and with little difference (ACA = 150°; PCA = 160°). The carapace has a normal overlap (LV > RV). The valve overlap grades from weak to almost absent, being homogeneous in the ventral and dorsal margins, though the overlap of the LV over the RV is stronger at anterior and posterior margins. The dorsal view is ovate with maximum width almost at mid-length. No internal characters were observed in the recovered material. Morphologic, ontogenetic or dimorphism variations were not observed.

Discussion: Despite being a Darwinulidae, its identification is relatively easy in the recovered assemblage, due to its parallel ventral and dorsal margins and its ovate dorsal view.

Differential diagnosis: Darwinulidae with parallel dorsal and ventral margins. The maximum height dislocation toward posterior, which is common in other *Alicenula*, was not observed in *A. sousaensis* sp. nov. Inclination of the hinge in relation to the base line is almost zero, differently from other species of *Alicenula*, in which it varies from 5° to 24°. This is the only *Alicenula* recovered in the material with an ovate dorsal view.

Faunal association: *Alicenula leguminella*, *A.* ex gr. *leguminella*, *A.* sp. 1, *A.* spp, *Brasacypris ovum*, *Cypridea ambigua*, *C. paraibensis* sp. nov., *C. vianai* sp. nov., *C.* spp., *Ilyocypris* sp. 1, *Reconcavona swaini* and R. spp.

Stratigraphic and geographic distribution: Sousa Formation, Sousa Basin, Berriasian-Hauterivian age.

Paleoecology: Most of the Darwinulidae taxa prefer freshwater; nevertheless, they include species that tolerate salinities up to seawater levels (Van Doninck et al., 2003). It is assumed here that *A. sousaensis* sp. nov. has an environmental preference for shallow, brackish and non-marine waters of ephemeral lakes.

5. Discussion and conclusions

The Sousa Basin was located in a low-latitude, arid to semi-arid climate zone with high temperatures (Anderson et al., 2007). These factors induced the high evaporation rates of the lake causing periods of dryness that are reflected in the lithology and in the low diversity of the Berriasian-Hauterivian ostracods, recovered from core 2-FC-01-PB. The lithology of the studied core reinforces the conditions of a shallow, ephemeral paleolake with a high evaporation rate evidenced by sedimentary structures (mud crack) and evaporite levels (gypsum). The non-marine ostracod associations of the Sousa Formation have less specific diversity, when compared to the faunas present in other formations of the same stratigraphical range in the Brazilian Northeastern basins (Recôncavo, Tucano, Jatobá, Sergipe/Alagoas, Araripe). These basins usually possess ostracods from the Cytherideidae Family that suggest permanent water bodies. The absence of Cytherideidae ostracods and the presence of Cyprideidae ostracods in the Sousa Basin are additional indicatiors, besides the sedimentology, that the Sousa deposits correspond to ephemeral (or temporary) lake deposits. Cyprideidae ostracods are commonly recorded in ephemeral water bodies, whereas Cytherideidae ostracods are indicators of permanent water bodies (Horne, 2002).

Alicenula leguminella, Brasacypris ovum, Cypridea ambigua and *Reconcavona swaini* were identified in the core. These species, although first recorded in sediments of permanent lakes, tolerate aridity conditions, high evaporation rates and brackish waters. The proposed species *Cypridea paraibensis* sp. nov., *Cypridea vianai* sp. nov. and *Alicenula sousaensis* sp. nov. are resistant to arid and semi-arid conditions, as well as high temperatures.

The severe climate conditions at the depositional site had a negative impact on faunal diversity and impaired ostracod preservation, with some taxa remaining in open nomenclature. *Alicenula* sp. 1 was left in open nomenclature, because the observed morphological features are insufficient for its inclusion in the existing species. The *Alicenula* ex gr. *leguminella* carapaces, although abundant, display a group of morphological traits similar to those from *Alicenula leguminella*; this, however, is not enough for its inclusion in the latter species. This nomenclatural choice was based on the fact that external carapace features in genus *Alicenula* are very similar, causing controversies in species designation. *Mantelliana* sp. and *Reconcavona*? spp. were kept in open nomenclature as a consequence of the low recovery and precarious state of preservation of their carapaces. Only one *Cypridea* sp. 1 carapace was recovered, making it unfeasible to obtain more precise morphological data. The *Ilyocypris* sp. 1 specimens are poorly preserved in general and, occasionally, represented by internal molds. The best-preserved *Ilyocypris* sp. 1 carapace is from a juvenile (Fig. 6.13-15), which is not ideal for a formal description.

It is expected that this taxonomic study will lead to a better understanding of the faunal associations in ephemeral lakes from tropical/subtropical climates, and to the improvement of interregional biostratigraphical correlations of the Lower Cretaceous.

Acknowledgements

The authors wish to thank Petrobras, for laboratorial procedures and for the SEM image capture, and geologist Gerhard Beurlen, for translation of the ostracod taxonomy from several articles originally in German. This study was supported by CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) and FAPERJ (Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro). We also thank three anonymous reviewers for their helpful comments. We also thanks the support of Lagesed - Geology Department, Rio de Janeiro Federal University for the sampling cores.

References

Albuquerque, J.P.T., 1986. O sistema aquífero Rio do Peixe. In: Anais Do 4° Congresso Brasileiro de Águas Subterrâneas. Brasília, pp. 194–207.
Anderson, F.W., 1966. New genera of Purbeck and Wealden ostracoda. Bulletin of the British Museum (Natural History) Geology II 436–487.
Anderson, F.W., 1985. Ostracod faunas in the Purbeck and Wealden of England. Journal of Micropalaeontology 4, 1–68.
Anderson, J.M., Anderson, H.M., Archangelsky, S., Bamford, M., Chandra, S., Dettmann, M., Hill, R., McLoughlin, S., Rösler, O., 1999. Patterns of Gondwana plant colonization and diversification. Journal of African Earth Sciences 28, 145–167.
Anderson, J.M., Anderson, H.M., Cleal, C.J., 2007. In: Strelitzia (Ed.), Brief History of the Gymnosperms: Classification, Biodiversity, Phytogeography and Ecology. South African National Biodiversity Institute, Pretoria.
Ayress, M.A., Whatley, R.C., 2014. Early Cretaceous non-marine ostracoda from the north Falkland basin, South Atlantic. Palaeontology 57, 1143–1175. http://dx.doi.org/10.1111/pala.12109.
Bate, R.H., 1972. Phosphatized ostracods with appendages from the lower Cretaceous of Brazil. Palaeontology 15, 379–393.
Bate, R.H., 1999. Non-marine Ostracod Assemblages of the Pre-salt Rift Basins of West Africa and Their Role in Sequence Stratigraphy 153. Geological Society of London, pp. 283–292. http://dx.doi.org/10.1144/GSL.SP.1999.153.01.17. Special Publications.
Benson, R.H., Borden, J.M., van der Bold, W.A., Hanai, T., Hessland, I., Howe, H.V., Kesling, R.V., Levinson, S.A., Reyment, R.A., Moore, R.C., Scott, H.W., Shaver, R.H., Sohn, I.G., Stover, L.E., Swain, F.M., Sylvester-Bradley, P.C., Wainwright, J., 1961. Treatise on Invertebrate Plaeontology, Part Q, Arthropoda, first ed. Geological Society of America and University of Kansas Press, Lawrence.
Brady, G.S., Norman, A.M., 1889. In: Section, I. (Ed.), A Monograph of the marine and Freshwater Ostracoda of the North Atlantic and of north Western Europe. Royal Dublin Society, Dublin.
Braun, O.P.G., 1969. Geologia da Bacia do Rio do Peixe, Nordeste do Brasil, Relatório de Prospecção., Ministério de Minas e Energia. Departamento Nacional de Produção Mineral (DNPM), Natal 4° Distrito do Nordeste.
Carignano, A.P., Paredes, J.M., Olazábal, S.X., Valle, M.N., 2017. Ostracoda (Crustacea) from the Pozo D-129 formation (upper Barremian?–Aptian), Golfo san Jorge basin, Patagonia, Argentina: taxonomic descriptions, palaeoenvironments and palaeogeographical implications. Cretaceous Research 78, 206–220. http://dx.doi.org/10.1016/j.cretres.2017.06.015.
Carvalho, I.S., 2000. Geological environments of dinosaur footprints in the intracratonic basins of northeast Brazil during the Early Cretaceous opening of the South Atlantic. Cretaceous Research 21, 255–267. http://dx.doi.org/10.1006/cres.1999.0194.
Carvalho, I.S., Carvalho, M.G.P., 1990. O significado paleoambiental dos conchostráceos da Bacia de Sousa. In: Campos, D.A., Viana, M.S.S., Brito, P.H., Beurlen, G. (Eds.), I Simpósio Sobre a Bacia do Araripe e Bacias Interiores do Nordeste. Crato, pp. 329–336.
Carvalho, I.S., Melo, J.H.G., 2012. Bacias interiores do nordeste. In: Hasui, Y., Carneiro, C.D.R., Almeida, F.F.M., Bartorelli, A. (Eds.), Geologia Do Brasil. Beca, São Paulo, pp. 502–509.
Cassab, R.C.T., Santos, E.C.M., Fernandes, A.C.S., Brito, I.M., Carvalho, I.S., Coimbra, J.C., Moura, J.A., Duarte, L., Freitas, L.C.S., Hessel, M.H.R., Carvalho, M.S.S., Viviers, M.C., Uesugui, N., 1994. The Sergipe-Alagoas Basin. In: Beurlen, G., Campos, D.A., Viviers, M.C. (Eds.), Stratigraphic Range of Cretaceous Mega and Microfossils of Brazil. Universidade Federal do Rio de Janeiro, Rio de Janeiro, pp. 161–231.
Coimbra, J.C., Arai, M., Carreño, A.L., 2002. Biostratigraphy of lower Cretaceous microfossils from the Araripe basin, northeastern Brazil. Geobios 35, 687–698. http://dx.doi.org/10.1016/S0016-6995(02)00082-7.
Cunha, M.C., Moura, J.A., 1979. Espécies novas de ostracodes não-marinhos da Série de Recôncavo: paleontologia e biostratigrafia. Boletim Técnico da Petrobrás 22, 87–100.
Feijó, F.J., 1994. Cartas estratigráficas das bacias sedimentares brasileiras. Boletim de Geociências da Petrobrás. pp. 8.
Frakes, L.A., Francis, J.E., Syktus, J.I., 1992. Climate Mode of the Phanerozoic. Cambridge University Press, Cambridge.
Françolin, J.B.L., Szatmari, P., 1987. Mecanismo de rifteamento da porção oriental da margem norte brasileira. Revista Brasileira de Geociências 17, 196–207.
Grosdidier, E., Bignoumba, J., 1984. Exemple de coupures écostratigraphiques basées sur un renouvellement des faune d'Ostracodes lacustres dans le Crétacé inférieur du rift atlantique au droit du Sud Gabon. Géologie Méditerranéenne 11, 87–95.
Grosdidier, E., Braccini, E., Dupont, G., Moron, J.-M., 1996. Biozonation du Crétacé inférieur non marin des bassins du Gabon et du Congo. In: Géologie de l'Afrique et de l'Atlantique Sud. Actes Colloques Angers 1994. Pau, pp. 67–82.
Guzmán-González, J., Piovesan, E.K., Fambrini, G.L., Oliveira, E.V., 2016. Non-marine ostracoda from the Aliança Formation in the north-central portion of the Jatobá Basin, northeastern Brazil. Revista Brasileira de Paleontologia 19, 15–24. http://dx.doi.org/10.4072/rbp.2016.1.02.
Horne, D.J., 2005. Ostracoda. Encyclopedia of Geology 453–463.
Horne, D.J., 2002. Ostracod biostratigraphy and Palaeoecology of the Purbeck limestone group in southern England. Special Papers in Palaeontology 68, 53–70.
Jones, T.R., 1885. The ostracoda of the Purbeck formation; with notes on the Wealden species. Quarterly Journal of the Geological Society of London 41, 311–352.
Keyser, D., 2005. Histological peculiarities of the noding process in Cyprideis torosa (Jones) (Crustacea, Ostracoda). Hydrobiologia 538, 95–106. http://dx.doi.org/10.1007/s10750-004-4940-x.
Keyser, D., Aladin, N., 2004. Noding in Cyprideis torosa and its causes. Studia Quaternaria 21, 19–24.

Krömmelbein, K., 1962. Zur taxionomie unb biochronologie stratigraphisch wichtiger Ostracoden-Arten aus der oberjurassich ? - unterkretazischen Bahia-Serie (Wealden-Fazies) NE-Brasiliens. Senckenbergiana Lethaea 43, 437–527.
Krömmelbein, K., 1965. Neue, für Vergleiche mit West-Afrika wichtige ostracoden-Arten der Brasilianischen Bahia Serie (Ober-Jura? Unter-Kreide in Wealden-Fazies). Sonderdruck aus Senncken bergiana Lethaea 46, 177–213.
Krömmelbein, K., 1966. On “Gondwana Wealden” ostracoda from NE Brazil and west Africa. In: Van Hinte, J.E. (Ed.), Proceedings of the Second West African Micropaleontological Colloquium. Idaban, pp. II3–II8.
Leonardi, G., Carvalho, I.S., 2002. Icnofósseis da Bacia do Rio do Peixe, PB. Sítios Geológicos e Paleontológicos do Brasil 1, 101–111.
Lima-Filho, M.F., 1991. Evolução Tectono-Sedimentar da Bacia do Rio do Peixe - PB. Master Diss. Universiade Federal de Pernambuco, Recife.
Lima, M.R., 1983. Paleoclimatic reconstruction of the Brazilian Cretaceous based on palynological data. Revista Brasileira de Geociências 13, 223–228.
Lima, M.R., Coelho, M.P.C. A., 1987. Estudo palinológico da sondagem estratigráfica da Lagoa do Forno, Bacia do Rio do Peixe, Cretáceo do Nordeste do Brasil. Boletim do Instuto de Geologia-USP, Série Científica 18. .
Lyell, C., 1855. Jurassic group - Purbeck beds and oolite. In: Lyell, C. (Ed.), A Manual of Elementary Geology: or, the Ancient Changes of the Earth and its Inhabitants as Illustrated by Geological Monuments. John Murray, London, pp. 294–297.
Mabesoone, J.M., Campanha, V.A., 1974. Caracterização estratigráfica dos grupos Rio do Peixe e Iguatu. Estudos Sedimentológicos 3/4 21–41.
Maisey, J.G., 2000. Continental break up and the distribution of fishes of Western Gondwana during the early Cretaceous. Journal of African Earth Sciences 33, 281–314. http://dx.doi.org/10.1016/S0899-5362(01)80081-6.
Martens, K., Rossetti, G., Horne, D.J., 2003. How ancient are ancient asexuals? Proceedings of the Royal Society B: Biological Sciences 270, 723–729. http://dx.doi.org/10.1098/rspb.2002.2270.
Mette, W., 1997. Palaeoecology and palaeobiogeography of the Middle Jurassic ostracods of southern Tunisia. Palaeogeography, Palaeoclimatology, Palaeoecology 131, 65–111. http://dx.doi.org/10.1016/S0031-0182(97)83384-6.
Moura, J.A., 1972. Algumas espécies e subespécies novas de ostracodes da bacia Recôncavo-Tucano. Boletim Técnico da Petrobrás 15, 245–263.
Nascimento, L.R.D.S.L., Tomé, M.E.T.R., Barreto, A.M.F., Oliveira, H.D., Neumann, V.H.M.L., 2017. Biostratigraphic analysis based on palynomorphs and ostracods from core 2-JNS-01PE, Lower Cretaceous, Jatobá Basin, northeastern Brazil. Journal of South American Earth Sciences 76, 115–136. http://dx.doi.org/10.1016/j.jsames.2017.02.012.
Néraudeau, D., Allain, R., Ballèvre, M., Batten, D.J., Buffetaut, E., Colin, J.P., Dabard, M.P., Daviero-Gomez, V., El Albani, A., Gomez, B., Grosheny, D., Le Lœuff, J., Leprince, A., Martín-Closas, C., Masure, E., Mazin, J.M., Philippe, M., Pouech, J., Tong, H., Tournepiche, J.F., Vullo, R., 2012. The Hauterivian-Barremian lignitic bone bed of Angeac (Charente, south-west France): stratigraphical, palaeobiological and palaeogeographical implications. Cretaceous Research 37, 1–14. http://dx.doi.org/10.1016/j.cretres.2012.01.006.
Nogueira, F.C.C., Oliveira, M.S., Castro, D.L., 2004. Estudo Magnético e Gravimétrico do Arcabouço Estrutural da Bacia Rio do Peixe - PB. Rev. Geol. da UFC 17, 71–87.
Pei-ji, C., 1983. A survey of the non-marine Cretaceous in China. Cretaceous Research 4, 123–143. http://dx.doi.org/10.1016/0195-6671(83)90045-9.
Ponte, F.C., 1992. Origem e evolução das pequenas bacias cretácicas do interior do Nordeste do Brasil. In: Simpósio Sobre as Bacias Cretácicas Brasileiras, 2. Rio Claro, pp. 55–58.
Regali, M.S.P., 1990. Biocronoestratigrafia e Paleoambiente do Eocretáceo das bacias do Araripe (CE) e Rio do Peixe (PB), NE - Brasil. In: 1° Simpósio Sobre a Bacia Do Araripe E as Bacias Interiores Do Nordeste. Crato, pp. 163–171.
Rocha, D., Amaral, C., 2006. Geologia da Bacia Rio do Peixe. Thecnical Report Serviço Geológico do Brasil (CPRM), Campina Grande, pp. 12.
Rossetti, G., Martens, K., 1998. Taxonomic revision of the Recent and Holocene representatives of the family Darwinulidae (Crustacea, Ostracoda), with a description of three new genera. Bulletin de l'Institut Royal des Sciences Naturelles de Belqique. Sciences de la Terre 68, 55–110.
Sames, B., 2011. Early Cretaceous *Cypridea* Bosquet 1852 in north America and Europe. Micropaleontology 57, 345–431.
Scotese, C.R., Boucot, A.J., McKerrow, W.S., 1999. Gondwanan paleogeography and paleoclimatology. Journal of African Earth Sciences 28, 99–114.
Silva-Filho, R.P., 2009. Análise de fácies da Formação Sousa (Cretáceo Inferior), bacia de Sousa (PB), e seu contexto em um sistema petrolífero. Universidade Federal do Rio de Janeiro (Thesis).
Silva, M., Ribeiro, E.M., Rosa, G.B., Lopes, J.A., Ribeiro, J.C., Neves, L.E., Olívio, B., Araripe, P.T., 1997. Análise comparativa da Paleogeologia dos Litorais Atlânticos Brasileiro e Africano comparative analysis of the Paleogeology along the Atlantic Brazilian and African Shores. Boletim de Geociências da Petrobrás 11, 1–18.
Smith, R.D.A., 1995. Reservoir Architecture of Syn-rift Lacustrine Turbidite Systems, Early Cretaceous, Offshore South Gabon 80. Geological Society, London, pp. 197–210. http://dx.doi.org/10.1144/GSL.SP.1995.080.01.10. Special Publications.
Smith, R.J., 2000. Morphology and ontogeny of Cretaceous ostracods with preserved appendages from Brazil. Palaeontology 43, 63–98.
Smith, R.J., Kamiya, T., Horne, D.J., 2006. Living males of the “ancient asexual” Darwinulidae (Ostracoda: Crustacea). Proceedings of the Royal Society B: Biological Sciences 273, 1569–1578. http://dx.doi.org/10.1098/rspb.2005.3452.
Srivastava, N.K., Carvalho, I.S., 2004. Bacias sedimentares brasileiras: bacias do Rio do Peixe. Phoenix 6, 1–4.
Swain, F.M., 1999. Fossil Nonmarine Ostracoda of the United States, Developments in Palaeontology and Stratigraphy. Elsevier Scientific Publishing Company, Amsterdam.
Tinoco, I.M., Katoo, I., 1975. Conchostráceos da Formação Sousa, Bacia do Rio do Peixe, Estado da Paraíba. In: VII Simpósio de Geologia. Fortaleza, pp. 135–147.
Tinoco, I.M., Mabesoone, J.M., 1975. Observações Paleoecológicas sobre as Bacias Mesozóicas de Iguatu, Rio do Peixe e intermediárias. In: Atas Do VII Simpósio de Geologia. Fortaleza, pp. 95–107.
Tomé, M.E.T.R., Lima Filho, M.F., Neumann, V.H.M.L., 2014. Taxonomic studies of non-marine ostracods in the lower Cretaceous (Aptian-lower Albian) of post-rift sequence from Jatobá and Araripe basins (northeast Brazil): stratigraphic implications. Cretaceous Reserach 48, 153–176. http://dx.doi.org/10.1016/j.cretres.2013.12.007.
Trabelsi, K., Sames, B., Salmouna, A., Piovesan, E.K., Rouina, S. Ben, Houla, Y., Touir, J., Soussi, M., 2015. Ostracods from the marginal coastal lower Cretaceous (Aptian) of the central Tunisian Atlas (north Africa): Paleoenvironment, biostratigraphy and paleobiogeography. Revue de Micropaleontologie 58, 309–331. http://dx.doi.org/10.1016/j.revmic.2015.09.002.
Van Doninck, K., Schön, I., Martens, K., Goddeeris, B., 2003. The life-cycle of the asexual ostracod Darwinula stevensoni (Brady & Robertson, 1870) (Crustacea, Ostracoda) in a temporate pond. Hydrobiologia 500, 331–340. http://dx.doi.org/10.1023/A:1024656920904.
Viana, C.F., 1966a. Stratigraphic distribution of ostracoda in the bahia Supergroup (Brazil). In: Proceedings of 2nd West African Micropaleontological Colloquium, pp. 240–256.
Viana, C.F., 1966b. Correspondência entre os ostracodes das série cocobeach (Gabão) e bahia (Brasil). Boletim Técnico da Petrobrás 9, 367–382.
Wanderley, M.D., 2004. Técnicas de Preparação de Microfósseis. In: Carvalho, I.S.de S (Ed.), Paleontologia. Interciência, Rio de Janeiro, pp. 17–25.
Wightman, W.G., 1990. Micropaleontology of the Kimmeridgian to Barremian Deposits of Portugal and the Grand Banks of Newfoundland. Dalhousie University.