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# LATE CRETACEOUS OSTRACODS FROM THE CENTRAL AREA OF THE POTIGUAR BASIN, NORTHEASTERN BRAZIL

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ABSTRACT – The Jandaíra Formation samples collected in the central region of the Potiguar Basin show a diverse Late Cretaceous ostracod fauna. The genera *Cytherella*, *Bairdoppilata*, *Triebelina*, *Paracypris*, *Fossocytheridea*, *Ovocytheridea*, *Perissocytheridea*, *Protocosta*, *Soudanella*, and *Leguminocythereis* indicate a marginal marine environment during the Santonian–Campanian. The analyzed material demonstrates that ostracods are significant indicators of changes in the depositional environment and paleoecological markers in marginal marine environments.

**Key words:** taxonomy, Upper Cretaceous, paleoecology, neritic assemblages.

RESUMO – As amostras provenientes da Formação Jandaíra, coletadas na região central da Bacia Potiguar, evidenciam uma diversificada fauna de ostracodes do Neocretáceo. Os gêneros *Cytherella*, *Bairdoppilata*, *Triebelina*, *Paracypris*, *Fossocytheridea*, *Ovocytheridea*, *Perissocytheridea*, *Protocosta*, *Soudanella* e *Leguminocythereis* indicam um ambiente marinho marginal no intervalo Santoniano–Campaniano. O material analisado demonstra que os ostracodes são indicadores significativos de modificações no ambiente deposicional e marcadores paleoecológicos em ambientes marinhos marginais.

**Palavras-chave:** taxonomia, Cretáceo Superior, paleoecologia, assembleias neriticas.

## INTRODUCTION

In the last decades research on Cretaceous ostracods of Brazilian basins have received considerable attention, especially those in marginal marine environments. Their biostratigraphical potential in the South Atlantic was demonstrated recently in the revision by Fauth *et al.* (2018). The Late Cretaceous ostracods from the Potiguar Basin were studied by Viviers (1995, 2000), Delicio *et al.* (2000), Piovesan *et al.* (2014a,b; 2015a,b), and Santos Filho *et al.* (2015), who improved significantly the knowledge on the evolution of this basin, and reinforced the correlation between Brazilian and North African ostracod faunas in the Upper Cretaceous.

Piovesan *et al.* (2015a) demonstrated the existence of four major palaeoenvironmental phases in the Turonian–Campanian interval of the Potiguar Basin, as follows: (i) mixohaline/marine 1, (ii) marine 1, (iii) marine 2, and (iv) mixohaline/marine 2. Assemblages in each of those phases differ on taxonomic composition and abundance, demonstrating their potential for the characterization of marine and marginal marine environments and sequence stratigraphic interpretation.

This paper is based upon a study of a new locality of the Jandaíra Formation, as part of an effort initiated by Piovesan *et al.* (2014a,b) whose objective is to supply new paleoecological and bioestratigraphical data to the Potiguar Basin based on brackish and marine ostracods.

## GEOLOGICAL SETTING

The Potiguar Basin (Figure 1) is located at the intersection of the Equatorial Margin with the East Continental Margin, covering an area of approximately 48,000 km². Geologically, it is limited on the south, east and west by the crystalline basement, extending northwards to the 2,000 m isobath. This basin is distributed mostly in the Rio Grande do Norte and Ceará states (Mohriak, 2003; Pessoa Neto *et al.*, 2007).

According to Pessoa Neto *et al.* (2007), the Potiguar Basin is comprised of three supersequences, as follows: (i) rift (Berriasian–Lower Aptian), represented by fluvial-deltaic and lacustrine deposits from the Pendência and Pescada formations; (ii) post-rift, deposited during the late Aptian–early Albian and characterized by fluvial-deltaic deposits, with the first records of the marine transgression (Alagamar Formation), and (iii) drift, including all the marine sedimentation from the early Albian onwards. The studied material was deposited during the last sequence, which represents the maximum expansion of the carbonate domain in the Potiguar Basin.

The Jandaíra Formation was deposited during a marine ingression and is composed of calcilutites and calcarenites deposited in marginal marine environments on a shallow platform (Monteiro & Faria, 1988; Araripe & Feijó, 1994; Piovesan *et al.*, 2015a) during the Turonian–Campanian interval.

## MATERIAL AND METHODS

The samples herein studied are from an outcrop (UTM 0673396/9411152) located in Rio Grande do Norte State, Brazil. The ages are based on Viviers *et al.* (2000) and Piovesan *et al.* (2014b). The outcrop was sampled at four different levels, named A, B, C and D from the base to the top (Figure 2). Lithologically, the rock samples are mostly composed of calcarenites, and occasionally interstratified layers of oysters occur. A total of 100 g of sediment from each sample was disaggregated with hydrogen peroxide ($H_2O_2$), washing through sieves with mesh 250, 180 and 63 micrometers and oven-dried at 60°C. All ostracod specimens from the three fractions were picked out and put on micropaleontological slides for taxonomic identification. Specimens representative of each taxa were selected for SEM (scanning electron microscopy) at Laboratório de Dispositivos e Nanoestruturas of Universidade Federal de Pernambuco (**LDN-UFPE**) and itt Fossil, UNISINOS.

The suprageneric taxonomy herein adopted follows Horne (2005). In the systematic descriptions, the following abbreviations/conventions are used: **L**, length; **H**, height; **W**, width; **C**, carapace; **RV**, right view; **LV**, left view; **DV**, dorsal view; **f**, female; **m**, male. Type and figured specimens are deposited in the collections of Laboratório de Micropaleontologia Aplicada (**LMA**) – Universidade Federal de Pernambuco (**UFPE**), Brazil, under the curatorial numbers LMA-00001 to LMA 00019.

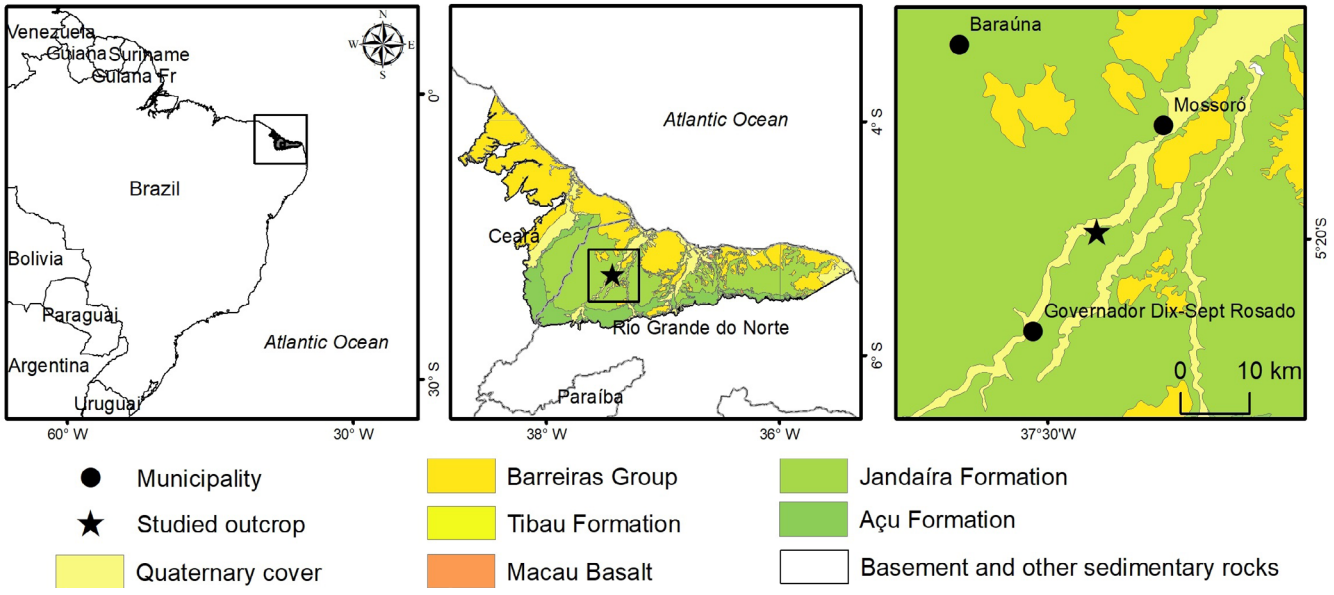


**Figure 1.** Map of the Potiguar Basin indicating the study area, elaborated in QGIS software (metadata from Geological Survey of Brazil – CPRM).

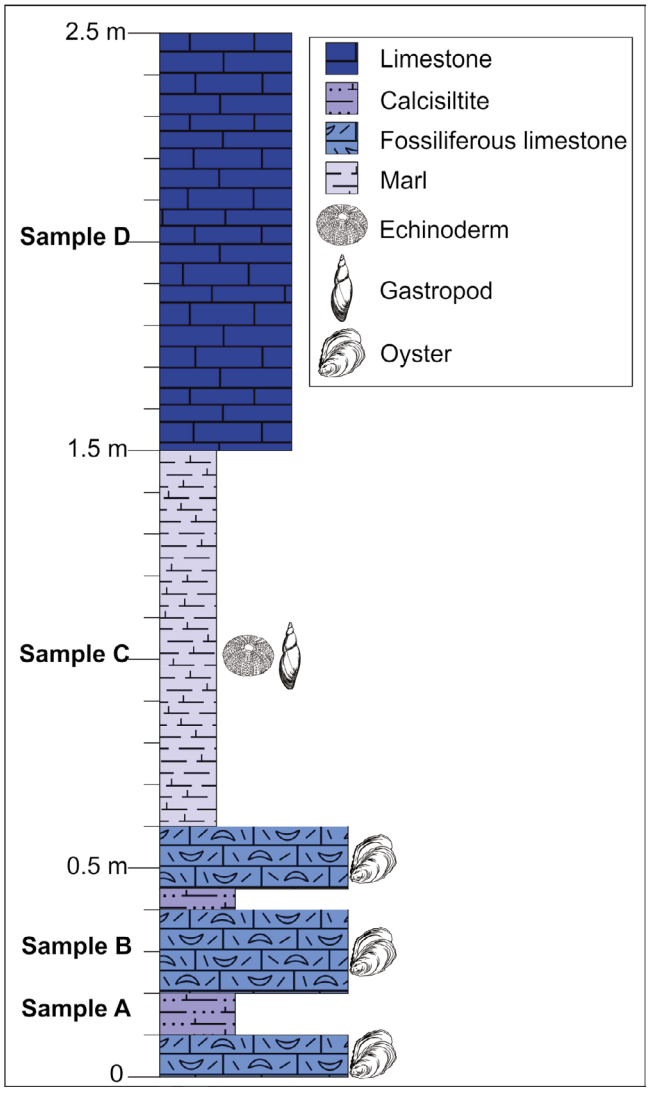


**Figure 2.** Lithologic profile of the studied outcrop with indication of the position of the sampling points and the macrofossils observed.

## SYSTEMATIC PALEONTOLOGY

Class OSTRACODA Latreille, 1802
Subclass PODOCOPA Sars, 1866
Order PLATYCOPIDA Sars, 1866
Suborder PLATYCOPINA Sars, 1866
Superfamily CYTHERELLOIDEA Sars, 1866
Family CYTHERELLIDAE Sars, 1866

*Cytherella* Jones, 1849

*Cytherella gambiensis* Apostolescu, 1963
(Figure 3A)

1963 *Cytherella gambiensis* Apostolescu, p. 1680, pl. 1, figs. 1–3.
non 1981 *Cytherella* cf. *gambiensis* Apostolescu-Bismuth *et al.*, p. 221–222, pl. 6, figs. 1–2.
1985 *Cytherella* cf. *gambiensis* Apostolescu - Vivière, p. 137–138, pl. 1, fig. 7.
2000 *Cytherella gambiensis* Apostolescu - Delicio *et al.*, p. 331–332, figs. 8.3–8.4.
2000 *Cytherella* aff. *C. gambiensis* Viviers *et al.*, p. 415, figs. 8, 5–6 and 9–11.
2014b *Cytherella gambiensis* Apostolescu - Piovesan *et al.*, p. 318, pl. 1, figs. A–D.

**Material.** 46 specimens (samples A and C).
**Illustrated specimen.** LMA-00001, C, LV, Figure 3A; l: 0.89 mm, h: 0.61 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Turonian of Algeria (Vivière, 1985), Senonian of Gambia (Apostolescu, 1963), Upper Cretaceous of the Potiguar Basin (Delicio *et al.*, 2000), Coniacian–Campanian (Viviers *et al.*, 2000) and Santonian–Campanian of the Potiguar Basin (Piovesan *et al.*, 2014b; Santos Filho *et al.*, 2015; in this work).
**Remarks.** Some *Cytherella* species seem to characterize the Late Cretaceous epoch in Brazilian marginal basins. *C. gambiensis* seems to be an important marker for Santonian–Campanian, and *Cytherella ovoidea* Alexander, 1929 is typical of Maastrichtian deposits in the Paraíba Basin (Fauth *et al.*, 2005; Barros *et al.*, 2018). This demonstrates the biostratigraphic potential of this widespread genus.

*Cytherella mediatlasica* Andreu, 1996
(Figure 3B)

1987 *Cytherella* sp. Okosun, p. 25, pl. 13, figs. 5–6.
1992 *Cytherella* sp. Okosun, p. 328, pl. 2, fig. 20.
1996 *Cytherella mediatlasica* Andreu, p. 484–485, 488, pl. 1, figs. 1–10.
2000 *Cytherella* sp. P6 Viviers, Koutsoukos, Silva-Telles & Bengtson, p. 415, fig. 8, 14–15.
2014a *Cytherella mediatlasica* Andreu - Piovesan *et al.*, p. 214, pl. 1, figs. A–D.
2014b *Cytherella mediatlasica* Andreu - Piovesan *et al.*, p. 318, pl. 1, figs. E–I.

**Material.** one specimen (sample C).
**Illustrated specimen.** LMA-00002, C, LV, Figure 3B; l: 0.63 mm, h: 0.34 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Turonian–Santonian of Nigeria (Okosun, 1987, 1992), Santonian of Morocco (Andreu, 1996), Turonian–Campanian of the Potiguar Basin (Viviers *et al.*, 2000; Piovesan *et al.*, 2014a,b; Santos Filho *et al.*, 2015) and Santonian–Campanian in this work.
**Remarks.** Andreu (1996) was the first author to comment on the polymorphism of this species, a characteristic observed years later by Piovesan *et al.* (2014a,b; 2015a).

Order PODOCOPIDA Sars, 1866
Suborder BAIRDIOCOPINA Sars, 1887
Superfamily BAIRDIOIDEA Sars, 1887

Family BAIRDIIDAE Sars, 1887

*Bairdoppilata* Coryell, Sample & Jennings, 1935

*Bairdoppilata* sp. 1
(Figure 3C)

**Material.** 11 specimens (sample C).
**Illustrated specimen.** LMA-00003, C, RV, Figure 3C; 1: 0.92 mm, h: 0.66 mm.
**Age.** Santonian–Campanian.
**Remarks.** *Bairdoppilata* sp. 1 differs from other species of this genus registered in the Potiguar Basin mainly in having the anterior and posterior ends blunt.

*Triebelina* Bold, 1946

*Triebelina anterotuberculata* Piovesan, Cabral & Colin, 2014
(Figure 3D)

2014b *Triebelina anterotuberculata* Piovesan, Cabral & Colin, p. 322, pl. 2, figs. H–L.

**Material.** One specimen (sample C).
**Illustrated specimen.** LMA-00004, C, RV, Figure 3D; 1: 0.95 mm, h: 0.54 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Piovesan *et al.*, 2014b; in this work).
**Remarks.** Despite the poor preservation, this specimen is identified at species level by the outline and the anterior tubercle.

Suborder CYPRIDOCOPINA Baird, 1850
Superfamily CYPRIDOIDEA Baird, 1845
Family CANDONIDAE Kaufmann, 1900
Subfamily PARACYPRIDINAE Sars, 1923

*Paracypris* Sars, 1866

*Paracypris* sp. 1
(Figure 3E)

**Material.** Nine specimens (sample C).
**Illustrated specimen.** LMA-00005, C, Figure 3E; 1: 0.80 mm, h: 0.42 mm.
**Age.** Santonian–Campanian.
**Remarks.** This species differs from others identified in the Potiguar Basin by the rounded posterior end. The material is scarce and poorly preserved and, for these reasons, cannot be described.

Suborder CYTHEROCOPINA Baird, 1850
Superfamily CYTHEROIDEA Baird, 1850

Family CYTHERIDEIDAE Sars, 1925

*Cophinia* Apostolescu, 1961

*Cophinia ovalis* Piovesan, Cabral & Colin, 2014
(Figures 3F–G)

2000 *Cophinia* aff. *C. apiformis* Viviers, Koutsoukos, Silva-Telles & Bengtson, p. 423, fig. 13, 1–4.
2014b *Cophinia ovalis* Piovesan, Cabral & Colin, p. 326, pl. 3, figs. D–I.

**Material.** 167 specimens (samples A and C).
**Illustrated specimens.** LMA-00006, C, RV, Figure 3F; 1: 0.89 mm, h: 0.75 mm; LMA-00007, C, DV, Figure 3G; 1: 1.02 mm, w: 0.45 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Viviers *et al.*, 2000; Piovesan *et al.*, 2014b; in this work).

*Fossocytheridea* Swain & Brown, 1964

*Fossocytheridea potiguarensis* Piovesan, Cabral & Colin, 2014
(Figures 3H–I)

2000 *Sarlatina* sp. P5 Viviers, Koutsoukos, Silva-Telles & Bengtson, p. 424, fig. 14, 5–8.
2014b *Fossocytheridea potiguarensis* Piovesan, Cabral & Colin, p. 326, pl. 3, figs. J–P.

**Material.** Nine specimens (sample A).
**Illustrated specimens.** LMA-00008, right valve, Figure 3H; m, 1: 1.12 mm, h: 0.55 mm; LMA-00009, C, RV, Figure 3I, f, 1: 1 mm, h: 0.58 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Viviers *et al.*, 2000; Piovesan *et al.*, 2014b; in this work).

*Ovocytheridea* Grékoff, 1951

*Ovocytheridea anterocompressa* Piovesan, Cabral & Colin, 2014
(Figure 3J)

2014b *Ovocytheridea anterocompressa* Piovesan, Cabral & Colin, p. 330, pl. 4, figs. I–M.

**Material.** 742 specimens (samples A, B and C).
**Illustrated specimen.** LMA-00010, C, RV, Figure 3J; 1: 0.76 mm, h: 0.46 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Piovesan *et al.*, 2014b; in this work).

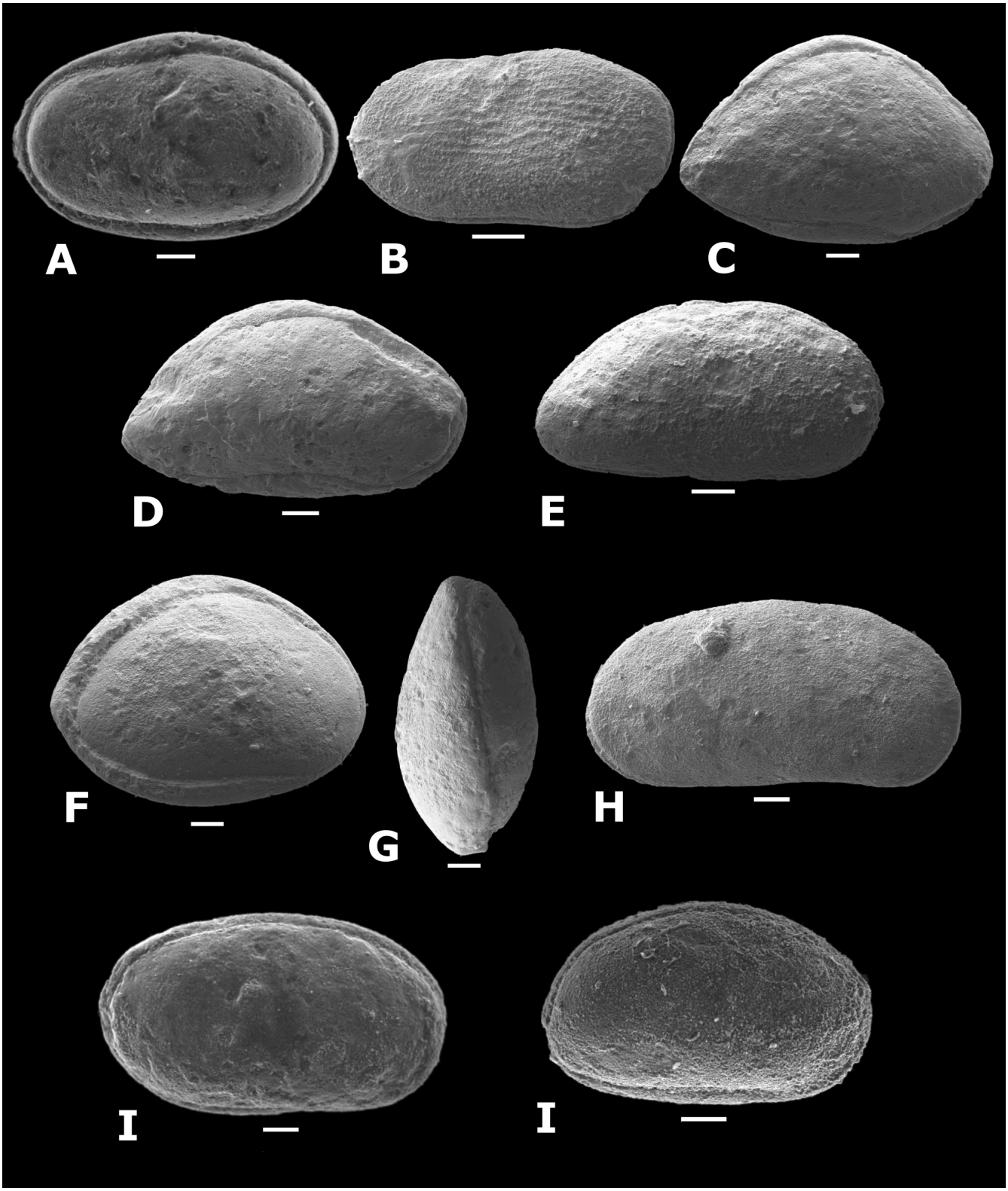


**Figure 3.** Ostracod species **A**, *Cytherella gambiensis*, C, LV (LMA-00001); **B**, *Cytherella mediatlasica*, C, LV (LMA-00002); **C**, *Bairdoppilata* sp. 1, C, RV (LMA-00003); **D**, *Triebelina anterotuberculata*, C, RV (LMA-00004); **E**, *Paracypris* sp. 1, C, RV (LMA-00005); **F**, *Cophinia ovalis*, C, RV (LMA-00006); **G**, *Cophinia ovalis*, C, DV (LMA-00007); **H**, *Fossocytheridea potiguarensis*, RV, m, RV (LMA-00008); **I**, *Fossocytheridea potiguarensis*, C, f, RV (LMA-00009); **J**, *Ovocytheridea anterocompressa*, C, RV (LMA-00010). Scale bars = 100 μm.

*Ovocytheridea triangularis* Piovesan, Cabral & Colin, 2014
(Figures 4A–B)

2000 *Ovocytheridea* aff. *O. producta* Grékoff, 1962 - Viviers *et al.*, p. 423, fig. 13, 21–22.
2014b *Ovocytheridea triangularis* Piovesan, Cabral & Colin, p. 330, pl. 4, figs. N–R.

**Material.** 34 specimens (sample C).
**Illustrated specimens.** LMA-00011, C, RV, Figure 4A; 1: 0.77 mm, h: 0.46 mm; LMA-00012, C, DV, Figure 4B; 1: 0.78 mm, w: 0.36 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Viviers *et al.*, 2000; Piovesan *et al.*, 2014b; in this work).

*Perissocytheridea* Stephenson, 1938

*Perissocytheridea jandairensis* Piovesan, Cabral & Colin, 2014
(Figure 4C)

2000 *Semicytherura* sp. P1 Viviers, Koutsoukos, Silva-Telles & Bengtson, p. 424, fig. 14, 19–23.
2014b *Perissocytheridea jandairensis* Piovesan, Cabral & Colin, p. 332, pl. 5, figs. E–I.

**Material.** Six specimens (samples A, B and C).
**Illustrated specimen.** LMA-00013, C, RV, Figure 4C; 1: 0.47 mm, h: 0.23 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Viviers *et al.*, 2000; Piovesan *et al.*, 2014b; in this work).

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948

*Protocosta* Bertels, 1969

*Protocosta babinoti* Piovesan, Cabral & Colin, 2014
(Figures 4D–E)

2000 *Cythereis*? sp. P8 Viviers, Koutsoukos, Silva-Telles & Bengtson, p. 433, fig. 19, 3–4.
2014b *Protocosta babinoti* Piovesan, Cabral & Colin, p. 335, pl. 5, figs. K–P.

**Material.** 22 specimens (samples A and C).
**Illustrated specimens.** LMA-00014, C, RV, f, Figure 4D; 1: 0.76 mm, h: 0.43 mm. LMA-00015, C, RV, m, Figure 4E; 1: 0.96 mm, h: 0.45 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Viviers *et al.*, 2000; Piovesan *et al.*, 2014b; in this work).

*Protocosta* POT 1 Piovesan, Cabral & Colin, 2014
(Figure 4F)

2014b *Protocosta* POT 1 Piovesan, Cabral & Colin, p. 335, pl. 6, figs. Q–S.

**Material.** One specimen (sample C).
**Illustrated specimen.** LMA-00016, C, RV, Figure 4F; 1: 0.63 mm, h: 0.32 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Piovesan *et al.*, 2014b; in this work).

Trachyleberididae indet. gen. 6 Piovesan, Cabral & Colin, 2014
(Figure 4G)

2014b Trachyleberididae indet. gen. 6. Piovesan *et al.*, p. 348, pl. 9, figs. P–Q.

**Material.** Three specimens (samples A and C).
**Illustrated specimen.** LMA-00017, C, RV, Figure 4G; 1: 0.88 mm, h: 0.41 mm
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Santonian–Campanian, Potiguar Basin (Piovesan *et al.*, 2014b; in this work).
**Remarks.** This is a very rare species registered by a single specimen in another locality of the Potiguar Basin by Piovesan *et al.* (2014b).

Subfamily BUNTONIINAE Apostolescu, 1961

*Soudanella* Apostolescu, 1961

*Soudanella semicostellata* (Grékoff, 1951)
(Figure 4H)

1951 *Buntonia semicostellata* Grékoff, p. 98, pl. 2, figs. 16–19.
1987 *Buntonia (P.) semicostellata* (Grékoff) - Okosun, p. 55-56, pl. 18, figs. 1–2; pl. 22, fig. 17.
1992 *Protobuntonia semicostellata* (Grékoff) - Okosun, p. 332, pl. 2, figs. 1–2.
2000 *Protobuntonia* sp. P6 Viviers, Koutsoukos, Silva-Telles & Bengtson, p. 432, fig. 18, 7–8.
2014b *Soudanella semicostellata* (Grékoff, 1951) - Piovesan *et al.*, p. 337, pl. 7, figs. O–Q.

**Material.** Five specimens (samples A and C).
**Illustrated specimens.** LMA-00018, C, RV, Figure 4H; 1: 1 mm, h: 0.51 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Turonian–Santonian, Nigeria (Okosun, 1987, 1992); Santonian–Campanian, Potiguar Basin (Viviers *et al.*, 2000; Piovesan *et al.*, 2014b; in this work); Campanian, Cameroon (Grékoff, 1951).

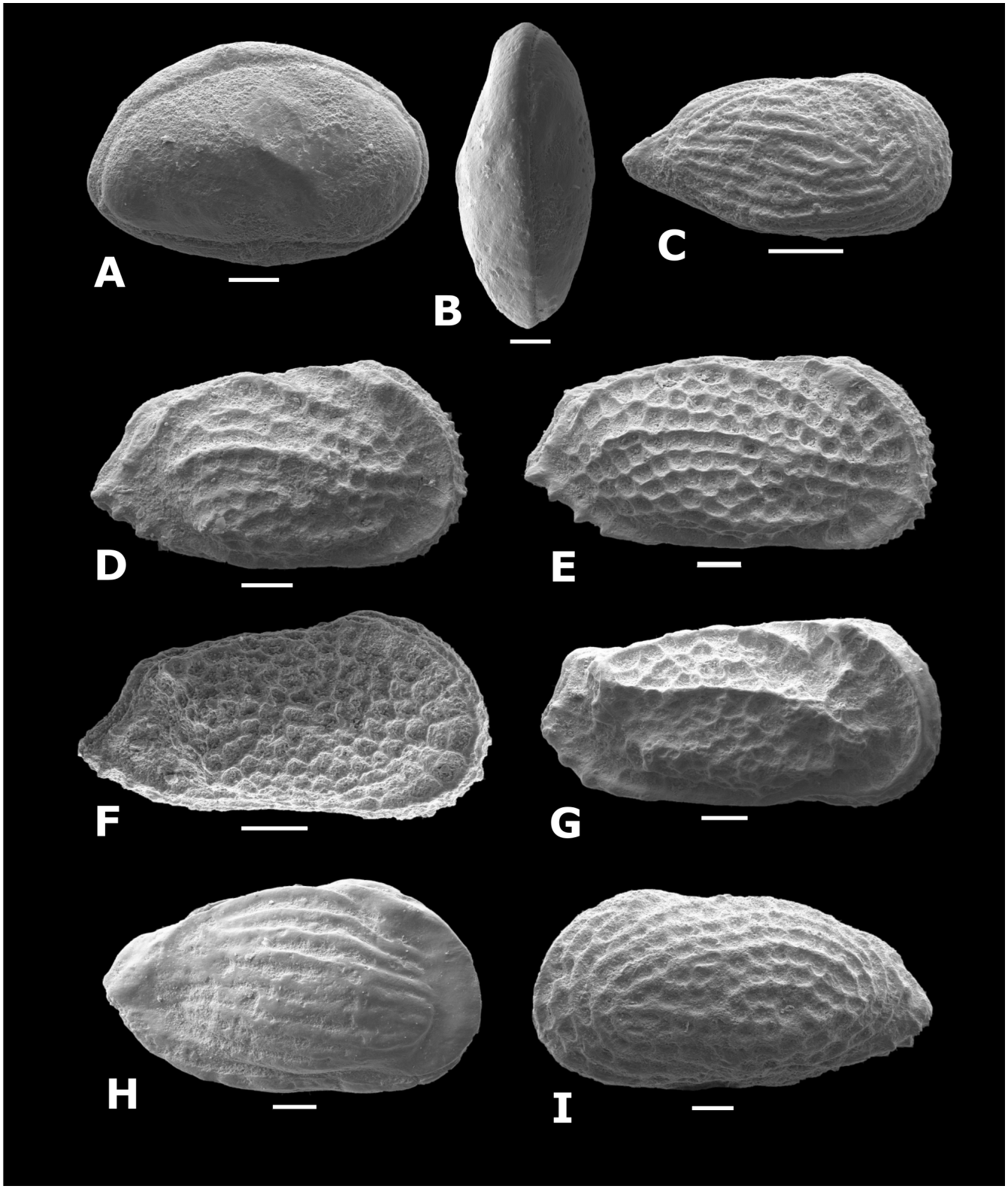


**Figure 4.** Ostracod species **A**, *Ovocytheridea triangularis*, C, RV (LMA-00011); **B**, *Ovocytheridea triangularis*, C, DV (LMA-00012); **C**, *Perissocytheridea jandairensis*, C, RV (LMA-00013); **D**, *Protocosta babinoti*, C, f, RV (LMA-00014); **E**, *Protocosta babinoti*, C, m, RV (LMA-00015); **F**, *Protocosta* POT 1, C, RV (LMA-00016); **G**, Trachyleberididae indet. gen. 6, C, RV (LMA-00017); **H**, *Soudanella semicostellata*, C, RV (LMA-00018); **I**, *Leguminocythereis reymenti*, C, LV (LMA-00019). Scale bars = 100 μm.

Subfamily CAMPYLOCYTHERINAE Puri, 1960

*Leguminocythereis* Howe, 1936

*Leguminocythereis reymenti* Neufville, 1973
(Figure 4I)

1960 *Leguminocythereis* sp.- Reyment, p. 139, pl. 7, fig. 6.
1973 *Leguminocythereis reymenti* Neufville, p. 49–50. pl. 2, fig. 3, 4a–b.
1999 *Leguminocythereis* sp. Gebhardt, p. 89, figs. 6.5–6.9.
2000 *Leguminocythereis reymenti* Neufville - Delicio *et al.*, p. 430, figs. 17, 1–2.
2000 *Leguminocythereis* aff. *L. reymenti* - Viviers *et al.*, p. 340-341, figs. 8.21–8.22.
2014b *Leguminocythereis reymenti* - Piovesan *et al.*, p. 337, pl. 7, figs. R–T.

**Material.** Three specimens (sample C).
**Illustrated specimens.** LMA-00019, C, LV, Figure 4I; 1: 1 mm, h: 0.5 mm.
**Age.** Santonian–Campanian.
**Stratigraphic and geographic distribution.** Turonian–Santonian, Nigeria (Reyment, 1960; Neufville, 1973; Gebhardt, 1999); Santonian–Campanian, Potiguar Basin (Delicio *et al.*, 2000; Viviers *et al.*, 2000; Piovesan *et al.*, 2014 b; in this work).

## DISCUSSION

The Santonian–Campanian assemblages of the studied outcrop are composed of fifteen taxa, typical of marginal marine environments. Variations in taxonomic composition is attributed to both ecological and sedimentary processes, as previously discussed by Piovesan *et al.* (2015a). The sample A (base of the studied section) records abundance of the mixohaline species *Ovocytheridea anterocompressa* associated with *Fossocytheridea potiguarensis* and *Perissocytheridea jandairensis*, and scarce marine species. The same pattern was registered by Piovesan *et al.* (2015a) in this basin and referred to as the interval "Mixohaline/ Marine 2". In the Santonian–Campanian of the Santos Basin (southeastern Brazilian margin), the association *Fossocytheridea-Perissocytheridea* is considered an indicator of oligohaline/mesohaline environments (Bergue *et al.*, 2011; Fauth *et al.*, 2012), and a revision by Piovesan *et al.* (2015b) reinforced the euryhaline character of both genera. The marine influence in these assemblages is indicated by rare but typical marine ostracods (cytherellids and trachyleberidids), miliolids foraminifera, echinoid spines, bryozoan fragments and bivalve mollusks.

A remarkable decrease in diversity and abundance occurs in sample B. The abundance of *Ovocytheridea anterocompressa* and *Perissocytheridea jandairensis* decreases significantly concomitant with reduction in the incidence of marine mollusk fragments, mainly oysters, which is interpreted as decreased marine influence. The most drastic turnover, however, is registered in the sample C, where diversified and typically marine assemblages dominated by cytherellids, bairdiids, and trachyleberidids replaced mixohaline taxa. Marine gastropods and echinoids are also recorded in this part of the section. The presence of *Ovocytheridea triangularis* and *Cophinia ovalis* in sample C demonstrate their ecological plasticity, occurring both in association with marine and brackish taxa, as also discussed by Piovesan *et al.* (2014b, 2015a). Sample D, the uppermost in the studied section, was barren of ostracods.

## CONCLUSIONS

Ostracods are effective indicators of changes in the studied depositional environments in the Jandaíra Formation in terms of faunal turnover and abundance of some taxa. The extant diversity is incompletely known and deserves more study, because some taxa are still in open nomenclature, not only in this, but also in previous studies. This paper demonstrates that patterns observed by Piovesan *et al.* (2014a,b) are not restricted to the site of the core analyzed in those studies, but possibly characterizes broader areas of Jandaíra Formation.

## ACKNOWLEDGMENTS

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