Ostracodes from the Upper Cretaceous deposits of the Potiguar Basin, northeastern Brazil: taxonomy, paleoecology and paleobiogeography.

Part 1: Turonian

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Abstract: This paper describes thirteen new species and two new genera of marine and brackish water ostracodes from the Turonian deposits of Potiguar Basin, NE Brazil, among a total of 53 taxa. The new species include Cophinia grekoffi, Fossocytheridea tiberti, Haughtonileberis dinglei, Hemicytherura viviersae, Jandairella obesa (new genus and species), Loxocorniculum? narendrai, Ovocytheridea posteroprojecta, O. reymenti, Perissocytheridea caudata, P. mossoroensis, Potiguarella grosdidieri (new genus and species), P. coimbrai and Procycytherura ballentae. The diversity and dominance indexes vary according to the paleoenvironment. Three assemblages were identified: a predominantly mixohaline fauna in the basal part of the section, followed by a diversified shallow marine fauna and, in the upper part, a marine and brackish water ostracode fauna. Most of the recorded species are endemic. Eight species are common to Northwest and North Africa, indicating a faunal link during the Turonian. The study of the Turonian faunas of the Potiguar Basin represents a significant improvement to understand the dynamic evolution of the Brazilian basins and the paleobiogeographical relationship with other regions.

Key Words: Ostracodes; Turonian; Potiguar Basin; Jandaíra Formation; paleoecology; paleobiogeography.

The present study contributes to the knowledge of the taxonomy of the Turonian ostracode assemblages from a long and fairly complete borehole of the Jandaíra Formation, Potiguar Basin and gives additional data on the paleoecology and paleobiogeography, based on these microfossils.

2. Study area

The Potiguar Basin (Fig. 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 state of Rio Grande do Norte and partially in the state of Ceará (MOHRIAK, 2003; PESSOA NETO et al., 2007).

The Potiguar Basin was formed by extensional processes during the Early Cretaceous associated with rifting that culminated in the separation of the South American and African plates. PESSOA NETO et al. (2007) divided the stratigraphic record into three supersequences: rift, deposited during the Early Cretaceous (Berriasian-Lower Aptian), represented by fluvial-deltaic and lacustrine deposits of the Pendência and Pescada formations; post-rift, deposited during the Late Aptian-Early Albian and characterized by fluvial-deltaic deposits, with the first records of marine ingressions (Alagamar Formation); drift, comprising the entire marine sedimentation that occurred after the Early Albian until the Recent.

The Jandaíra Formation was deposited during the first major marine transgression from the north (BRITO, 1976). This unit consists predominantly of bioclastic calcarenites and calcilutites deposited in marginal marine environments on a shallow platform (MONTEIRO & FARIA, 1988; ARARIPE & FEIJÓ, 1994). ARARIPE & FEIJÓ (1994) reviewed internal reports of Petrobras and attributed the Turonian-Campanian age to this formation, which was later corroborated by PESSOA NETO et al. (2007). The base of Turonian is marked by the last occurrence of the palynomorph Gnetaceae pollenites similis and the top is marked by the last occurrence of Tricolpites S427 (VIVIERS et al., 2000). The ostracode biozone OP-4 (from VIVIERS et al., 2000) is characterized by the presence of Jandairella obesa gen. nov. sp. nov. (=Trachyleberididae sp. P5 of VIVIERS et al., 2000) and Indet. gen 1 POT 1 (= Cypridopsis sp. P1 VIVIERS et al., 2000).
3. Material and methods

Twenty-eight samples were analyzed, covering 57 m of the Turonian interval in the 9-MO-13-RN well (Fig. 2). The average weight of the samples was 60 g and were dominantly calcaremites. The samples were processed using standard laboratory techniques for the study of fossil ostracodes, which consists in disaggregation with hydrogen peroxide ($H_2O_2$), washing through sieves with mesh 250, 180 and 63 micrometers and dried at 60° C. More than 4,800 specimens were picked for this study. The selected specimens were imaged using a Zeiss EVO MA15 scanning electron microscope. Some of the material is only illustrated (Appendix 1) and includes the taxa that remained undetermined due to the small number of the specimens, their poor preservation, limited stratigraphic value, or because it was impossible to include them in any known taxon.

The study area map was created using ArcGIS® software version 9.3 by ESRI (Environmental Systems Research Institute). The complete micropaleontological data were plotted in colour using the StrataBugs® software, with depth in Y-axis and the identified taxa in X-axis in the well. The statistical data were run with the PAST software (HAMMER et al., 2001; HAMMER & HARPER, 2006) and Microsoft Excel®.

4. Paleontology

Taxonomy follows the classification of Hörne (2005). In the systematic descriptions, the following abbreviations/conventions are employed: L: length, H: height, W: width; very small (<0.400 mm), small (0.400-0.500 mm), medium (0.510-0.700 mm), large (0.710-0.900 mm), very large (>0.900 mm); C: carapace, RV: right valve, LV: left valve, DV: dorsal view, VV: ventral view, EV: external view (valve), IV: internal view; f: female, m: male. All dimensions are in mm. Type and figured specimens are deposited in the collections of Museu de História Geológica do Rio Grande do Sul, Universidade do Vale do Rio dos Sinos, under the prefix ULVG followed by their respective catalogue numbers. All dimensions of the figured specimens are in the plate captions.
Class Ostracoda
Latreille, 1802
Subclass Podocopa
Sars, 1866
Order Platycopida
Sars, 1866
Suborder Platycopina
Sars, 1866
Superfamily Cytherelloidea
Sars, 1866
Family Cytherellidae
Sars, 1866
Genus Cytherella
Jones, 1849
Cytherella mediatlasica
Andreu, 1996
(Pl. 1, figs. A-D)
1987 Cytherella sp. Okosun, p. 25, Pl. 13, figs. 5-6.
Material: 268 specimens.
Age: Turonian.
Remarks: The presence of different morphotypes in this species was observed by Andreu (1996) in the Santonian of Morocco. The specimens recorded in this work are smaller than those recorded in Morocco.

Order Podocopida
Sars, 1866
Suborder Bairdiocopina
Sars, 1887
Superfamily Bairdioidae
Sars, 1887
Family Bairdiidae
Sars, 1887
Genus Bairdopilata
Coryell, Sample & Jennings, 1935
Bairdopilata potiguarenensis
(Delicio, Coimbra & Carreño, 2000)
(Pl. 1, figs. E-H)
2000 Bairdia potiguarenensis Delicio, Coimbra & Carreño, p. 333-334, Figs. 8.5-8.7.
Material: 267 specimens.

Figure 2: Lithological profile and electrical logs of the studied interval of the well 9-MO-13-RN.
Age: Turonian.
Stratigraphic and geographic distribution: Upper Cretaceous, Potiguar Basin, Brazil (Delicio et al., 2000; this work).
Remarks: This species was reassigned to the genus Bairdopilata due to the observation of the auxiliary dentition of the hinge at anterior and posterior ends, which corresponds to Bairdopilata’s diagnosis. The specimens illustrated by Delicio et al. (2000) are smaller (average = 0.850 mm) and were considered juveniles. Bairdia sbaenensis Andreu, 1996, described from the Upper Turonian (?)-Coniacian (?)-Santonian of Morocco is more elongate and
the posterior margin is straighter. Gebhardt (1999a, 1999b) recorded Bairdia sp. in the Turonian of Nigeria, which is similar to B. potiguarensis, but more elongate and with the dorsal margin straighter. Bairdia sp. C Bold, 1964, from the Turonian of Egypt, differs by the more rounded dorsal margin and by the pronounced overlap. B. potiguarensis differs from B. cespedesensis (Bold, 1946) from the Maastrichtian of Cuba and the Pará-Maranhão Basin (Piovesan et al., 2009) by the marked difference in the size and by the overlapping of the dorsal margin.

Family Bythocyprididae

Maddock, 1969

Genus Bythocypris Brady, 1880

"Bythocypris" POT 1

(Pl. 1, figs. I-K)

Material: 141 specimens.

Brief description: carapace large, sub-rectangular to suboval in lateral view, narrow in dorsal view, with the greatest height at mid-length. LV overlaps the right one along all margins, except in the dorsal one. Dorsal margin convex, ventral margin almost straight. Anterior and posterior margins rounded. Surface predominantly smooth with punctuations scarcely and irregularly distributed. Sexual dimorphism not observed.

Age: Turonian.

Remarks: Although the Cretaceous species with this shape are usually assigned to the genus Bythocypris, we are not sure about the generic status of this species. Bythocypris Brady, 1880 is more reniform and the posterior margin is much more asymmetrical than in the species recorded here. In addition, the internal features of the studied material are not available. This species differs from Bythocypris gohrbandti Esker, 1968, described from the Upper Cretaceous of Tunisia and recorded in the Santonian of Algeria by Vivière (1985) and Turonian of Brazil (this work).

Subfamily Paracypridinae Sars, 1923

Genus Paracypris Sars, 1866

Paracypris aff. caudata (BOLD, 1964)

(Pl. 1, figs. L-O)

aff. 1964 Ovocyttheridea caudata Bold, p. 119, Pl. 14, figs. 4a-b.

1973a Paracypris caudata (van den Bold) - Neufville, p. 125-126, Pl. 7, fig. 4.

1985 Paracypris sp. 2 Vivière, p.150-151, Pl. 3, fig. 10.

Material: 52 specimens.

Brief description: Carapace large, robust, sub-triangular in lateral view and suboval in dorsal view. Overlap of the LV along all margins of the RV, more pronounced in the dorsal margin. Maximum height and maximum width at mid-length. Dorsal margin strongly convex, with a small concavity in the anterodorsal part of the RV, ventral margin almost straight in the LV and slightly concave at mid-length of the RV. Anterior margin obliquely rounded, posterior acuminate. Surface smooth.

Age: Turonian.

Stratigraphic and geographic distribution: probably in the Turonian of Egypt (Bold, 1964), Turonian of Gabon (Neufville, 1973a), Middle Turonian-Santonian of Algeria (Vivière, 1985) and Turonian of Brazil (this work).

Remarks: This species is higher in the posterior third, when compared with P. caudata (Bold, 1964). In general, P. aff. caudata differs from other species of Paracypris from Potiguar Basin in being higher and wider and in having a more sub-triangular outline.

Paracypris aff. dubertreti

DAMOTTE & SAINT-MARC, 1972

(Pl. 1, figs. P-Q)

aff. 1972 Paracypris dubertreti DAMOTTE & SAINT-MARC, p. 276, Pl. 1, fig. 1.

1985 Paracypris dubertreti DAMOTTE & SAINT-MARC - VIVIERE, p.149, Pl. 3, figs. 6-7.

Material: 71 specimens.

Brief description: Carapace of medium size, thin, sub-triangular and elongate in lateral view; narrow and lanceolate in dorsal view. LV slightly larger than the right one along all margins. Greatest height positioned at the anterior third. Dorsal margin almost straight; ventral margin with a pronounced concavity at mid-length. Anterior margin rounded, posterior very acuminate. Surface smooth.

Age: Turonian.

Stratigraphic and geographic distribution: Cenomanian-Turonian of Algeria (Vivière, 1985) and Turonian of Potiguar Basin, Brazil (this work).

Remarks: This species is similar to Paracypris dubertreti DAMOTTE & SAINT-MARC, 1972, recorded in the Upper Cenomanian of Lebanon and a common species in the Cenomanian of Africa (e.g., Israel: Rosenfeld & Raab, 1974; Algeria: Majoran, 1989; Morocco: Andreu, 1991; Andreu et al., 2013; Tunisia: Bismuth et al., 1995; Jordan: Morsi & Wendler, 2010). However, the Brazilian species is significantly smaller than P. dubertreti and has a straighter dorsal margin, the ventral margin is more concave and the cardinal angles less marked.

Paracypris POT 1

(Pl. 1, figs. R-T)

Material: 45 specimens.

Brief description: Carapace sub-triangular and elongate in lateral view, lanceolate in dorsal view. LV overlaps the right one along all margins, more pronounced in the anterodorsal
margin, where the RV has a small concavity. Maximum height and greatest width in front of the mid-length. Dorsal margin convex; ventral margin straight. Anterior margin obliquely rounded, posterior margin subacute, with the extremity positioned ventrally. Surface smooth or with faint longitudinal stries near the ventral margin.

**Age:** Turonian.

**Remarks:** This species differs from *Paracypris* sp. P3 *VIVIERS, KOUTSOUKOS, SILVA-TELLES & BENTGSON, 2000*, from the Coniacian-Santonian of Potiguar Basin, Brazil, by its more acute posterior margin and the location of the maximum length, which is more ventral.

**Superfamily Cytheroidea Baird, 1850**

**Family Cytherideidae SARS, 1925**

**Genus Cophinia APOSTOLESCU, 1961**

*Cophinia grekoffi*

PIOVESAN, CABRAL & COLIN sp. nov.

(Pl. 2, figs. A-E)

**Derivatio nominis:** This species is named after N. GRÉKOFF, in honor of his important contribution to the knowledge of ostracodes.

**Material:** 140 specimens.

**Holotype:** C, f, ULVG-9941 (Pl. 2, fig. A), sample 297.60 m.

**Paratypes:** ULVG-9942, ULVG-9943, ULVG-9944, ULVG-9946.

**Dimensions:** Holotype: L: 0.900, H: 0.570, W: 0.401. Paratypes: L: 0.817-0.939, H: 0.470-0.521, W: 0.409-0.427.

**Type-locality:** 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 297.60 m, Potiguar Basin, Brazil.

**Diagnosis:** A species of *Cophinia* characterized by an ovoid outline in lateral and dorsal views, with the anterior and posterior regions strongly depressed.

**Description:** Carapace very large, ovoid and elongate in lateral view, ovoid and inflate in dorsal view. LV larger than the right one, uniformly overlapping it along all margins, except in the anteroventral margin. Maximum height and maximum width at mid-length. Dorsal margin convex on both valves. Ventral margin convex in the LV, almost straight and with a concavity in the posterior half in the RV. Anterior margin obliquely rounded, posterior margin with a projection in both valves below mid-height. Anterior and posterior regions strongly compressed, more easily seen in dorsal view. Merodont hinge. Surface smooth.

**Sexual dimorphism:** Pronounced, with the females higher, less elongated and less inflated than males. The maximum width in the females is located at mid-length, in the males it is located at the posterior third and the LV is more inflated.

**Age:** Turonian.

**Remarks:** This species is more elongated and has the anterior and posterior regions more compressed than *Cophinia POT 2* (Pl. 9, figs. N-O). Moreover, in dorsal view, *Cophinia POT 2* exhibits more symmetric valves than *C. grekoffi* sp. nov. "Cophinia" GA B I GROSIDIER, 1979, from the Cenomanian-Turonian of Gabon has the posterior projection more pronounced and the overlap more developed than in *C. grekoffi* sp. nov.

**Cophinia POT 1**

(Pl. 2, figs. F-H)

**Material:** 8 specimens.

**Brief description:** Carapace large, sub-triangular to sub-rectangular in lateral view, ovoid with almost parallel margins, in dorsal view. Strong overlap of the right valve along all margins. Dorsal margin convex in the LV, almost straight in the RV, with well defined anterior cardinal angle. Ventral margin convex in the LV and straight in the RV. Anterior margin asymmetrically rounded, posterior obliquely rounded. In the posterior region, the left valve has a projection, located below the mid-height of the carapace. Surface irregularly punctuated. Sexual dimorphism not observed, probably due to the scarcity of the material.

**Age:** Turonian.
Remarks: This species has similarities with *Cophinia pulvinata* APOSTOLESCU, 1963 (Senonian of Gambia), *Cophinia apiformis* (REYMENT, 1960) from the Coniacian-lower Santonian of Nigeria and *Ovocytheridea ashakaensis* OKOSUN, 1987, from the Turonian of Nigeria. However, in dorsal view, this species differs markedly from the others by its parallel margins. The species was not described due to the scarcity of the material and the lack of internal views.

**Genus Fossocytheridea** SWAIN & BROWN, 1964

**Fossocytheridea tiberti**

PIOVESAN, CABRAL & COLIN nov. sp.

(Pl. 2, figs. I-M)

**Derivatio nominis:** In honor of Dr. Neil TIBERT for his contribution to the knowledge of the genus *Fossocytheridea*.

**Material:** 52 specimens.

**Holotype:** C, f, ULVG-9938 (Pl. 2, figs. I-J), sample 319.30 m.

**Paratypes:** ULVG-10661, ULVG-9939, ULVG-9940.

**Dimensions:** Holotype: L: 0.880, H: 0.519, W: 0.424-0.500, W: 0.400.

**Type-locality:** 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 272.40 m, Potiguar Basin, Brazil.

**Diagnosis:** A species of the genus *Fossocytheridea* characterized by a large and sub-rectangular to sub-ovoid carapace in lateral view, evenly swollen in dorsal view; surface smooth.

**Description:** Carapace large, sub-rectangular to sub-ovoid in lateral view, ovoid in dorsal view. Left valve larger than right one, along all margins, more pronounced in the ventral margin. Greatest height near the mid-length in females, and in males at the anterior third. Dorsal margin convex, ventral margin nearly straight in the RV, slightly convex in LV. Anterior margin rounded, posterior margin rounded to slightly acuminated. Surface smooth. Anterior region slightly compressed. Cardinal angles well developed. The hinge of the RV is the typical of the genus.

**Age:** Turonian.

**Remarks:** This species resembles *Clithrocytheridea senegali* APOSTOLESCU, 1961, from the Senonian of Senegal, in general outline and dimensions of the carapace, but differs in the position of the maximum length which is higher. Moreover, the African species is smaller and has a DV with almost parallel margins in the female.

**Genus Ovocytheridea** GRÉKOFF, 1951

**Ovocytheridea reymenti**

PIOVESAN, CABRAL & COLIN sp. nov.

(Pl. 2, figs. N-T)


**Derivatio nominis:** In honor of Dr. Richard REYMENT for his contribution to the knowledge of the Cretaceous ostracodes from Africa.

**Material:** 448 specimens.

**Holotype:** C, f, ULVG-9959 Pl. 2, figs. N-O), sample 272.40 m.

**Paratypes:** ULVG-9960 - ULVG-9963.

**Dimensions:** Holotype: L: 0.631, H: 0.386, W: 0.297-0.371, H: 0.280-0.292.

**Type-locality:** 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 272.40 m, Potiguar Basin, Brazil.

**Diagnosis:** A species of *Ovocytheridea* with a medium-size carapace, suboval to sub-rectangular in lateral view, narrow in dorsal view and strongly punctuated.
Description: Carapace of medium size, sub-oval to sub-rectangular in lateral view, ovoid and narrow in dorsal view. Slightly wider at mid-length. Left valve overlapping the right one strongly along all margins, less pronounced in the posteroventral margin. Anterior region very slightly compressed. Anterior margin asymmetrically rounded, posterior margin obliquely rounded, with marked posterior cardinal angle. Dorsal margin convex. Ventral margin straight in the RV and convex in the LV. Greatest height just in front of the mid-length. Surface densely punctuated, except near the margins, where it is smooth. Adductor muscle represented by four scars vertically aligned: the upper and the lower ones are rounded and the median ones more elongated. Frontal muscle scar rounded and mandibular scar more elongated. Antimerodont hinge: in the LV the anterior socket is larger than the posterior one.

Sexual dimorphism: Males are proportionally narrower, lower and more elongated than females.

Age: Turonian.

Stratigraphic and geographic distribution: Cenomanian-Maastrichtian of Nigeria (Okosun, 1987, 1992) and Turonian, Potiguar Basin, Brazil (Viviers et al., 2000).

Remarks: This species is similar to *Ovocytheridea symmetrica* Reyment, 1960, recorded in the Coniacian of Nigeria. However, the Brazilian species is shorter, less inflated and more inequivalve than *O. symmetrica*. In the description of Reyment (1960), the punctuations in the valves of *O. symmetrica* are treated as “false ornamentation”. In the Potiguar species, the surface is strongly covered with punctuations.

**Ovocytheridea posteroprojecta**

PIOVESAN, CABRAL & COLIN sp. nov.

(Pl. 3, figs. A-E)

Derivatio nominis: Related to the diagnostic feature in the posteroventral margin of this species.

Material: 40 specimens.

Holotype: C, f, ULVG-9976 (Pl. 3, figs. A-C), sample 277.25 m.

Paratypes: ULVG-10486, ULVG-9977.

Dimensions: Holotype: L: 1.040, H: 0.600, W: 0.460. Paratypes: L: 0.760-1.100, H: 0.438-0.580, W: 0.410.

Type-locality: 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 277.25 m, Potiguar Basin, Brazil.

Diagnosis: An elongate species of the genus *Ovocytheridea* with a posteroventral projection on the right valve.

Description: Carapace very large and elongate, sub-triangular in lateral view, ovoid in dorsal view. Strongly inequivalve, with the LV overlapping the right one along all margins, except in the posteroventral margin where the RV is larger. Anterior region slightly compressed, posterior region projecting downward in the RV. This projection is more pronounced in juvenile specimens. Dorsal margin convex. Ventral margin almost straight in males and slightly convex in females. Anterior margin rounded, posterior margin acuminate and projected downward. Surface smooth. Middle region with a shallow sulcus, more visible in DV in the female carapaces, which are more inflated in the posterior region. Hinge in LV with a crenulated and elongated anterior socket extending anteriorly from dorsal apex, the middle element is a crenulated bar along the posterodorsal slope, and another long crenulated socket is observed in posterodorsal angle.

Sexual dimorphism: Females with a more ovoid outline, higher and shorter than males.

Age: Turonian.

Remarks: In the posterior region, this species is similar to *Ovocytheridea rostrata* Apostolescu, 1963, from the Senonian of Gambia. However, *O. rostrata* is smaller, higher and has a very pronounced anterodorsal sulcus. *Ovocytheridea* sp. B 780 Donze, 1973, recorded by Vivière (1985) in the Coniacian of Algeria is similar in lateral view, though the left valve overlaps the right one in the posterior region and differs clearly in dorsal view.

Plate 3: Scale bar: 100 µm

A-E: Ovocytheridea posteroprojecta PIOVESAN, CABRAL & COLIN sp. nov. A-C: holotype, C, f, ULVG-9976, sample 277.25 m; L: 1.040, H: 0.600, W: 0.460; A: right view, B: DV, C: left view; D: paratype 1, C, right view, m, ULVG-10486, sample 275.80 m, L: 1.100, H: 0.580, W: 0.410; E: paratype 2, LV, IV, f, ULVG-9977, sample 277.25 m, L: 0.760, H: 0.438.

F-K: Perissocytheridea caudata PIOVESAN, CABRAL & COLIN sp. nov. F-H: holotype, C, f, ULVG-9932, sample 272.40 m, L: 0.546, H: 0.322, W: 0.330; F: right view, G: DV, H: left view; I-J: paratype 1, C, m, ULVG-9933, sample 297.60 m, L: 0.606, H: 0.310, W: 0.303; I: right view, J: dorsal view; K: paratype 2, LV, IV, f, ULVG-9934, sample 297.60 m; L: 0.350, H: 0.342.

L-P: Perissocytheridea mossoroensis PIOVESAN, CABRAL & COLIN sp. nov. L-N: holotype, C, f, ULVG-9930, sample 319.80 m; L: 0.450, H: 0.295, W: 0.233; L: right view, M: DV, N: left view; O-P: paratype 1, C, m, ULVG-9931, sample: 319.80 m; L: 0.539, H: 0.272, W: 0.247; O: right view, P: DV.

Q-S: Rostrocytheridea? POT 1. Q-R: C, f, ULVG-9954, sample 276.25 m; L: 0.510, H: 0.338 mm, W: 0.283 mm, Q: right view, R: DV; S: EV, m, ULVG-9955, sample 276.25 m. L: 0.539, H: 0.289.
Genus *Perissocytheridea*  
**STEPHENSON, 1938**

*Perissocytheridea caudata*  
PIOVESAN, CABRAL & COLIN sp. nov.  
(Pl. 3, figs. F-K)

**Diagnosis:** A species of *Perissocytheridea* characterized by a sub-pyrimform carapace in lateral view, with a short and narrow caudal process; surface of the valves covered with small punctuations.

**Description:** Carapace of medium size, sub-pyrimform in lateral view, suboval in dorsal view. LV larger with overlap more pronounced in the anterior margin. Greatest height and width near the mid-length. Anterior and posterior regions compressed. Dorsal margin straight, ventral margin convex, partially covered by the ventrolateral expansion. Anterior margin broadly rounded, posterior slightly triangular, forming a short and narrow caudal process, situated near the upper third of the height and projected upwards. Anterodorsal sulcus moderately deep. The males present a posteroventral depression. Surface completely punctuated and with weak ribs in the ventral and ventrolateral regions. Antimerodont hinge.

**Sexual dimorphism:** Pronounced, with males more elongated and narrower than females. The ventrolateral expansion and the postero-ventral depression are more prominent in the males.

**Material:** 515 specimens.

**Holotype:** C, f, ULVG-9932 (Pl. 3, figs. F-H), sample 272.40 m.

**Paratypes:** ULVG-9933, ULVG-9934.

**Dimensions:** Holotype: L: 0.546, H: 0.322, W: 0.330. Paratypes: L: 0.550-0.606, H: 0.310-0.342, W: 0.303.

**Type-locality:** 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 272.40 m, Potiguar Basin, Brazil.

**Diagnosis:** A species of *Perissocytheridea* with a small to medium carapace, with dorsal margin straight to slightly convex, posterior margin sub-triangular and projected downwards. Surface entirely reticulated.

**Description:** Carapace small (females) to medium (males), tumid, sub-pyrimform in lateral view, sub-romboid (females) or ovoid (males) in dorsal view. Maximum height in the anterior cardinal angle. LV larger than RV. Dorsal margin slightly convex to almost straight, ventral margin slightly convex, partially covered by the ventrolateral expansion. Anterior margin obliquely rounded; posterior margin sub-triangular with extremity projected downward and located below the mid-height. The ornamentation consists of strong reticulation covering the entire surface of the valves, with small and dense punctuations in the solum of the reticulum; concentric ribs parallel to the margin convex, partially covered by the ventrolateral expansion. Anterior margin slightly convex to almost straight, posterior slightly triangular with extremity projected downward. The ventrolateral expansion and the postero-ventral depression are more prominent in the posterior end of this species.

**Material:** 20 specimens.

**Holotype:** C, f, ULVG-9930 (Pl. 3, figs. L-N), sample 319.80 m.

**Paratypes:** ULVG-9931, ULVG-10555 (not illustrated).

**Dimensions:** Holotype: L: 0.450, H: 0.259, W: 0.233. Paratypes: L: 0.480-0.539, H: 0.270-0.272, W: 0.247-0.250.

**Type-locality:** 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 319.80 m, Potiguar Basin, Brazil.

**Diagnosis:** A species of *Perissocytheridea* with a small to medium carapace, with dorsal margin straight to slightly convex, posterior margin sub-triangular and projected downwards. Surface entirely reticulated.

**Description:** Carapace small (females) to medium (males), tumid, sub-pyrimform in lateral view, sub-romboid (females) or ovoid (males) in dorsal view. Maximum height in the anterior cardinal angle. LV larger than RV. Dorsal margin slightly convex to almost straight, ventral margin slightly convex, partially covered by the ventrolateral expansion. Anterior margin obliquely rounded; posterior margin sub-triangular with extremity projected downward and located below the mid-height. The ornamentation consists of strong reticulation covering the entire surface of the valves, with small and dense punctuations in the solum of the reticulum; concentric ribs parallel to the margin convex, partially covered by the ventrolateral expansion.
periphery of the valves, running from the anteroventral region to dorsomedian region can also be seen. Anterodorsal sulcus deep. Internal features not seen.

**Sexual dimorphism:** pronounced, males larger, more inflated in the posterior region, with a more developed ventrolateral expansion and marked anteromedian sulcus than females.

**Age:** Turonian.

**Remarks:** This species resembles *Perissocytheridea cavelieri* (Carbonnel & Monciardini, 1995), recorded in the Campanian-Maastrichtian of Mali (Colin et al., 1996). Both species have a sub-triangular posterior margin, although in *P. mossoroensis* sp. nov it is much more pronounced. Also the dorsal margin of *P. mossoroensis* sp. nov. is more convex and the ventrolateral expansion is much more developed than *P. cavelieri*. *Perissocytheridea cretacea* (Piovesan, Bergue & Faught, 2010), recorded in the Santonian-Campanian of Brazilian continental margin, differs by the posterior margin, which is more rounded and projected upwards, and it is wider than the species recorded herein, *Metacytheropteron?* sp. Musacchio, 1973, from the Maastrichtian of Argentina, which is probably a species of *Perissocytheridea*, is more elongated, with the ventrolateral projection less pronounced and more inflated and with the posterior margin projected upwards.

**Genus Rostrocytheridea DINGLE, 1969**

**Rostrocytheridea? POT 1**

(Pl. 3, figs. Q-S)

**Material:** 10 specimens.

**Brief description:** carapace of medium size, suboval to sub-triangular in lateral view, ovate in dorsal view. Maximum height near the mid-length in females, at anterior third in males; maximum width at mid-length. LV larger than the right one, with a strong overlap in the dorsal region. Dorsal margin convex, ventral margin almost straight to slightly convex. Anterior margin rounded, posterior margin obliquely rounded, with the extremity under mid-height and slightly projected downwards.

Surface with large and irregularly distributed pits, which decrease in size towards the margins. Anterior margin with stout and short spines, posteroventral region with four robust spines. Very strong sexual dimorphism, with males lower and more elongate than females.

**Age:** Turonian.

**Remarks:** The general outline of this species has similarities to *Rostrocytheridea DINGLE, 1969*, but its generic attribution is doubtful because the diagnostic internal features are poorly preserved and the ventral margin is straight, while in all the species of the genus it is clearly convex. Piovesan et al. (2009) recorded a possible species of *Rostrocytheridea* in the Brazilian equatorial margin, in the Maastrichtian, but it is larger, not punctuated and has no spines in the anterio and posteroventral margins.

**Family Cytheruridae**

**Genus Eucytherura G.W. Müller, 1894**

**Eucytherura aff. speluncosus (Andreu, 1996)**

(Pl. 4, figs. A-E)


**Material:** 102 specimens.

**Brief description:** carapace very small, sub-rectangular in lateral view, posteromedian region inflated in dorsal view. LV slightly larger than the RV. Greatest height at anterior cardinal angle. Dorsal margin straight, ventral margin convex. Anterior margin obliquely rounded, posterior sub-rounded and projected upwards with the extremity situated in the upper third of the height. Anterior and posterior regions compressed. The entire surface is reticulated and with the presence of three tubercles in posteroventral, posterodorsal and anterodorsal regions. Anteromedian sulcus very deep. Eye tubercle present, followed by postocular sulcus. Sexual dimorphism pronounced, with females less elongated and wider.

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**Plate 5: Scale bar:**

*A-G: Loxocorniculum? narendrai* Piovesan, Cabral & Colin sp. nov.  
**A-B:** holotype, C, f, ULVG-9924, sample 272.40 m, L: 0.390, H: 0.252, W: 0.202, **A:** right view, **B:** DV;  
**C-D:** paratype 1, C, m, ULVG-9925, sample 272.40 m, L: 0.410, H: 0.249, W: 0.198, **C:** right view, **D:** DV;  
**E:** paratype 2, C, left view, m, ULVG-10681, sample 275.80 m, L: 0.377, H: 0.220, W: 0.202;  
**F-G:** paratype 3, LV, m, ULVG-9926, sample 272.40 m, L: 0.407, H: 0.224, **F:** detail of central muscular scar, **G:** LV, IV.

**H-J:** "Phlyctocythere?" POT 1.  
**H-I:** C, f, ULVG-9929, sample 275.80 m, L: 0.379, H: 0.222, W: 0.160, **H:** right view, **I:** DV;  
**J:** C, left view, m, ULVG-10480, sample 275.80 m, L: 0.420, H: 0.210, W: 0.140.

**K-L:** *Bicornicythereis?* POT 1.  
**K-L:** C, ULVG-10023, sample 285.30 m, L: 0.522, H: 0.269, W: 0.241, **K:** DV, **L:** right view.

**M-S: Haughtonileberis dinglei* Piovesan, Cabral & Colin sp. nov.  
**M:** holotype, morphotype 1, C, right view, f, ULVG-10002, sample 277.25 m, L: 0.654, H: 0.324, W: 0.280;  
**N:** paratype 1, morphotype 1, C, left view, m, ULVG-10676, sample 276.65 m, L: 0.760, H: 0.350, W: 0.260;  
**O-P:** paratype 2, morphotype 1, C, m, ULVG-10001, sample 276.65 m, L: 0.710, H: 0.328, W: 0.265;  
**Q:** right view, **P:** DV;  
**Q:** paratype 3, morphotype 2, C, right view, m, ULVG-10009, sample 276.25 m, L: 0.624, H: 0.228;  
**R:** paratype 4, morphotype 2, C, left view, m, ULVG-10603, sample 276.25 m, L: 0.640, H: 0.260, W: 0.220;  
**S:** paratype 5, morphotype 2, C, DV, m, ULVG-10008, sample 277.25 m, L: 0.639, H: 0.276, W: 0.223.
Age: Turonian.

Remarks: The species recorded in the Potiguar Basin is very similar to the males of *Eucytherura speluncosus* (Andreu, 1996), from the Santonian of Morocco, but some features of the females from Potiguar Basin are different: they are more inflated, the posterior region is more compressed, more projected upwards and with the ribs more robust. The species was reassigned to the genus *Eucytherura* because *Schizocythere Trierbel, 1950*, has the caudal process at mid-height and has no sulcus or tubercles.

**Genus Hemicytherura Eloffson, 1941**

*Hemicytherura viviersae* (Pl. 4, figs. F-I)

Derivatio nominis: This species is named after Marta Claudia Viviers, in honor of her important contribution to the study of Brazilian marine ostracodes.

Material: 53 specimens.

Holotype: C, ULVG-9902 (Pl. 4, figs. F-H), sample 275.80 m.

Paratypes: ULVG-10669, ULVG-9901 (not figured).

Dimensions: Holotype: L: 0.390, H: 0.251, W: 0.165. Paratypes: L: 0.340-0.380, H: 0.200-0.210, W: 0.149-0.150.

Type-locality: 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 275.80 m, Potiguar Basin, Brazil.

Diagnosis: A species of the genus *Hemicytherura*, very small, sub-rhomboidal to suboval in lateral view, with a regular reticulation and a triangular caudal process at mid-height, straightly pointing backwards.

Description: Carapace very small, sub-rhomboidal to suboval in lateral view, suboval elongated in dorsal view. The LV overlaps slightly the right one along all margins, except in the dorsal margin, where the RV overlaps the LV strongly. Greatest height at mid-length. Dorsal margin strongly convex, ventral margin convex, especially in the posterior third. Anterior margin rounded, posterior acuminate. Anterior region slightly compressed, posteroventral region compressed. Caudal process at mid-height, weakly reticulated. Presence of a small ventrolateral expansion. Surface ornamented by asymmetrically rounded reticula, regularly arranged. Dorsal region densely punctuated near the margin. Ribs in the ventral region, with intercostal region punctuated. Internal features not observed.

Sexual dimorphism: evident, with males lower and more elongated than females.

Age: Turonian.

Remarks: Few records of the genus *Hemicytherura* in the "mid" Cretaceous are known, possibly due to its difficult identification, which is strongly dependent on internal features. Andreu (1996) described, in the Santonian of Boulimane region, Middle Atlas, Morocco, the species *Hemicytherura sexangula*. The outline of both species is similar, but the African species is much more robust, with a different reticulation, ventral margin straight to slightly convex and a caudal process projected downwards.

**Genus Pelecocythere Athersuch, 1979**

*Pelecocythere POT 1* (Pl. 4, figs. J-L)

Material: 6 specimens.

Brief description: carapace of medium size, sub-trapezoidal in lateral view. Dorsal margin straight, ventral margin flattened and not visible due to a large ventrolateral carina. Anterior and posterior margins very similar, asymmetric and projected downwards. Maximum height and maximum width at mid-length. Anterodorsal region compressed. Surface with fine ribs, more visible in the posterior and posterodorsal regions.

Age: Turonian.

Remarks: Dingle (2009) suggested that, during the Cretaceous, *Pelecocythere* lived in shallow water and during the Cenozoic it migrated into deeper or colder environments, characterizing a retrothermal adaptation. PIOVESAN et al. (2010) proposed the reassignment of some Cretaceous species into *Pelecocythere*, in addition to describing a new species from the Brazilian margin (*Pelecocythere dinglei*) found in the Santonian-Campanian interval of the Santos Basin.

**Genus Procytherura Whatley, 1970**

*Procytherura ballentae* (Pl. 4, figs. M-P)

Derivatio nominis: In honor of the late Dr. Sara Ballent for her great legacy in the study of ostracodes.

Material: 52 specimens.

Holotype: C, f, ULVG-9913 (Pl. 4, figs. M-N), sample 275.80 m.

Paratypes: ULVG-9914, ULVG-10675.

Dimensions: Holotype: L: 0.389, H: 0.196, W: 0.123. Paratypes: L: 0.394-0.430, H: 0.166-0.190, W: 0.120-0.140.

Type-locality: 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 275.80 m, Potiguar Basin, Brazil.

Diagnosis: A species of the genus *Procytherura* with a very small, elongate and fragile carapace, very narrow in dorsal view and with faintly developed ribs on the surface of the valves.

Description: Carapace very small and fragile, sub-ovoid elongate to sub-rectangular in la-
teral view, acuminated and posteroventrally compressed, very narrow in dorsal view. "Caudal process" at mid-height. RV overlapping the LV dorsally. Greatest height at anterior cardinal angle. Maximum width at mid-length. Dorsal and ventral margins almost straight, both with a slight concavity at mid-length. Anterior margin rounded, posterior margin acuminate. Presence of an eye swelling and a very weak dorso-median sulcus. The ornamentation consists of weak ribs, extending along the entire length of the valves. Internal features not observed.

**Sexual dimorphism:** females higher and less elongated than males.

**Age:** Turonian.

**Remarks:** This is the first record of this genus in the Brazilian Cretaceous. ANDREU (1991) recorded a similar species in the Vraconian-Cenomanian of Morocco, Procytherura? sp. 1. The species recorded by ANDREU differs by the smooth surface and the caudal process projected downwards. Procytherura? sp. 2 recorded in the Cenomanian of Algeria (Vivitère, 1985) is smooth and has the caudal process in the upper third of the height, differing from the species recorded herein.

**Genus Semicytherura WAGNER, 1957**

*Semicytherura aff. adversainflata* ANDREU, 1996

(Pl. 4, figs. Q-U)


**Material:** 8 specimens.

**Description:** carapace very small, sub-rectangular and elongate in lateral view, inflated in dorsal view. Valves nearly equal, with the LV slightly larger than the right one. Greatest width in the posterior third. Dorsal margin straight, parallel to the ventral margin which is almost straight with a slight median concavity just behind the mid-length. Anterior margin rounded, posterior sub-triangular, with a caudal process in the upper third of the height. The ventrolateral region has a small alar expansion. Ventral region flattened and striate, particularly in the anterior part. Surface with large and weak reticula. Intramural region with a dense secondary reticulation. Sexual dimorphism not observed.

**Age:** Turonian.

**Remarks:** *Semicytherura adversainflata* ANDREU, 1996, is very similar to this species, but has a more regular reticulated ornamentation and the caudal process projected slightly downward.

**Family Loxoconchidae SARS, 1925**

**Genus Loxocorniculum**

BENSON & COLEMAN, 1963

*Loxocorniculum? Narendrai* PIOVESAN, CABRAL & COLIN sp. nov.

(Pl. 5, figs. A-G)

**Derivatio nominis:** In honor of Dr. Narendra Kumar SRIVASTAVA for his significant contribution to the knowledge of the Potiguar Basin.

**Material:** 1215 specimens.

**Holotype:** C, f, ULVG-9924 (Pl. 5, figs. A-B), sample 272.40 m.

**Paratypes:** ULVG-9925, ULVG-10681, ULVG-9926.

**Dimensions:** Holotype: L: 0.390, H: 0.252, W: 0.202. Paratypes: L: 0.377-0.410, H: 0.198-0.249, W: 0.198-0.202.

**Type-locality:** 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 272.40 m, Potiguar Basin, Brazil.

**Diagnosis:** A species assigned with doubt to the genus *Loxocorniculum*, because it lacks the diagnostic "hornlike protuberance on postero-dorsum", characterized by very compressed anterior and posterior regions, straight dorsal margin, eye tubercle developed, surface with a distinct reticulation and a weak postero-dorsal rib.

**Description:** Carapace small, sub-rhomboidal in lateral view, inflated in dorsal view. LV larger than the right one, with overlap not pronounced. Maximum height and width at mid-length. Dorsal margin straight, ventral margin slightly convex. Anterior margin obliquely rounded, with an extremity more developed in males; posterior margin almost truncated and projected upwards. Anterior, posterior and posteroventral regions strongly compressed. Surface covered by reticulation of different sizes. The reticulum is larger in the middle part of the valves and shorter towards the periphery. In the anterior and posterior regions, where the carapace is compressed, the reticulum is large and with thin muri. A small rib, starting below and after the eye tubercle, is present in the dorsal region. Presence of a well marked tubercle in the posteroventral region. Prominent eye tubercle. Hinge gongylodont with the anterior element of the LV composed of a tooth and a very small socket separated from the posterior one (elongated horseshoe-shaped socket with a prominent tooth in the middle) by a crenulated bar. Central muscle scars composed of only a vertical row of four elongate adductor scars and a rounded frontal scar.

**Sexual dimorphism:** males longer and narrower than females.

**Age:** Turonian.

**Remarks:** *Loxocorniculum? narendrai* sp. nov. resembles *Loxocorniculum miocenicum* BONADUCE *et al.*, 1992, from the Miocene of Tuni-
More recently, ANDREU et al. (2002) in a review of the biochronology of ostracodes from Morocco, cites the occurrence of Phlyctocythere? in the upper Cenomanian of Agadir Basin. VIVIERE (1985) described Phlyctocythere citreum in the Cenomanian-Turonian of Algeria, also recorded by BISMUTH et al. (1995) in the Cenomanian of Tunisia. P. citreum is shorter and has the dorsal margin more convex and the anterior part less compressed than the Brazilian species. The carapace of P. citreum is poorly calcified, which usually results in poor preservation, commonly with a broken posterior end. More recently, ANDREU et al. (2013) recorded a very similar species in the Cenomanian of Morocco, identified as Pseudocythere sp. 21 which presents a more straight dorsal margin. Probably, this is the first record of the genus in the Brazilian Cretaceous.

Family Trachyleberididae
SYLVESTER-BRADLEY, 1948

Genus Bicornicythereis PUCKETT, 2009
Bicornicythereis? POT 1
(Pl. 5, figs. K-L)

Material: 1 specimen.

Brief description: carapace of medium size, robust, sub-rectangular in lateral view, very compressed anteriorly and posteriorly in dorsal view. LV overlaps the RV, less pronounced in the dorsal margin. Maximum height at anterior cardinal angle. Greatest width at posterior third. Dorsal margin almost straight, ventral margin convex. Anterior margin broadly rounded, posterior margin sub-triangular and projected downwards. Anterior and posterior regions compressed. Ornamentation represented by three strong and large ribs: ventral, median and dorsal, the two last ones linked in the posterodorsal part; both dorsal and ventral ribs almost linked in the posterior region, forming a kind of vertical rib. Intercostal area reticulated. Subcentral and eye tubercles present.

Age: Turonian.

Remarks: This species is similar to Bicornicythereis bicornis (ISRAELSKY, 1929), from the Santonian to Campanian of North America (see revision of the genus in PUCKETT, 2009) being, however, significantly smaller. On the other hand, the sinuosity of the ventral margin and the presence of more robust ribs indicate that they might even belong to different genera.

Genus Haughtonileberis DINGLE, 1969
Haughtonileberis dinglei
PIOVESAN, CABRAL & COLIN sp. nov.
(Pl. 5, figs. M-S)

1992Dumontina sp. OKOSUN, p. 330, Pl. 1, figs. 21, 25.

Derivatio nominis: After Dr. Richard DINGLE, in honor of his important contribution to the knowledge of ostracodes.

Material: 104 specimens.

Holotype: C, f, morphotype 1, ULVG-10002 (Pl. 5, fig. N), sample 277.25 m.

Paratypes: ULVG-10676 (morphotype 1), ULVG-10001 (morphotype 1), ULVG-10009 (morphotype 2), ULVG-10603 (morphotype 2), ULVG-10008 (morphotype 2).

Dimensions: Holotype: L: 0.654, H: 0.324, W: 0.280. Paratypes: L: 0.624-0.760, H: 0.324-0.365, W: 0.220-0.265.

Type-locality: 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 277.25 m, Potiguar Basin, Brazil.

Plate 6: Scale bar: 100 μm

A-C: Haughtonileberis POT 1. A-B: C, f, ULVG-10005, sample 272.40 m, L: 0.685, H: 0.365, W: 0.236, A: right view, B: DV; C, right view, m, ULVG-10006, sample 272.40 m, L: 0.718, H: 0.362, W: 0.229.

D-M: Jandairella obesa PIOVESAN, CABRAL & COLIN sp. nov. D-E: holotype, C, f, ULVG-10012, sample 272.40 m, L: 0.684, H: 0.420, W: 0.334, D: right view, E: left view; F: paratype 1, C, f, ULVG-10634, sample 272.40 m, L: 0.763, H: 0.443, W: 0.390, G: paratype 2, C, VV, f, ULVG-10013, sample 272.40 m, L: 0.770, H: 0.417, W: 0.323, F: DV, G: VV; H: paratype 3, C, right view, m, ULVG-10014, sample 272.40 m, L: 0.742, H: 0.396, W: 0.360; I: paratype 4, C, DV, m, ULVG-10015, sample 272.40 m, L: 0.773, H: 0.406, W: 0.325; J-K: paratype 5, RV, ULVG-10016, sample 272.40 m, L: 0.678, H: 0.390, J: LV; IV, K: detail of muscle scars; L-M: paratype 6, LV, ULVG-10017, sample 272.40 m; L: 0.676, H: 0.375, L: RV, IV, M: detail of the hinge anterior element.

N-R: Nigeria cf. rotunda REYMENT, sensu ANDREU, 1991. N-O: C, f, ULVG-9980, sample 272.40 m, L: 0.694, H: 0.331, W: 0.365, N: right view, O: DV; P-R: C, m, ULVG-9981, sample 272.40 m, L: 0.756, H: 0.345, W: 0.338, P: right view, Q: left view, R: DV.
**Diagnosis:** Species of *Haughtonileberis* sub-rectangular and elongate in lateral view; finely to strongly reticulated, with the median and dorsal ribs linked, in the posterior zone, by a small vertical rib.

**Description:** Carapace of medium (females) to large (males) size, sub-rectangular in lateral view. In dorsal view, outline sub-rectangular, with anterior and posterior zones compressed. LV larger than RV. Greatest height at anterior cardinal angle. Dorsal and ventral margins straight, the latter with a concavity before the mid-length. Anterior margin broadly rounded, posterior sub-triangular. Anteromarginal rib prominent. Dorsal rib convex and protruding slightly beyond the margin; ventral rib weakly developed; median rib parallel to the dorsal one and bifurcated in the anterior region. The dorsal and median ribs are linked by a small vertical rib in the posterior end. Subcentral tubercle poorly developed. Spines in the anterior, posterior and posterovernal margins. Eye tubercle moderately developed. Internal features not seen. The morphotypes differ in the ornamentation:

Morphotype 1: intercostal region strongly reticulated and ribs less developed.

Morphotype 2: intercostal region finely reticulated and ribs well developed.

**Sexual dimorphism:** Males more elongated and narrower than females.

**Age:** Turonian.

**Stratigraphic and geographic distribution:** Turonian-Santonian of Nigeria (Okosun, 1992); Turonian (this work).

**Remarks:** *Haughtonileberis propeplanus Andreu* (1995) from the Late Santonian of Morocco is similar in the outline, but differs by the much more developed marginal rib, the stronger spines in the anterior margin and the dorsal and the median rib, which are not linked. *H. mdaouerensis* (Bassouillet & Damotte, 1969), from the Tunison of Algeria, also recorded by Vivière (1985) in the same age and country has no anteromarginal rib, a less prominent "hinge ear", ribs less developed, with the median one connected to the subcentral tubercle and posterior margin more symmetrical, not upturned. Until now it can be considered as a monospecific genus.

**Diagnosis:** Carapace sub-rectangular in lateral view, with anterior margin rounded, posterior margin sub-triangular, subparallel and nearly straight dorsal and ventral margins. Overlap of the RV pronounced at anterodorsal and posterodorsal regions. Surface with three subparallel weak ribs; intercostal region with small and dense punctuation. The median ridge is connected with the subcentral tubercle. Eye tubercle prominent, subcentral tubercle present. Spines in the anterior and posterior margins. Anteromarginal rib absent. Anterior and posterior regions compressed. Robust holamphidont hinge: in the RV it consists of an anterior tooth and a posterior lobate tooth separated by a smooth median groove, anteriorly enlarged forming a deep socket. Central muscle scars: frontal V-shaped and four adductors scars arranged in semi-circle; mandibular scar elliptical. Very strong sexual dimorphism, with females higher and more inflated than males.

**Genus Jandairella**

**Derivatio nominis:** From the Jandaíra Formation, Potiguar Basin, Brazil.

**Type-species:** *Jandairella obesa* Piovesan, Cabral & Colin sp. nov.

**Diagnosis:** Carapace sub-rectangular in lateral view, narrow in dorsal view. Maximum height at anterior region. Dorsal and ventral margins almost straight, converging slightly posteriorly. Anterior margin broadly rounded, posterior margin sub-triangular. Anterior and posterior regions strongly compressed. The anteromarginal rib, Surface ornamented with three subparallel, sharp and unconnected ribs: ventral, dorsal and median. A small rib below the eye tubercle is present. Intercostal surface smooth. Anterior margin denticate. Subcentral and eye tubercles weakly developed. Sexual dimorphism: females higher, shorter and slightly wider than males.

**Age:** Turonian.

**Remarks:** This species is similar to "Imhotepia" GA C 8 Grosdidier, 1979(Cenomanian of Gabon), but it is higher, narrower and the subcentral tubercle is less developed.

**Genus Piovesan, Cabral & Colin gen. nov.**

**Diagnosis:** Carapace sub-rectangular in lateral view, with anterior margin rounded, posterior margin sub-triangular, subparallel and nearly straight dorsal and ventral margins. Overlap of the RV pronounced at anterodorsal and posterodorsal regions. Surface with three subparallel weak ribs; intercostal region with small and dense punctuation. The median ridge is connected with the subcentral tubercle. Eye tubercle prominent, subcentral tubercle present. Spines in the anterior and posterior margins. Anteromarginal rib absent. Anterior and posterior regions compressed. Robust holamphidont hinge: in the RV it consists of an anterior tooth and a posterior lobate tooth separated by a smooth median groove, anteriorly enlarged forming a deep socket. Central muscle scars: frontal V-shaped and four adductors scars arranged in semi-circle; mandibular scar elliptical. Very strong sexual dimorphism, with females higher and more inflated than males.

**Genus Jandairella**

**Type-species:** *Jandairella obesa* Piovesan, Cabral & Colin sp. nov.

**Diagnosis:** Carapace sub-rectangular in lateral view, narrow in dorsal view. Maximum height at anterior region. Dorsal and ventral margins almost straight, converging slightly posteriorly. Anterior margin broadly rounded, posterior margin sub-triangular. Anterior and posterior regions strongly compressed. The anteromarginal rib, Surface ornamented with three subparallel, sharp and unconnected ribs: ventral, dorsal and median. A small rib below the eye tubercle is present. Intercostal surface smooth. Anterior margin denticate. Subcentral and eye tubercles weakly developed. Sexual dimorphism: females higher, shorter and slightly wider than males.

**Age:** Turonian.

**Remarks:** This species is similar to "Imhotepia" GA C 8 Grosdidier, 1979(Cenomanian of Gabon), but it is higher, narrower and the subcentral tubercle is less developed.

**Genus Jandairella**

**Derivatio nominis:** From the Jandaíra Formation, Potiguar Basin, Brazil.

**Type-species:** *Jandairella obesa* Piovesan, Cabral & Colin sp. nov.

**Diagnosis:** Carapace sub-rectangular in lateral view, narrow in dorsal view. Maximum height at anterior region. Dorsal and ventral margins almost straight, converging slightly posteriorly. Anterior margin broadly rounded, posterior margin sub-triangular. Anterior and posterior regions strongly compressed. The anteromarginal rib, Surface ornamented with three subparallel, sharp and unconnected ribs: ventral, dorsal and median. A small rib below the eye tubercle is present. Intercostal surface smooth. Anterior margin denticate. Subcentral and eye tubercles weakly developed. Sexual dimorphism: females higher, shorter and slightly wider than males.

**Age:** Turonian.

**Remarks:** This species is similar to "Imhotepia" GA C 8 Grosdidier, 1979(Cenomanian of Gabon), but it is higher, narrower and the subcentral tubercle is less developed.

**Genus Jandairella**

**Derivatio nominis:** From the Jandaíra Formation, Potiguar Basin, Brazil.

**Type-species:** *Jandairella obesa* Piovesan, Cabral & Colin sp. nov.

**Diagnosis:** Carapace sub-rectangular in lateral view, narrow in dorsal view. Maximum height at anterior region. Dorsal and ventral margins almost straight, converging slightly posteriorly. Anterior margin broadly rounded, posterior margin sub-triangular. Anterior and posterior regions strongly compressed. The anteromarginal rib, Surface ornamented with three subparallel, sharp and unconnected ribs: ventral, dorsal and median. A small rib below the eye tubercle is present. Intercostal surface smooth. Anterior margin denticate. Subcentral and eye tubercles weakly developed. Sexual dimorphism: females higher, shorter and slightly wider than males.

**Age:** Turonian.

**Remarks:** This species is similar to "Imhotepia" GA C 8 Grosdidier, 1979(Cenomanian of Gabon), but it is higher, narrower and the subcentral tubercle is less developed.
Jandairella obesa
PIOVESAN, CABRAL & COLIN sp. nov.

(Pl. 6, figs. D-M)


Derivatio nominis: After the general aspect of the female carapace.

Material: 79 specimens.

Holotype: C, f, ULVG-10012 (Pl. 6, figs. D-E), sample 272.40 m.


Dimensions: Holotype: L: 0.684, H: 0.420, W: 0.334. Paratypes: L: 0.676-0.773, H: 0.375-0.443, W: 0.323-0.390.

Type-locality: 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 272.40 m, Potiguar Basin, Brazil.

Diagnosis: A species of Jandairella with the posterior margin sub-triangular to slightly rounded; inflated in dorsal view; surface with three weak ribs, almost straight and parallel; intercostal area with dense and small punctuation; eye tubercle large, sub-central tubercle moderately developed.

Description: Carapace of medium (females) to large (males) size, sub-rectangular in lateral view. LV larger than RV, with more pronounced overlap in the anterodorsal and posterodorsal margins. Greatest height before the anterior third, at anterior cardinal angle, greatest width near the mid-length. Dorsal margin straight, ventral margin with a slight concavity in front of the mid-length. Anterior margin obliquely rounded, posterior margin sub-triangular to sub-rounded. Ornamentation: three fine ribs, median, ventral and dorsal. The median rib is fused to the subcentral tubercle; the ventral rib is curved and it is bifurcated in the posterior region. The dorsal rib, strongly convex, starts in the anterodorsal region, under the eye tubercle, and ends in the posterodorsal region. Intercostal region densely covered by punctuation. Posterior and anterior margins spinose. Eye tubercle developed and rounded. In dorsal view, carapace very inflated in females, thinner in males with well marked dorsal and median ribs. Hinge and muscle scars as in the genus.

Sexual dimorphism: pronounced, with females higher and much more inflated than males.

Age: Turonian.

Stratigraphic and geographic distribution: Turonian, Potiguar Basin, Brazil (VIVIERS et al., 2000; this work).

Remarks: There are no other species of the same genus to be compared.

Genus Nigeria REYMENT, 1963
Nigeria cf. rotunda
REYMENT, sensu ANDREU, 1991

(Pl. 6, figs. N-R)


Material: 23 specimens.

Brief description: Carapace large, sub-rectangular in lateral view, inflate in dorsal view. LV larger than the right one, with more pronounced overlap in the anterodorsal and posterodorsal margins. Greatest height at anterior cardinal angle, greatest width at posterior third. Dorsal margin straight, ventral margin slightly concave. Anterior margin broadly rounded, posterior margin sub-triangular. Anterior and posterior regions compressed. Surface reticulate. The reticulation is larger near the sub-central tubercle and decreases in size towards the periphery of the valves. Dorsal rib poorly developed. Four spines present in the posteroverentral region. Eye tubercle well developed. Sexual dimorphism present, with females proportionally higher and wider.

Age: Turonian.

Stratigraphic and geographic distribution: Cenomanian of Morocco (ANDREU, 1991) and Turonian of Potiguar Basin, Brazil (this work).

Remarks: The specimens recorded in Potiguar Basin are smaller than Veenia (Nigeria) cf. rotunda recorded by ANDREU (1991), in the Cenomanian of Morocco. Despite this difference, we prefer to consider them as the same species due to the strong similarity in shape and ornamentation.

Genus Potiguarella PIOVESAN, CABRAL & COLIN gen. nov.

Derivatio nominis: From Potiguar Basin.

Type-species: Potiguarella grosdidieri PIOVESAN, CABRAL & COLIN sp. nov.

Other species: P. coimbrai sp. nov and P. POT 1.

Diagnosis: Medium to large size carapace, sub-rectangular in lateral view; tricostate with the dorsal rib strongly convex, starting below and behind the eye tubercle; median rib irregular, thin to relatively thick and acute, with sub-central tubercle weak and linked to it; ventral rib short and not connected with the anteromarginal rib; intercostal area reticulate. Internal features not seen.

Stratigraphic and geographic distribution: Turonian, Potiguar Basin, Brazil.

Remarks: Although the internal features were not observed, all the external characteristics of the carapaces correspond to those of the family Trachyleberididae. The most similar genera are Rehacythereis GRÜNDEL, 1971, and Cythereis JONES, 1849. The new genus differs from Rehacythereis by the weaker
sub-central tubercle and the ventral rib not connected with the anteromarginal rib; the dorsal rib of Cythereis is discontinuous and represented by a row of spines and the ventral rib is connected with the anteromarginal rib too.

**Potiguarella grosdidieri**

PIOVESAN, CABRAL & COLIN sp. nov.  
(Pl. 7, figs. A-H)

1979 "Rehacythereis" GA E 10 GROSIDI DIER, Pl. 2, fig. 5.  
1979 "Rehacythereis" GA F 18 GROSIDI DIER, Pl. 2, fig. 6.  
2000 Cythereis? sp. P11 VIVIERS, KOUTSOUKOS, SILVA-TELLES & BENGTSON, p. 434, Fig. 20, 1-2.  

derivatio nominis: In honor of the late Dr. Emmanuel GROSIDI DIER for his important contribution to the knowledge of African ostracodes.

Material: 62 specimens.  
Holotype: C, f, morphotype 1, ULVG-9998 (Pl. 7, figs. A-B), sample: 272.40 m.  
Paratypes: ULVG-9999 (morphotype 1), ULVG-10689 (morphotype 1), ULVG-10647 (morphotype 1), ULVG-10649 (morphotype 1), ULVG-9993 (morphotype 2), ULVG-10663 (morphotype 2).

Dimensions: Holotype: L: 0.910, H: 0.483, W: 0.433. Paratypes: L: 0.665-1.100, H: 0.373-0.480, W: 0.272-0.410.

Type-locality: 9-MO-13-RN, coordinates UTM: 682595E / 9428410N (zone 24S), 272.40 m, Potiguar Basin, Brazil.

Diagnosis: A species of the genus *Potiguarella* characterized by a very robust carapace, strongly reticulated, with sharp and pronounced ribs and post-ocular sulcus well marked.

Description: Carapace very large, sub-rectangular in lateral view, very compressed anteriorly and posteriorly in dorsal view. LV larger than RV, with more pronounced overlapping in the posterodorsal margin. Greatest height at anterior cardinal angle, greatest width in the posterior region. Dorsal margin straight, partially covered by the dorsal rib. Ventral margin almost straight, with a concavity in front of the mid-length. Anterior margin broadly rounded, posterior margin sub-triangular. Anterior region strongly compressed, with a very prominent anteromarginal rib. Dorsal rib convex starting in the anterodorsal region, after the deep ocular sulcus, extending until the posterodorsal region. Median rib very irregular extending from the subcentral tubercle to the posteromedian region. Ventral rib straight in the middle, convex in the anterior extremity. Intercostal region heavily reticulated. In the posterior compressed region, the reticulation is more tenuous. Posteroventral region with four stout spines. Anterior margin with small spines. The morphotype 2 is smaller and with weak ornamentation pattern. Internal features not seen.

Sexual dimorphism: Males more elongated than females.

Age: Turonian.

Stratigraphic and geographic distribution: Turonian, Gabon (GROSIDI DIER, 1979) and Turonian, Potiguar Basin, Brazil (VIVIERS et al. 2000; this work).

Remarks: This species resembles *Cythereis gabonensis Neufville, 1973a(Cenomanian-Turonian of Gabon)*, but differs in the rib pattern. The median rib of *C. gabonensis* is divided in two parts; the ventral rib is bifurcated and connected with the anteromarginal rib.

**Potiguarella coimbrai**

PIOVESAN, CABRAL & COLIN sp. nov.  
(Pl. 7, figs. I-N)

In honor of the late Dr. João Carlos COIMBRA for his important contribution to the knowledge of Brazilian ostracodes.

Material: 24 specimens.  
Holotype: C, m, ULVG-9990 (Pl. 7, figs. I-J), sample 319.80 m.  
Paratypes: ULVG-10554, ULVG-10660.

Dimensions: Holotype: L: 0.880, H: 0.419, W: 0.431. Paratypes: L: 0.780-0.860, H: 0.420-0.460, W: 0.380-0.520.

Diagnosis: A species of the genus *Potiguarella* characterized by a broadly rounded anterior margin, very convex dorsal rib and rounded reticulum ornamentation.

Plate 7: Scale bar: 100 μm

A-H: Potiguarella grosdidieri PIOVESAN, CABRAL & COLIN sp. nov. A-B: holotype, morphotype 1, C, f, ULVG-9998, sample: 272.40 m, L: 0.910, H: 0.483, W: 0.433, A: right view, B: DV; C: paratype 1, morphotype 1, C, left view, f, ULVG-9999, sample: 272.40 m, L: 0.890, H: 0.458, W: 0.408; D: paratype 2, morphotype 1, C, left view, m, ULVG-10689, sample: 272.40 m, L: 1.100, H: 0.450, W: 0.400; E: paratype 3, morphotype 1, C, VV, f, ULVG-10647, sample 272.40 m, L: 0.900, H: 0.480, W: 0.410; F: paratype 4, morphotype 1, C, right view, juvenile, ULVG-10649, sample 272.40 m; L: 0.800, H: 0.400, W: 0.350; G: paratype 5, morphotype 2, C, right view, f, ULVG-9993, sample 272.40 m, L: 0.678, H: 0.396, W: 0.272; H: paratype 6, morphotype 2, C, left view, f, ULVG-10663, sample 304.10, L: 0.665, H: 0.373, L: 0.250.

I-N: Potiguarella coimbrai PIOVESAN, CABRAL & COLIN sp. nov. I-K: holotype, C, m, ULVG-9990, sample 319.80 m; L: 0.880, H: 0.419, W: 0.431, I: right view, J: left view, K: DV; L-M: paratype 1, C, f, ULVG-10554, sample 319.30 m, L: 0.780, H: 0.460, W: 0.520, broken, L: right view, M: DV; N: paratype 2, C, right view, m, ULVG-10660, sample 319.30 m; L: 0.860, H: 0.420, W: 0.380.
Description: Carapace large, elongated and sub-rectangular in lateral view, with parallel margins in dorsal view, anteriorly and posteriorly compressed. LV larger than RV, with pronounced overlapping in the posterior margin. Greatest height at anterior cardinal angle. Maximum length below the mid-height and maximum width in front of the mid-length. Dorsal margin almost straight and partially hidden by the dorsal rib. Ventral margin very slightly sinuous. Anterior margin broadly rounded, posterior margin strongly triangular and acuminate. Anterior and posterior regions very compressed. Ornamentation: reticulated, with the reticulum rounded and larger in the central region of the carapace and punctuated in the posterior region; posteroventral margin with few spines. Anterior margin denticulate. Anteromarginal rib weakly developed. Presence of three sub-parallel and horizontal ribs not connected: the dorsal one very pronounced, sharp and strongly convex, the median one thin and fused to subcentral tubercle and the ventral one less prominent and slightly convex. Eye tubercle present. Internal features not seen.

Sexual dimorphism: Females less elongated and wider than males.

Age: Turonian.

Remarks: Grosdidier (1979) recorded a very similar species, *Rehacythereis GA F 10*, from the Turonian of Gabon, but it differs in the ornamentation, which consists mainly of polygonal reticulations and in the anterior region, which is less compressed in the African species. *P. grosdidieri* sp. nov. has a less strongly convex dorsal rib, a polygonal reticulation and a much more marked anteromarginal rib.

*Potiguarella POT 1*

(Pl. 8, figs. A-C)

Material: 17 specimens.

Brief description: Carapace large, sub-rectangular in lateral view, inflated in dorsal view, with anterior and posterior regions very compressed. LV larger than the right one, with most marked overlap in the ventral margin. Greatest height at anterior cardinal angle. Dorsal margin straight, partially covered by the dorsal rib, ventral margin slightly concave.

Anterior margin rounded, posterior margin sub-triangular to sub-rounded. Anterior region very compressed. Surface reticulate with three prominent ribs: dorsal rib strongly convex, median rib slightly convex and ventral rib slightly sinuous. Anteromarginal rib moderately marked. Eye tubercle present, sub-central tubercle poorly developed.

Age: Turonian.

Remarks: The posterior margin of this species is less elongated and much more rounded than *P. grosdidieri* sp. nov. and *P. coimbrai* sp. nov.

Subfamily Brachycytherinae

Puri, 1954

Genus Brachycythere Alexander, 1933

"Brachycythere" aff. jodhpurensis SINGH, 1997

(Pl. 8, figs. D-I)

aff. 1997 Brachycythere jodhpurensis SINGH, p. 9-10, Pl. 2, figs. 9-12; Pl. 3, fig. 1.

aff. 2007 Brachycythere jodhpurensis SINGH - ANDREU et al., Pl. 3, figs. 11-13.

Material: 283 specimens.

Brief description: Carapace of medium (females) to large (males) size, sub-triangular in lateral view, inflated in dorsal view. LV larger than RV, with overlap more pronounced in the dorsal margin. Maximum height at anterior cardinal angle; maximum width behind the mid-length. Dorsal and ventral margins almost straight. Anterior margin asymmetrically rounded, posterior margin sub-triangular and projected downward. Anterior and posterior regions compressed. Surface densely punctuated, except in the anterior and posterior regions. Ventral region flat and with parallel rows of punctuations. Anterior denticles present. Ventrolateral rib well developed, more clearly observed in ventral view. Eye tubercle small, post-ocular sulcus deep. Sexual dimorphism present with females higher and more inflated than males.

Age: Turonian.

Plate 8: Scale bar: 100 µm

A-C: *Potiguarella POT 1*. A: C, right view, ULVG-10019, sample 319.30 m, L: 0.755, H: 0.426, W: 0.325; B-C: C, ULVG-10020, sample 319.80 m, L: 0.747, H: 0.419, W: 0.350; D: DV, C: left view.

D-I: "Brachycythere" aff. jodhpurensis SINGH, 1997. D: C, right view, f, ULVG-10028, sample 272.40 m, L: 0.684, H: 0.407, W: 0.373; E: C, right view, m, ULVG-10031, sample 272.40 m, L: 0.739, H: 0.390, W: 0.352; F: C, DV, f, ULVG-10586, sample 272.40 m, L: 0.690, H: 0.390, W: 0.390; G: C, DV, m, ULVG-10030, sample 272.40 m, L: 0.760, H: 0.380, W: 0.370; H: C, left view, m, ULVG-10587, sample 272.40 m, L: 0.740, H: 0.385, W: 0.380; I: C, VV, f, ULVG-10588, sample 272.40 m, L: 0.710, H: 0.430 mm, W: 0.385.

J-N: "Brachycythere" POT 1. J-K: C, f, ULVG-10025, sample 276.65 m, L: 0.801, H: 0.445, W: 0.402; J: right view, K: DV; L-M: C, m, ULVG-10026, sample 275.80 m; L: 0.799, H: 0.441, W: 0.380, L: DV, M: right view; N: C, left view, m, ULVG-10027, sample 277.25 m; L: 0.800, H: 0.430, W: 0.390.

O-P: *Kestoleberis POT 1*. O: C, right view, ULVG-10047, sample: 275.80 m, L: 0.426, H: 0.291, W: 0.283; P: C, DV, ULVG-10683, sample: 275.80 m; L: 0.410, H: 0.280, W: 0.280.
Remarks: This species is similar to *B. jodhpurensis* Singh, 1997, from the Turonian-Coniacian of India, but differs by its much more elongated general outline and by the position of the maximum width. *B. ventrocomplanatus* Delicío, Coimbra & Carreño, 2000, also from the Upper Cretaceous Jandaira Formation, Potiguar Basin, is similar but it is less elongated and with the ventrolateral rib less pronounced. This species is also similar to *B. multidifferentis* Nicolaides & Piovesan, 2013, from the Cenomanian-Turonian of the Santos Basin, Brazil, but differs in the position of maximum width and in the more compressed anterior region. According to Pickett (2002) *Brachycythere* is restricted to North America and the brachycytherines of South America and Africa should belong to a different, but undescribed genus (Pickett & Colin, in prep.).

"Brachycythere" POT 1

(Pl. 8, figs. J-N)

Material: 25 specimens.

Brief description: Carapace large, subtriangular in lateral view, inflated in dorsal view. LV larger than RV, with overlap more pronounced in dorsal, ventral and posterior margins. Maximum height at anterior cardinal angle; maximum width at mid-length. Dorsal margin almost straight; ventral margin of the RV almost straight, slightly convex in the LV. Anterior margin broadly and obliquely rounded; posterior margin sub-triangular, strongly acute and projected downwards. Carapace very compressed in the anterior and posterior regions. The middle part of the carapace is punctuated; the anterior and posterior regions are almost smooth. Eye tubercle poorly developed. Sexual dimorphism present: females shorter, higher and wider than males.

Age: Turonian

Remarks: This species differs from *Brachycythere aff. jodhpurensis* Singh (see above) by the much more acuminate posterior margin and by the position of maximum width. *B. reymenti* Emani, 1989, recorded in the Campanian of Iran resembles "B." POT 1 due to its acuminate posterior end, but *B. reymenti* is more elongated and the posterior projection is located near the mid-height.

Family Xestoleberididae Sars, 1928

Genus Xestoleberis Sars, 1866

*Xestoleberis* POT 1

(Pl. 8, figs. O-P)

Material: 60 specimens.

Brief description: Carapace small, suboval in lateral and dorsal views. LV larger than RV, with overlap less pronounced in the ventral margin. Maximum height near the mid-length; maximum width at the posterior third. Dorsal margin convex, ventral margin almost straight. Anterior margin obliquely rounded, posterior margin rounded. Surface smooth.

Age: Turonian.

Remarks: *Xestoleberis* POT 1 differs from *Xestoleberis dissimilissummis* Andréu, 1996 from the Santonian of Morocco, mainly by the straighter ventral margin, the position of the maximum width and by the maximum height.

5. Distribution of ostracodes and paleoecology

Diversity and dominance indexes were used to identify ecologically induced variation in Cretaceous ostracode assemblages. Studies by POKORNÝ (1971), HAZEL (1975), DINGLE (1980), COLIN et al. (1982), ROSS & MADDOCKS (1983), VIÈRE (1985), Pickett et al. (2012), using Shannon or Simpson indexes, have demonstrated how the diversity varies according to the environmental fluctuations. The advantage of using diversity indexes is the measurement of two attributes of the community together (richness and evenness), despite the sampling effort (Ross & Maddocks, 1983; Melo, 2008). The Shannon index is calculated on not only the number of species but how their abundance is distributed within the community.

The studied Turonian assemblages characterize shallow shelf environments. A total of 4,841 specimens were recorded, distributed among 53 taxa (Appendix 2). Based on the vertical distribution of the species in the well, their abundance, diversity and dominance, the ostracode assemblages have been identified, with variable ecological preferences.

Assemblage 1 (A1)

This assemblage (Fig. 3) is situated in the interval 327.80 m - 287.10 m and it is characterized by the presence of several species mainly belonging to brackish genera, such as *Perissocytheridea* and *Fossocytheridea*. It may be divided into two sub-assemblages: Assemblage 1A (327.80 m - 310.90 m) and Assemblage 1B (304.10 m - 287.10 m). The most abundant species in the first sub-assemblage are *Fossocytheridea tiberti* sp. nov., *Perissocytheridea mossoroensis* sp. nov., Indet. Gen. 4 POT 1, and Indet. Gen. 5 POT 1. The two Indet. Gen. seem to be brackish because both possess a median sub-vertical sulcus, which is very common in brackish genera (*e.g.*, *Fossocytheridea* and *Perissocytheridea*). In the second sub-assemblage (1B) *Perissocytheridea caudata* sp. nov. (~57%) is the dominant species, followed by *Cophinia grekoffi* sp. nov. (~18%) and *Perissocytheridea?* POT 1 (~10%).

Although some authors state that the genus *Cophinia* is commonly associated with typical marine species (*e.g.*, Apostolescu, 1963; Andréu et al., 1998), *C. grekoffi* sp. nov. seems to be euryhaline, associated with brackish species and with a few marine ones (*Bairdopilata potiguarensis, Brachycythere POT 1, Cytherella mediaslaca*) too. The levels 297.60 m and 287.10 m, the two highest ones of Assemblage 1, 236
Figure 3: Stratigraphic ranges and paleoecological assemblages of the Turonian species from the well 9-MO-13-RN.
have the strongest marine signal of all this assemblage.

The Shannon values are low and the dominance is high (Fig. 4), which is characteristic of brackish water environments (HAMMER & HARPER, 2006).

The mixohaline character (probably lagoon) of this first interval, especially at the base (Assemblage 1A) is reinforced by the presence of the Fossocytheridea-Perissocytheridea association. This association is considered the fossil equivalent of the Cyprideis-Perissocytheridea association found from the Neogene to the Recent. Previous studies show that these associations can occur both with marine ostracodes (GARBETT & MADDOKS, 1979; CRONIN, 1988; ANDREU, 1986; COIMBRA et al., 2007; MORSI & WENDLER, 2010) and non-marine ostracodes (ULIANA & MUSACCHIO, 1978; COLIN et al., 1996; NICOLAUDIS & COIMBRA, 2008; GROSS et al., 2013). The genera Cyprideis and Perissocytheridea, associated with marine ostracodes, have also been found in hyperhaline environments (NEALE, 1988).

In the upper interval of Assemblage 1B, the fauna records an increase in salinity as evidenced by the presence of the marine genera Cophinia, Bairdopilata, Brachycythere, Xestoleberis and Jandairella associated with the brackish genus Perissocytheridea.

**Assemblage 2 (A2)**

In the interval 285.30 m - 275.80 m a highly diversified shallow marine association is recorded (Fig. 4). The dominant species are Loxocorniculum? narendrai sp. nov. (~21%), Cytherella mediatlasica (~15%), "Bythocypris" POT 1 (±8%) and Bairdopilata potiguarensis (~7%), though many species of trachyleberidids, cypridids and cytherurids were also recorded.

In contrast to the first assemblage, the diversity is high and the dominance is low (Fig. 4), except in the sample 285.30, where only one specimen was recorded. PUCKETT et al. (2012) found similar values in the Upper Cretaceous of Caribbean that was considered by the authors as indicative of normal marine and stable environments.

The increase in diversity could be related to sea-level highstands that contribute to an expansion of available biotopes and promote evolutionary radiations of shallow-marine organisms.

**Assemblage 3 (A3)**

The interval 272.60 m - 270.80 m reflects a mixture of faunas from marine and brackish water environments (Fig. 3). Diversity decreases and dominance increases (Fig. 4), characterizing more unstable environmental conditions.

The species Loxocorniculum? narendrai sp. nov. (40%), Ovocytheridea reymenti sp. nov. (21%) and "Brachycythere" aff. jodhpurensis (13%) are dominant. Species of the brackish genus Perissocytheridea are also representative of this assemblage and, to a lesser degree, Fossocytheridea spp. According to a study on Recent sediments from Florida, Perissocytheridea is an euryhaline genus, with a species inhabiting mesohaline waters and another preferring polyhaline waters (KEYSER, 1977). This paleoecological plasticity was also observed in the Upper Cretaceous species of Morocco, where ANDREU (1996) recorded Perissocytheridea konatei VIVIERE, 1985, associated with several marine ostracode species. Another example is P. cretacea (PIVESAN, BERGUE & FAUTH, 2010), which occurs predominantly with Fossocytheridea spp. in Upper Cretaceous deposits from Santos Basin, Brazil.

Based on these data, we can infer that the depositional environment of the Jandaíra Formation was marginal marine. Initially, a more restricted lagoonal environment was dominated by almost only brackish genera (assemblage 1A); subsequently the environment became more open in the upper part (Assemblage 1B), with the presence of typical brackish genera (dominant) mixed with some more marine ones such as Cophinia grekoffi. This is corroborated by the interpretation of CORDOBA (2001) who suggests a tidal flat to lagoonal facies for this interval. Superimposing these deposits is a fauna representative of higher salinity (assemblage 2), and probably deeper water, dominated by the species Loxocorniculum? narendrai, Cytherella mediatlasica and Bairdopilata potiguarensis. Above this a reduction in salinity was probably related to the more restricted environments, though not so restricted as in assemblage 1, which is represented by tidal flat and open lagoonal facies dominated by Loxocorniculum? narendrai and "Brachycythere" aff. jodhpurensis associated with the cytherideid Ovocytheridea reymenti and the brackish Perissocytheridea and Fossocytheridea.

The study by DELICIO et al. (2000) of the Jandaíra Formation in more distal offshore wells records an ostracode fauna characteristic of outer neritic environment. The only species in common with the present work is Bairdopilata potiguarensis (DELICIO et al.), which ranges from the Cenomanian to the Paleocene, according to those authors. About the ecology of Bairdopilata, PUCKETT (1996) concludes that the temperature and depth are apparently less restrictive than the salinity gradient. In the case of B. potiguarensis the tolerance seems to be also relative to the salinity, because it is associated with brackish species. This difference in faunal composition is probably due to the more distal position of the wells studied by DELICIO et al. (2000). Another hypothesis is that DELICIO et al. (2000) did not sample the Turonian interval. However, a more accurate discussion on this subject is not possible because the stratigraphic control is not precise in DELICIO et al. work.
The top of the studied interval seems to correspond to the K88 Sequence (PESSOA NETO et al., 2007), which base is marked by abrupt modifications in seismic profiles, also reflected in both environmental and stratigraphical changes.

6. Paleogeography

Paleobiogeographical reconstructions using fossil groups depend on the accuracy of the available taxonomic data from the involved regions. This type of study is still in an early stage in Brazilian basins. This work represents an additional contribution for paleobiogeographic correlations using ostracode faunas. Pioneering works demonstrating the potential of ostracodes in correlation studies were published in the 1960 and 1970 decades (e.g., KROHMELBEN, 1966a, 1966b, 1976) dealing with faunas from Gabon and NE Brazil. Paleobiogeographic syntheses of the Upper Cretaceous ostracodes were developed by several authors, including TAMBALEAU (1982), BAINOT & COLIN (1988, 1992), DINGLE (1988, 1999), GEBHARDT (1999c), FAUTH (2002) and LUGER (2003).

DELICIO et al. (2000) demonstrated that the ostracode fauna of the Potiguar Basin was endemic except for Cytherella austinensis, previously recorded in North America (ALEXANDER, 1929; SWAIN & BROWN, 1964) and Africa (KOBE & MEHES, 1986), for Cytherella gambiensis, recorded in Senegal (APOSTOLESCU, 1963), and for Veenia glabella recorded in Senegal (APOSTOLESCU, 1963), Gabon (NEUFVILLE, 1973a) and Algeria (VIVIÈRE, 1985). At the generic level, VIviers et al. (2000) demonstrated a strong affinity between eastern Brazilian basins and West African basins in the Turonian, especially by the presence of the genera Brachycythere and Haughtonileberis.

According to the Turonian ostracode data, the Potiguar Basin and West/North Africa have strong similarity as demonstrated by sharing eight common species (Fig. 5). Cytherella mediatlascica occurs in the Turonian-Santonian of Nigeria (OKOSUN, 1987, 1992) and Santonian of Morocco (ANDREU, 1996); both Potiguerella grosdidi sp. nov. and Potiguerella coimbrai sp. nov. occur in the Turonian of Gabon (GROS-DIDIER, 1979); Nigeria cf. rotunda REYMENT, sensu ANDREU, occurs in the Cenomanian of Morocco (ANDREU, 1991); Paracypris aff. dubetreti was also recorded in the Cenomanian-Turonian of Algeria (VIVIÈRE, 1985); Paracypris aff. caudata occurs probably in the Turonian of Egypt (BOLD, 1964), Turonian of Gabon (NEUFVILLE, 1973a) and Middle Turonian-Santonian of Algeria (VIVIÈRE, 1985); Ovocytheidea reymenti is present in the Cenomanian-Maastrichtian of Nigeria (OKOSUN, 1987, 1992) and Haughtonileberis dinglei sp. nov. was recorded in the Turonian-Santonian of Nigeria (OKOSUN, 1992).

ANDREU (1993) and ANDREU et al. (2013) noted the existence of an almost continuous Cenomanian-Turonian carbonate platform in Northwest and North Africa, which acted probably as the migratory route for the species shared with the Potiguar Basin.

The presence of the genera Ovocytheidea, Cophinia, "Brachycythere" and Haughtonileberis is evidence that the Potiguar Basin is in the Afro-Arabian Bioprovince (that includes north-northeastern Africa and the Middle East) proposed by BAINOT & COLIN (1988, 1992). This also reinforces the initial proposal of TAMBALEAU (1982) of a "Brazil-Central/West Africa Province".
Figure 5: Paleogeographic distribution of Turonian species in Potiguar Basin (Turonian map after SMITH et al., 1994).

The possible presence of the genus Bicornicythereis PUCKETT, 2009, is particularly interesting. Species of this genus occur in Santonian-Maastrichtian deposits of the United States according to PUCKETT (2009) and they are not present in the Caribbean region (PECKETT et al., 2012). REYMENT (1980) infers that the migration of shallow water marine benthic organisms by passive transport from North Atlantic to South Atlantic occurred until the Cenomanian or even Early Turonian. On the other hand, biogeographic distribution patterns of benthic foraminifers indicate the existence of a "Brazilian-Caribbean-Gulf Coast Province" in the Coniacian-Maastrichtian (KOUTSOUKOS & KLASZ, 2000).

Some elements from South Gondwana (the Pan-Gondwana Fauna proposed by DINGLE, 1988), such as the widely distributed genera Brachycythere, Haughtonileberis, and Nigeria, are recorded in this study. Rostrocythereidea, a typical Gondwanine genus (DINGLE, 1999; BALLENT & WHATLEY, 2007), probably occurs both in Potiguar and Pará-Maranhão Basins, Brazilian equatorial margin (PIOVESAN et al., 2009). Similarities with Indian fauna are related to "Brachycythere" aff. jodhpurenensis. The species Brachycythere jodhpurenensis SINGH, 1997, was recorded in the Turonian-Coniacian of India (SINGH, 1997; ANDREU et al., 2007). All these taxa possibly had the same migration pattern as Majungaella and Aracajuia, indicating that the northward migration across the Walvis Ridge-Rio Grande Rise barrier to Northeast Brazilian margin, which began in Late Aptian-Albian, was still effective during the Late Cretaceous (DINGLE, 1988; PIOVESAN et al., 2012; ANTONIETTO et al., 2013).

7. Conclusions

This detailed taxonomic study of Turonian ostracodes from the Jandaíra Formation, Potiguar Basin has significantly improved the micropaleontological knowledge of this area. More precisely, 53 taxa were recognized with two new genera and 13 new species; several of the 53 taxa probably are new species, but were only compared with species already described or left in open nomenclature.

We propose three faunal assemblages indicative of different paleoenvironmental contexts, within the marginal marine environment, varying from lagoonal to more open marine (probably subtidal), which supports the potential of ostracodes as paleoecological indicators.

We reinforce the inclusion of this region in the "Brazil-Central/West Africa Province" based on the strong similarity verified by the occurrence of eight common species. The Turonian ostracode data presented in this paper indicate that migration occurred from the South Africa and South America and North Africa, according to the bidirectional opening of the Atlantic Ocean.
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Appendix 1: Illustrated species.

This appendix (Pls. 9-11) presents the taxa which remained in open nomenclature or undetermined due to their scarcity and poor preservation, or that were not included in the taxonomy chapter due to their reduced stratigraphic value.
**Plate 10: Scale bar: 100 µm**

A-B: *Acuminacythere? POT 1.* A-B: C, ULVG-9910, sample 276.65 m, L: 0.308, H: 0.138, W: 0.145, A: right view, B: DV.

C-D: *Metacytheropteron POT 1.* C-D: C, ULVG-9903, sample 272.60 m, L: 0.525, H: 0.262, W: 0.210, C: right view, D: DV.

E-F: *Semicytherura POT 1.* E-F: C, ULVG-9916, sample 319.80 m, L: 0.424, H: 0.220, W: 0.257, E: DV, F: right view.

G-H: *Cursina? POT 1.* G-H: C, ULVG-10003, sample 276.65 m, L: 0.619, H: 0.300, W: 0.209, G: right view, H: DV.

I-L: *"Brachycythere?" POT 2.* I; K: C, ULVG-10034, sample 271.40 m, L: 0.800, H: 0.440, W: 0.420, I: left view, K: DV; J; L: RV, ULVG-10035; 271.40 m, L: 0.800, H: 0.400, J: EV, L: RV, IV.

M-N: *Trachyleberididae indet. gen. 1.* M-N: C, ULVG-10024, sample 272.40 m, L: 0.889, H: 0.429, W: 0.410, M: right view, N: DV.

O-Q: *Platyleberis? POT 1.* O-P: C, ULVG-10048, sample 275.80 m, L: 0.480, H: 0.222, W: 0.340, O: right view, P: DV; Q: C, VV, ULVG-10670, sample 277.25 m, L: 0.450, H: 0.220, W: 0.320.

R-S: *Xestoleberididae indet. gen. 1.* R-S: C, ULVG-10049, sample 276.65 m, L: 0.485, H: 0.251, W: 0.380, R: right view, S: DV.
Plate 11: Scale bar: 100 µm

A-D: Indet. gen. 1 POT 1. A-B: C, f, ULVG-9892, sample 276.65 m, L: 0.645, H: 0.444, W: 0.416, A: right view, B: DV; C-D: C, m, ULVG-9893; 276.25 m, L: 0.614, H: 0.419, W: 0.349, C: right view, D: DV.

E-G: Indet. gen. 2 POT 1. E-F: C, f, ULVG-9952, sample 272.40 m, L: 0.675, H: 0.413, W: 0.278, E: right view, F: DV; G: C, left view, m, ULVG-9953, sample 272.40 m, L: 0.730, H: 0.370, W: 0.300.


K-M: Indet. gen. 4 POT 1. K-L: C, ULVG-9917, sample 319.80 m, L: 0.537, H: 0.254, W: 0.306, K: right view, L: DV; M: C, left view, ULVG-10659, sample 319.80 m, L: 0.460, H: 0.233, W: 0.270.

N-P: Indet. gen. 5 POT 1. N-O: C, f, ULVG-9874, sample 317.90 m, L: 0.705, H: 0.441, W: 0.354, N: right view, O: DV; P: C, left view, m, ULVG-9875, sample 319.80 m, L: 0.760, H: 0.420, W: 0.302.
### Appendix 2: Distribution of the ostracode species, with their abundances.

<table>
<thead>
<tr>
<th>SAMPLES/SPECIES</th>
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<tbody>
<tr>
<td>Cophina POT 2</td>
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<tr>
<td>Potiguarellia colombraii sp. nov.</td>
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<tr>
<td>Perissocytheridea mossoroensis sp. nov.</td>
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<tr>
<td>Indet. gen. 5 POT 1</td>
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<tr>
<td>Xestoleberis POT 1</td>
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<tr>
<td>Fossocytheridea tiberti sp. nov.</td>
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<tr>
<td>Indet. gen. 4 POT 1</td>
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<tr>
<td>Potiguarella POT 1</td>
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<tr>
<td>Semicytherura POT 1</td>
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<tr>
<td>Indet. gen. 2 POT 1</td>
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<tr>
<td>Bairdapsilata potiguarensis</td>
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<tr>
<td>&quot;Brachycythere&quot; POT 1</td>
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<tr>
<td>Perissocytheridea caudata sp. nov.</td>
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<tr>
<td>Potiguarella sp. nov.</td>
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<tr>
<td>Cophina grekoffi sp. nov.</td>
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<tr>
<td>Cytherella mediatlasica</td>
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<tr>
<td>Jandialrelia obesa sp. nov.</td>
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<tr>
<td>Perissocytheridea ? POT 1</td>
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<tr>
<td>Bicornicythere ? POT 1</td>
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<td>&quot;Bythocypris&quot; POT 1</td>
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<tr>
<td>Eucytherura aff. speluncosus</td>
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<td>Haughtonleberis dingli sp. nov.</td>
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<tr>
<td>Haughtonleberis POT 1</td>
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<td>Hemicytherura viviersae sp. nov.</td>
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<td>Indet. gen. 1 POT 1</td>
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<tr>
<td>Loxocorniculum? marenzulai sp. nov.</td>
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<tr>
<td>Ovocytheridea posterojecta sp. nov.</td>
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<td>Paracypris aff. caudata</td>
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<tr>
<td>Paracypris aff. dubberteti</td>
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<td>Paracypris POT 1</td>
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<td>Paracypris POT 2</td>
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<td>Paracypris POT 3</td>
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<td>Platybleberis ? POT 1</td>
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<td>Procyrtherura ballentoe sp. nov.</td>
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<tr>
<td>Semicytherura aff. adversinfluata</td>
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<tr>
<td>Acuminocythere ? POT 1</td>
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<tr>
<td>Cophina POT 1</td>
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<tr>
<td>Curfsina ? POT 1</td>
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<tr>
<td>Paracypris POT 4</td>
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<td>Pontocypris POT 1</td>
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<td>Xestoleberididae indet. gen. 1</td>
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<td>&quot;Brachycythere&quot; aff. jodhpurensis</td>
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