Revista Brasileira de Paleontologia, 26(4):241–255, Outubro/Dezembro 2023
A Journal of the Brazilian Society of Paleontology

doi:10.4072/rbp.2023.4.01

THE CRITICAL ROLE OF ACCURATE FOSSIL IDENTIFICATION: THE CASE OF THE OSTRACODS OF THE CODÓ FORMATION (LOWER CRETACEOUS), NE BRAZIL

JOÃO CARLOS COIMBRA
Departamento de Paleontologia e Estratigrafia, Universidade Federal do Rio Grande do Sul, 91501-970,
Porto Alegre, RS, Brazil. *joao.coimbra@ufrgs.br* (Corresponding author)

SANDRO MONTICELLI PETRÓ
Instituto Tecnológico de Paleontologia e Mudanças Climáticas, Universidade do Vale do Rio dos Sinos, 93022-970,
São Leopoldo, RS, Brazil. *sandro.m.petro@gmail.com*

ABSTRACT – The Class Ostracoda comprises bivalve microcrustaceans with great diversity and abundance in the Lower Cretaceous paleolakes of Brazil and the world. With species generally well-preserved and of relatively short biochrons, it has provided high-resolution biostratigraphic frameworks that permit long-distance correlations. In this context, the Lower Cretaceous biozones of the NE Brazilian basins have allowed the establishment of correlations between coeval geological sections not only in this region but also with those of the Brazilian marginal basins, including the rocks of the pre-salt deposits, as well as with West African basins. In addition to biostratigraphy, these microfossils have proved indispensable in paleoenvironmental and paleogeographical analyses, including studies on the opening of the South Atlantic Ocean. However, some publications have emerged that, regrettably, exhibit errors in species identification and/or the accurate interpretation of biostratigraphic works. These mistakes have led to proposed modifications in both the biochron and geographic distribution of index taxa and taxonomic synonymizations that are incongruent with the current state of knowledge of the species. Consequently, these inaccuracies have given rise to erroneous biochronostratigraphic correlations and paleoenvironmental inferences. In this context, we meticulously examine the current understanding of the taxonomy of ostracods from the Codó Formation (NE Brazil), which is essential for the debate on the use of Lower Cretaceous ostracods in stratigraphy.

Keywords: biostratigraphy, paleoecology, microfossils, Lower Cretaceous, Brazil.

RESUMO – A Classe Ostracoda compreende microcrustáceos bivalves que exibem grande diversidade e abundância nos paleolagos do Cretáceo Inferior do Brasil e do mundo. Com espécies geralmente bem preservadas e de biocrons relativamente curtos, tem proporcionado a criação de biozoneamentos de alta resolução que permitem correlações a grandes distâncias. Neste contexto, as biozonas do Cretáceo Inferior das bacias do NE do Brasil têm permitido o estabelecimento de correlações entre seções geológicas coevas não apenas nessa região, mas também com as bacias marginais do país, incluindo as rochas presentes nos depósitos do pré-sal, bem como com bacias da África Ocidental. Para além da bioestratigrafia, esses microfósseis têm se mostrado indispensáveis em análises paleoambientais e paleogeográficas, incluindo os estudos sobre a abertura do Oceano Atlântico Sul. No entanto, nos últimos anos têm surgido publicações que, devido à identificação equivocada das espécies e/ou à interpretação incorreta de trabalhos de cunho bioestratigráfico, têm proposto (i) modificações no biocron e na distribuição geográfica de táxons índices e (ii) sinonimizações taxonômicas incompatíveis com o estado atual do conhecimento das espécies, promovendo, assim, correlações biocronoestratigráficas e interpretações paleoambientais incorretas. Neste contexto, examinamos meticulosamente o entendimento atual da taxonomia dos ostracodes da Formação Codó (NE do Brasil), o qual é essencial para o debate sobre o uso de ostracodes do Cretáceo Inferior na estratigrafia.

Palavras-chave: bioestratigrafia, paleoecologia, microfósseis, Cretáceo Inferior, Brasil.

INTRODUCTION

Science is subject to a process of social control, as scientific communities are structured in such a way as to allow research methods, data interpretations, and conclusions to be constantly revised. The concept of "organized skepticism", as proposed by Merton (1973), permeates scientific practice and is fundamental to our understanding of the natural world. "Organized skepticism" implies adopting research methods and data analysis that aim to control scientists' biases, desires and expectations, to generate research results as reliable as possible. In essence, when applied to individuals, "organized skepticism" involves protective mechanisms against self-deception. With this view of science, this paper presents a critical review of studies on ostracods from the Codó Formation, Cretaceous of the Parnaíba Basin, NE Brazil.

The non-marine Mesozoic ostracods are recognized as a valuable biochronostratigraphic tool for understanding the geological history of lacustrine basins on all continents (Neale, 1984). In Brazil, the tectonic paleolake known as the Recôncavo/Tucano Basin has the differential of containing the first petroleum rocks economically exploited in the country. Viana *et al.* (1971) documented and named numerous biozones and subzones within this basin, benefiting from the abundance and species diversity of an ostracod fauna with short biochrons. Furthermore, in 1969, Schaller formally proposed an Aptian/Albian ostracod biozone for a transitional sequence found in the Sergipe/Alagoas Basin, which he named *Cytheridea*? spp. 201–218.

However, the biostratigraphic application of the ostracods found in the NE non-marine Brazilian basins was only possible because a meticulous taxonomic study of most species was previously carried out by the paleomicrontologist Karl Krömmelbein between 1961 and 1966 (see Coimbra 2020 for references). Subsequently, Krömmelbein & Weber (1971) described more 51 new species and one new genus mainly for the Recôncavo/Tucano and Sergipe/Alagoas basins. These works played an essential role in establishing the biozoning and paleoenvironmental interpretation of Lower Cretaceous sections, and this approach proved successful in correlating with other contemporary sections of NE and SE Brazil, including the pre-salt rocks that harbor one of the largest oil reservoirs in the world. For a detailed exploration of the advancements and complexities associated with this fascinating subject, we recommend referring to the comprehensive study conducted by Poropat & Colin (2012).

The Brazilian rift basins have performed a crucial function in documenting the evolutionary process of the West Gondwana break-up. This evolution is typically divided into three tectono-stratigraphic stages (i) the pre-rift stage, which is characterized by regional subsidence resulting from the visco-elastic stretching of the lithosphere; (ii) the rift stage, marked by significant mechanical subsidence and the formation of graben and/or half-graben systems; and (iii) the post-rift stage, distinguished by the prevalence of thermal subsidence (Ponte & Ponte Filho, 1996). During the pre-rift stage, the dominant ostracods primarily belong to the genus *Theriosynoecum* Branson, 1936. As the basin transition to the rift stage, the dominant ostracods shift mainly to species assigned to the genus *Cypridea* Bosquet, 1852, and secondarily to the genus *Paracypridea* Swain, 1946. In the post-rift stage, smooth-shelled ostracods become abundant, with a predominance of those classified by Schaller (1969) as *Cytheridea*? spp. 201–218. Nevertheless, further studies have resulted in the reclassification of many specimens, which are now attributed mainly to the genera *Damonella* Anderson, 1966 and *Pattersoncypris* Bate, 1972, remembering that for some authors *Pattersoncypris* is a junior synonym of *Harbinia* Tsao, 1959 (*e.g.*, Ramos *et al.,* 2006; Do Carmo *et al.*, 2008, 2013, 2018; Barros *et al.*, 2022). Noteworthy is that the genus *Cytheridea* Bosquet, 1952 does not occur in the biozone defined by Schaller (1969), which is probably why he used a question mark after the genus name.

The study of ostracods from the Codó Formation was carried out mainly by Ramos *et al.* (2006) and Barros *et al.* (2022). Ramos *et al.* (2006), studying many samples from a limestone mine, identified one species of *Candona* Baird, 1845, and six species of *Harbinia* Tsao, 1959 emend. Hou, 1984. According to the authors, these microfossils indicated a late Aptian age and confirmed the paleoenvironmental model proposed by Rossetti & Góes (2000) and Paz & Rossetti (2001, 2005). Barros *et al.* (2022) examined 24 samples from a poorly preserved and inadequately stored core. The microfossils were also poorly preserved, leading the authors to identify only 38% of the total recovered specimens, some of which were steinkerns. The proposed age was late Aptian, and the sedimentary environment was interpreted as a lagoon with intermittent direct connection to the sea. Two species were suggested as potential chronostratigraphic markers.

Two other works are also worth noting. The oldest, Krömmelbein & Weber (1971), is a study where were described 51 ostracod species from the upper Mesozoic of NE Brazil, 46 of which were new species, including *Hourcqia angulata symmetrica* (= *Harbinia symmetrica* in the present paper) for the Codó Formation. In turn, Maizatto *et al.* (2011) analyzed palynomorphs and ostracods from three samples collected from two outcrops, one of which contained poorly preserved ostracod specimens. Two carapaces considered complete by the authors were identified as an adult of *Harbinia sinuata* (Krömmelbein & Weber, 1971) and a juvenile of *Harbinia* sp.

The ostracods that comprise the studies cited above have traditionally correlated with the Alagoas local Brazilian Stage and the Aptian/Albian interval (Coimbra & Freire, 2021 and references therein). More recently, in a study of ostracods and foraminifera from the Santana Group, Araripe Basin, Northeastern Brazil, Guzmán *et al.* (2023) proposed that the *Pattersoncypris micropapillosa* Biozone – OST-011, also known as the *Cytheridea*? spp. 201/218 Biozone or *Harninia* spp. 201/2018 Biozone (both under code RT-011), is restricted to the Aptian. For a better understanding of the subject addressed in this work, we chose to use the nomenclature *Harninia* spp. 201/218 Biozone.

This study deals with the taxonomy and stratigraphic application of the ostracod fauna identified and illustrated by Ramos *et al.* (2006) and Barros *et al.* (2022). Considering that the last work has more species, it is the first to be focused in the results and discussion chapter. Finally, the identification of supposed bioevents by Barros *et al.* (2022), which could be regional or even supraregional chronostratigraphic markers, is also discussed.

GEOLOGICAL SETTING AND PALEOENVIRONMENTS

Geology

The Parnaíba Basin shows an area of 600,000 km^2 between the states of Piauí, Tocantins, Pará, Ceará, Bahia, and Maranhão, NE Brazil (Góes & Feijó, 1994; Vaz *et al.*, 2007) (Figure 1). The basin developed on the continental basement

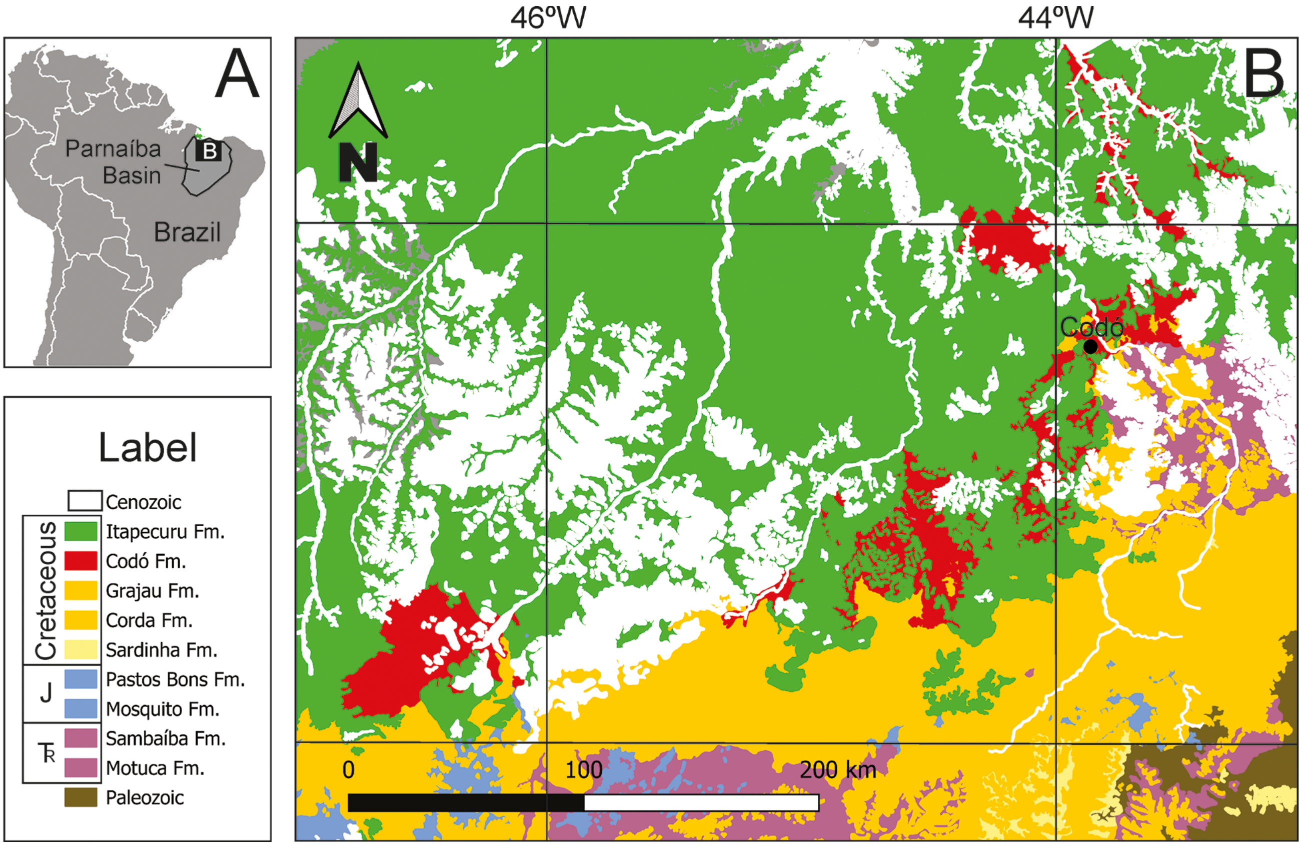

Figure 1. General location of the Parnaíba Basin (**A**) and geological scheme of part of the northern portion of the Parnaíba Basin and Codó Formation (**B**) (data from Sousa *et al.* (2012).

of the South American platform during a stabilization stage. In the initial phase, until the Early Carboniferous, larger structures such as the Picos-Santa Inês, Marajó-Parnaíba, and the Transbrasiliano lineaments controlled the direction of the depositional axes. After the Late Carboniferous, the depocenter of the basin moved towards the central part, acquiring an oval shape due to its interior syneclisis structure. The thickness of the sediment reaches 3,500 m at its depocenter (Almeida & Carneiro, 2004; Vaz *et al.*, 2007).

The succession of rocks in the Parnaíba Basin occurs in five supersequences: Silurian, Middle Devonian to Lower Carboniferous, Upper Carboniferous to Lower Triassic, Jurassic, and Cretaceous. These supersequences are delimited by regional unconformities generated by fluctuations in the eustatic level of epicontinental seas. In the Cretaceous sequence, the first deposits formed under the influence of the Atlantic Ocean in its initial stage are observed, unlike the previous four sequences that were still related to the transgressions and regressions of the Tethys Ocean. The Cretaceous sequence consists of the Codó, Corda, Grajaú, and Itapecuru formations. In turn, the Codó formation comprises shales, limestones, siltstones, gypsum/anhydrite, and sandstone (Vaz *et al.*, 2007). The Grajaú and Codó formations were deposited in shallow marine, lacustrine, and fluvio-deltaic environments and show late Aptian to early Albian age (Rossetti *et al.*, 2001) (Figure 2).

Paleoenvironments

Góes & Rossetti (2001) divided the Codó Formation into three paleoenvironments. The lower one was deposited in lagoon to restricted marine environment, the middle one is constituted by fluvio-deltaic sediments, and the upper one corresponds to a lacustrine system with a transgressive event at the base. Paz & Rossetti (2001), studying outcrops of the Codó Formation near the town of Codó, Maranhão State, identified three lacustrine broad facies based on sedimentology and microfossils.

Antonioli & Arai (2002), based on faciological and palynological analyses, also subdivided the Codó Formation into three lithostratigraphic units. The lower unit rocks represent an incipient marine environment, the middle unit is essentially evaporitic, and the upper unit is typically marine. Paz *et al.* (2005), analyzing Sr isotopes, proposed the occurrence of predominantly continental depositional systems.

Ramos *et al.* (2006), studying the stratigraphic distribution of paleocommunities of ostracods, inferred the presence of a lacustrine depositional environment subject to cyclic expansion and retraction events, variation in salinity and oxygen content. Arai (2014) observed a series of marine fossil groups in the Aptian/Albian interval of NE Brazilian basins, evidencing the marine influence in some deposits, including the Codó Formation. Bastos *et al.* (2014), using marine

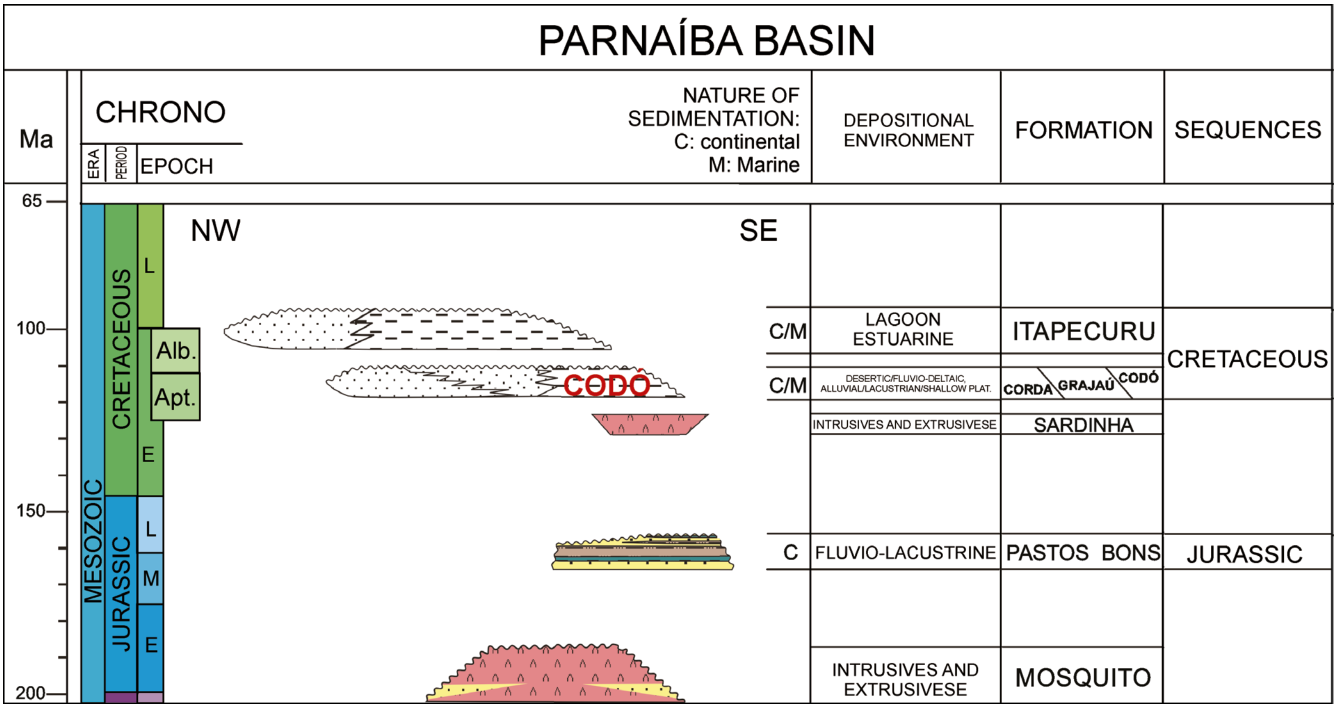

Figure 2. Stratigraphic chart for the Jurassic and Cretaceous of Parnaíba Basin (modified from Vaz *et al.*, 2007).

geochemical indicators, interpreted a possible environment formed by a gulf, where periods of restricted conditions occurred, generating hypersalinity and anoxia. Bahniuk *et al.* (2015), studying well-preserved carbonate microbialites from the edge of the basin, identified a closed lacustrine system developed in an arid climate with high evaporation rates. Lindoso *et al.* (2016), studying fossil fish assemblages recovered from outcrops near Brejo town, Maranhão State, inferred a restricted lacustrine environment with little marine influence.

Sousa *et al.* (2019), through analyzes of the composition of organic matter and biomarkers, identified a saline to hypersaline paleoenvironment, with the influence of organic matter of marine origin. Bastos *et al.* (2022) conducted a study involving biomarkers, nitrogen isotopes and organic carbon isotopes, revealing a sequence of events within the Codó Formation. Initially, they identified a high-saline environment with intermittent marine influxes, transitioning into a closed evaporitic system. This was followed by a marine flood, leading to the development of an anoxic epicontinental sea. Subsequent water circulation and depth increases transformed the environment into an oxygenated marine setting. Finally, the closure of marine connections along with terrestrial contributions prompted a process of continentalization, giving rise to a lacustrine environment.

Barros *et al.* (2022) studied mainly ostracod assemblages recovered from a core drilled at the eastern edge of the basin. The paleoenvironmental analysis is somewhat confusing, as can be seen on page 16: *"This lagoon seems to have been permanently connected to seawater (e.g., via aquifers penetrating the barrier to the sea), from which it derived its salinity. Open connection to the sea would only occur intermittently, where foraminifera and marine gastropoda are present. This way, the lagoon could largely retain the relatively stable, higher salinities, despite intermittent fluvial inflow and introduction of non-marine ostracod faunal elements indicative of lower salinities.*"

Bobco *et al.* (2023), using a multiproxy approach, identified five depositional stages: expanded lake, brackish ephemeral lake, perennial shallow lake, evaporitic sabkha, and stratified lake. They also proposed alternating between open, semi-closed, and closed lakes, with occasional marine incursions. The processes that control the lake level are inflow rates, evaporation, and changes in sea level in an arid to semi-arid climate.

Despite the work already done, there is still no clear understanding of the paleoenvironmental evolution of the Codó Formation. In general, the studies have identified a lacustrine system with occasional marine incursions, generally at the top (Góes & Rossetti, 2001; Antonioli & Arai, 2002; Bastos *et al.*, 2014, 2022; Lindoso *et al.*, 2016; Sousa *et al.*, 2019; Bobco *et al.*, 2023). On the other hand, some works recognized a lacustrine paleoenvironment without direct marine influence (Paz & Rossetti, 2001; Paz *et al.*, 2005; Bahniuk *et al.*, 2015).

RESULTS AND DISCUSSION

On the ostracod taxonomy by Barros *et al.* (2022)

Despite Barros *et al.* (2022) having collected 24 samples along borehole 1-UN-24-PI, relatively few ostracods were recovered when compared to coeval deposits in other Brazilian basins, such as the Araripe Basin (see Guzmán *et al.*, 2022 and references therein). In addition, the ostracod assemblage was predominantly represented by poorly preserved juvenile valves and some steinkerns, which led the authors to identify only 38% of the microfossils at the genus level and an even smaller percentage at the species level. According to Barros *et al.* (2022, section 4.2), the most abundant species was *Harbinia micropapillosa* (Bate, 1972) (146 specimens), followed by *H. salitrensis* (Krömmelbein & Weber, 1971) (107 specimens) and *H. symmetrica* (Krömmelbein & Weber, 1971) (88 specimens). The other ostracod species recorded from one to a maximum of 28 specimens each. However, the total number of specimens of some of the 19 species, such as *H. alta* Antonietto *et al.*, 2012, *H. angulate* (Krömmelbein & Weber, 1971), *H. crepata* Do Carmo *et al.*, 2013, and *H. sinuata* (Krömmelbein & Weber, 1971) was not revealed.

The *"Taxonomic notes"* of Barros *et al.* (2022, section 4.1) did not bring any new taxonomic information about the ostracod species they studied. The most they did was inform the geographic and stratigraphic distribution of the ostracods determined at the species level, often simply repeating almost literally what had already been presented by other authors and sometimes reproducing incorrect information or leaving out some previous records. It is also important to point out that Barros *et al.* (2022) did not discuss the pros and cons of the taxonomic assignment given to each species despite the biases inherent to the fossil material they analyzed. In the next paragraphs, most of the ostracods illustrated and identified by those authors are discussed in detail. Subsequently, the taxonomic study by Ramos *et al.* (2006) is appraised, as well as the proposal of Barros *et al.* (2022) on bioevents as chronostratigraphic markers.

***Harbinia alta* Antonietto *et al.*, 2012.** Barros *et al.* (2022) figured two valves in lateral view, both juvenile. Figure 3A (length 0.462 mm, height 0.335 mm) is a left valve that would be among the smallest morphotypes of ontogenetic stage A-2, already very close to stage A-3 according to figure 6A in Antonietto *et al.* (2012). In turn, the right valve in figure 3B (length 0.339 mm, height 0.241 mm) is even smaller, and would be a morphotype of the ontogenetic stage A-4 of Antonietto *et al.* (2012). Assuming that the two valves are the best found by them, it is strange that the outline is not similar to any ontogenetic stages of *H. alta* figured in the work where the species was formally named. In this scenario, we understand that the best option should be to keep these ostracods in open nomenclature.

With regard to the geographic and stratigraphic distribution of the true *Harbinia alta*, the authors left out the occurrence of the species in the Alagamar Formation, Potiguar Basin (see Do Carmo *et al.*, 2013, p. 95).

***Harbinia angulata* (Krömmelbein & Weber, 1971).** As pointed out by Krömmelbein & Weber (1971), this species is easily distinguished mainly by its obliquely truncated posterior margin. Also, according to these authors, with regard to morphological variability, *H. angulata* has a very distinct outline and ornamentation. However, the ornaments may occasionally be less conspicuous due to taphonomic processes. The holotype is 0.86 mm in length and 0.58 mm in height.

In turn, the material illustrated by Barros *et al.* (2022, figures 3C, D) is two left valves of juveniles, the largest 0.640 mm and the smallest 0.496 mm in length. Despite being the best specimens obtained by the authors, we understand that they do not represent *Harbinia angulata*. Both show outline incompatible with this species, even considering they are juveniles. Besides, they probably do not belong to the same species.

Regarding the occurrences of the true *Harbinia angulata*, the authors mention the studies of Silva-Telles Jr. & Viana (1990) and Ramos *et al.* (2006). However, since Antonietto *et al.* (2012), it has been accepted that specimens identified as *H. angulata* by Silva-Telles Jr. & Viana (1990, Santana Group, Araripe Basin) and Ramos *et al.* (2006, Codó Formation, Parnaíba Basin) belong to the species *H. alta*. Surprisingly, this is mentioned by Barros *et al.* (2022) in section "*5.1. Biostratigraphic considerations"* but not followed in section "*4.1. Taxonomic notes"*, rendering the geographic and stratigraphic distribution of the true *H. angulata* inaccurate.

***Harbinia crepata* Do Carmo *et al.*, 2013.** It seems that the ostracod in figure 3E of Barros *et al.* (2022) is close to the A-1 stage of Do Carmo *et al.* (2013), which is 0.80 mm in length. However, the height between them is different, as the A-1 of the Alagamar Formation is 0.44 mm in height, while Barros's material is 0.498 in height. Thus, the length/height ratio is different between the specimens figured by Barros *et al.* (2022) and Do Carmo *et al.* (2013), besides the outline of the species, which is also somewhat distinct.

The left valve in figure 3F of Barros *et al.* (2022) is smaller than the previous one, with 0.615 mm in length and 0.396 mm in height. It appears to be somewhat flattened, which may have affected the outline and measurements taken by the authors. Do Carmo *et al.* (2013) identified, measured and illustrated, in addition to the holotype, the juvenile stages up to A-7 of *Harbinia crepata*. The measurements and outline of the material of Barros *et al.* (2022) do not coincide with any of the stages studied by Do Carmo *et al.* (2013). In this context, it is strange that Barros *et al.* (2022) did not discuss what led them to consider this juvenile left valve conspecific with *H. crepata*.

Considering the geographic and stratigraphic occurrences of *Harbinia crepata*, we found some inconsistencies when Barros *et al.* (2022, p. 4) state: *"Romualdo Member, Santana Formation, Araripe Basin, upper Aptian (Regali, 1990; Coimbra et al., 2002; Melo et al., 2020)"*. Nonetheless, from the three cited works, only Melo *et al.* (2020) recorded this species in those lithostratigraphic units. On the other hand, the presence of *H. crepata* in the Riachuelo Formation, Sergipe-Alagoas Basin, recorded by Antonietto *et al.* (2016), was omitted.

***Harbinia micropapillosa* (Bate, 1972).** This species was the most abundant in the material studied by Barros *et al.* (2022), totaling 146 specimens. *Harbinia micropapillosa*, assigned to the genus *Pattersoncypris* by other authors (*e.g.*, Tomé & Lima Filho, 2010; Tomé *et al.,* 2014; Guzmán *et al.*, 2022), is one of the most typical ostracods of the *Harbinia* spp. 201/218 Biozone, whose age is restricted to the Aptian/Early Aptian (*e.g.*, Teixeira *et al.*, 2017; Arai & Assine, 2020; Melo *et al.*, 2020; Coimbra & Freire, 2021; Fauth *et al.*, 2023).

Despite its great contribution to biostratigraphy and paleoenvironmental analysis, this species requires revision on both morphology and ontogeny, given the inconsistencies found in the material studied by different authors. In this scenario, it should be noted that these inconsistencies could rarely be attributed to taphonomic biases that would have affected the original morphology of isolated carapaces and valves. Why? Because most of the illustrated fossils are well preserved.

Concerning the adult size and outline, there are different approaches. In the original description by Bate (1972), recently reproduced by Bate *et al.* (2022, figure 14:1A–D), the holotype (adult, number Io.4680, The Natural History Museum, London) has the following dimensions: length 0.93 mm, height 0.67 mm, and width 0.61 mm. On the other hand, according to the material studied by Smith (2000), adults are 1.122 mm to 1.244 mm long, with height between 0.756 mm and 0.842 mm. The width range was not revealed. If we follow the ontogeny of size present in text-figure 3 of Smith (2000), the holotype of *H. micropapillosa* belongs to instar A-1. However, the outline of stage A-1 illustrated by Smith (2000) is somewhat different from the holotype figured by Bate (1972) and Bate *et al.* (2022).

Following this subject, the figure 6G–I of Guzmán *et al.* (2022) provides a second example. The adult is 0.99 mm in length, 0.66 mm in height, and 0.46 mm in width. It can be seen that not only its dimensions differ from the presented by the adult in Smith (2000), but the outline also diverges (compare with the stereophotographs on plate 1, figures 3A–B, from Smith, 2000). Let us now recall the dimensions of the holotype: length 0.93 mm, height 0.67 mm, and width 0.61 mm. It appears that the specimen figured by Guzmán *et al.* (2022), although longer, is a little lower and much narrower than the holotype proposed by Bate (1972) and also illustrated in Bate *et al.* (2022), as mentioned in the paragraph above.

Considering the studies where specimens attributed to *Harbinia micropapillosa* were illustrated and its abundance and morphological similarities with other species, there is much morphological, ontogenetic, and taxonomic work ahead. However, a revision of this species is far beyond the scope of the present work.

In the work by Barros *et al.* (2022, figures 3G, H), two specimens are figured in right lateral view. The one in figure 3G, as reported by the authors, is a juvenile. Considering the length of 0.657 mm and the height of 0.446 mm, this fossil would represent an A-2 stage (see text-figure 4 of Smith, 2000). The specimen in figure 3H, considered an adult by the authors, measures 1.038 mm in length and 0.708 mm in height. Given these measures, it should be assigned to the A-1 stage proposed by Smith (2000).

Regarding the geographic and stratigraphic distribution presented by Barros *et al.* (2022), the text is confusing and does not include the record performed by Ramos *et al.* (2006) in the Codó Formation. Furthermore, among other misquotations, Moura (1987, 1988) and Smith (2000) did not study ostracods from the Sergipe-Alagoas Basin, as stated by the authors, but specimens from the Campos and Araripe basins, respectively. Finally, regarding the Araripe Basin, *H. micropapillosa* was never restricted to the Romualdo Member (= Romualdo Formation), as stated by Barros *et al.* (2022). At least since Coimbra *et al.* (2002, figure 3) it is known that this species occurs along the Santana Formation (= Santana Group), in addition to the Rio da Batateira Formation (= Barbalha Formation).

Harbinia salitrensis **(Krömmelbein & Weber, 1971) emend. Antonietto *et al.* (2012).** This species is the second most abundant in the material studied by Barros *et al.* (2022), where it is represented by 107 specimens. Both illustrated left valves represent juveniles, which is also attested by the authors. Considering the length of figure 3I (length 0.682 mm, height 0.438 mm), it would be an A-2 stage as proposed by Antonietto *et al.* (2012, figure 5). However, the outline of this valve does not fit well with any ontogenetic stage presented by Antonietto *et al.* (2012).

The specimen shown in figure 3J is even smaller, being only 0.473 mm in length and 0.317 mm in heigth. According to Antonietto *et al.* (2012, figure 5) and based only on its dimensions, it would be included in the A-4 stage, which is impossible since this valve has a contour incompatible with any juvenile stage of *Harbinia salitrensis*.

Concerning the geographic and stratigraphic distribution proposed for *Harbinia salitrensis* by Barros *et al.* (2022), there are some mistakes. Contrary to what is reported, Piovesan *et al.* (2013) did not record this species in the Campos, Santos, and Espírito Santo basins. In turn, Leite *et al.* (2018, figure 3:7–9) illustrated carapaces that were very poorly preserved, whose outlines and dimensions do not match *H. salitrensis* either in lateral or dorsal views. The record by Do Carmo *et al.* (2008) for the Alagamar Formation, Potiguar Basin, as well as the works of Syrio & Rios-Netto (2002) and Poropat & Colin (2012), were not discussed by Barros *et al.* (2022).

Harbinia sinuata **(Krömmelbein & Weber, 1971).** Adults of *H. sinuata* are relatively similar in size and outline to juveniles of *H. micropapillosa*, and the restudy of both species is strongly recommended in the future. With regard to the material illustrated by Barros *et al.* (2022, figure 3K), its dimensions (0.374 mm in length, 0.269 mm in height) indicate that it is a very juvenile specimen. The holotype of this species is 0.78 mm long, 0.54 mm height and 0.37 mm wide. Assuming that the specimen figured by Barros *et al.* (2022) is the best that the authors recovered, it is understood that in the current state of knowledge of the ontogeny of *H. sinuata* it is impossible to attribute this tiny and poorly preserved left valve − which to us looks like a steinkern − to the present species.

Considering the geographic and stratigraphic distribution of this species, Barros *et al.* (2022) made some mistakes. Silva-Telles Jr. & Viana (1990), studying the Araripe Basin, did not record specimens of *Harbinia sinuata*. Besides, the work of Poropat & Colin (2012), which was ignored by Barros *et al.* (2022), presents a more extensive list of occurrences, including records in African basins.

***Harbinia symmetrica* (Krömmelbein & Weber, 1971).** This ostracod was the third most abundant in the material studied by Barros *et al.* (2022), with 88 specimens recovered. The species diagnosis, as proposed by Krömmelbein & Weber (1971, p. 36), differs a little from the description made by the same authors, as follows: (i) in the diagnosis, it is written that *"the maximum carapace height is more or less in the middle",* while the description informs *"greater carapace height immediately before the middle"*; (ii) in the diagnosis it is found that from the middle *"the dorsal margin descends in more or less the same way forwards and backwards"*, while the description asserts that from the middle *"the dorsal margin (= cardinal margin) descends, from there, with a moderate backward inclination, to the quite and evenly curved posterior margin, which is slightly truncated. Forward follows the anterior portion of the dorsal margin (= more appropriately the upper portion of the anterior margin), with a slightly less inclination, passing without interruption to the lower portion of the anterior margin, wide and evenly curved".* With regard to intraspecific variability, Krömmelbein & Weber (1971, p. 36) reported that (i) more elongated morphotypes and more compact ones occur, (ii) the *"angularity of dorsal outline"* is sometimes more pronounced, (iii) the *"cardinal margin itself can be little or much sunken between the valve margins that swell with variable intensities",* (iv) some specimens can be ornamented by *"delicate and irregular scars".* Considering item (i) of intraspecific variability, which deals with the presence of more elongated morphotypes and others more compact, it should be noted that Krömmelbein & Weber (1971) suggested the possibility of sexual dimorphism in this species. However, it is well known that in Cypridoidea the presence of sexual dimorphism in the carapace is rare. The original work of Krömmelbein & Weber (1971) is in German, with the above excerpts in English being as faithful as possible to the original.

Concerning the holotype, Bate *et al.* (2022) in an illustrated catalogue of the type specimens of Krömmelbein & Weber (1971), show the following dimensions: length 1.12 mm, height 0.72 mm, width 0.58 mm. In turn, the left valve illustrated in figure 3L by Barros *et al.* (2022) has 1.073 mm in length and 0.648 mm in height. Other authors registered different dimensions for what they consider an adult of *Harbinia symmetrica*. Do Carmo *et al.* (2008) figured a carapace in right lateral view, whose length is 0.96 mm and height 0.60 mm, which is much more elongated and has a posterior outline distinct from the holotype. Piovesan *et al.* (2013) registered a right valve with 0.97 mm in length, 0.65 mm in height, and 0.37 mm in width, highlighting that "*This species identification remains in doubt due to the preservation of the specimens"* (p. 246). According to the Appendix (Systematic Paleontology) by Araripe *et al.* (2021), the carapace of *H. symmetrica*, illustrated by them in the lateral and dorsal views in figure 5D-F, is 0.720 mm long and 0.435 mm height (they erroneously inform that it is in figure 3D–F). Although they did not give the width, it can be seen in figure 5D, which, despite being small, is a very wide carapace. The adult dimensions recorded by Guzmán *et al.* (2022) were as follows: 0.96 mm in length, 0.57 mm in height and 0.42 mm in width. If the carapace of *Hourcqia*? sp. 2 by Silva-Telles & Viana (1990, pl. III, figures 5, 6) is in fact conspecific with *H. symmetrica*, as proposed by Guzmán *et al.* (2022), it would be smaller than the ones registered so far, being 0.80 mm long, 0.51 mm height and 0.37 mm wide. Surprisingly, Guzmán *et al.* (2022) also included in the list of synonyms of *H. symmetrica* the material illustrated in figure 5D–F by Araripe *et al.* (2022), further suggesting that the carapace of figure 5G–I by Araripe *et al.* (2022), erroneously identified as juveniles of *Pattersoncypris sinuata*, actually belong to *H. symmetrica*. The synonymy list by Guzmán *et al.* (2022) also includes, mentioning one more example, the specimen figured by Do Carmo *et al.* (2008, figure 6.9) which, as described above, presents essential differences in outline with the holotype as well as the material figured by Guzmán *et al.* (2022).

Returning to the left valve illustrated by Barros *et al.* (2022, figure 3L), and analyzing it in the light of what was presented in the two paragraphs above, it is understood that it does not belong to *Harbinia symmetrica*. As for the outline, for example, the curvature of the anterior and posterior margins differs from that present in the holotype (compare with Krömmelbein & Weber, 1971, pl. 6, fig. 25A; and Bate *et al.*, 2022, figure 11.5A). Furthermore, according to the original description, as already mentioned in the first paragraph referring to *H. symmetrica*, the highest height is immediately before the middle. However, in the left valve figured by Barros *et al.* (2022), it is immediately after the middle.

The geographic and stratigraphic distribution presented by Barros *et al.* (2022) is somewhat confusing. As with other species, it can be seen that the authors also assumed the identifications of *Harbinia symmetrica* present in previous works to be correct, and they did so without presenting any discussion. An emblematic case is the material attributed to *H. symmetrica* in the works by Leite (2017, figure 9:4–6) and Leite *et al.* (2018, figure 3:4–6), from the Quiricó Formation, Sanfranciscana Basin. Leite's specimens are strongly different from that illustrated by Barros *et al.* (2022, figure 3L) and also from the type-material, but the occurrence proposed by Leite (2017) appears in Barros *et al.* (2022). In turn, Antonietto *et al.* (2012) and Tomé *et al.* (2014) appear as works that would have recorded this species in the Araripe Basin, but this is not true. Finally, we will look at juveniles of *H.* aff. *H. symmetrica* identified by Ramos *et al.* (2006, figure 4M–P) in the Codó Formation. As reported by Guzmán *et al.* (2022), in fact the material by Ramos *et al.* (2006) does not belong to *H. symmetrica*. However, Barros *et al.* (2022) assumed the occurrence of Ramos *et al.* (2006) as correct, committing another mistake.

In the context of what has been discussed so far, different interpretations regarding the morphology and dimensions of *Harbinia symmetrica* must be underlined. It is imperative to review the species, establish its ontogeny, and define the existence or absence of intraspecific variability.

?*Ilyocypris* sp. The material illustrated by Barros *et al.* (2022) is a large and very poorly preserved left valve, 1.040 mm long and 0.599 mm height. Even considering that the authors attributed this ostracod only tentatively to *Ilyocypris* Brady & Norman, 1889, it does not preserve the outline and any other feature typical of this genus. For an extensive investigation into the taxonomic significance of the morphological features found in both the soft parts and valves of *Iyocypris*, refer to the work conducted by Mazzini *et al.* (2014). It should also be noted that this genus belongs to the family Ilyocyprididae Kaufmann, 1900 and not to the family Cyprididae Baird, 1845, as attributed by Barros *et al.* (2022).

***Damonella grandiensis* Tomé *et al.*, 2014.** According to Barros *et al.* (2022), this species was represented by only 12 specimens. The carapace and the left valve shown in figures 4B–C, respectively, have length and height similar to those of the holotype (see Tomé *et al.*, 2014, tab. 5, p. 166). It should be noted right away that Tomé *et al.* (2014, p. 161) defined as holotype the carapace number DG-CTG-UFPE-1158, which would be a female, while the carapace number DG-CTG-UFPE-1157 would be a male. However, in the captions of figures 10 and 11, and in table 5, the authors made mistakes in indicating the female and male carapaces, making it difficult for the reader to identify males and females in the illustrations correctly. Moreover, it is surprising that although *D. grandiensis* was dominant in the material recovered by Tomé *et al.* (2014), reaching around 1300 well-preserved carapaces (see p. 163), the authors defined a very juvenile specimen as a holotype, with the illustrated paratype also being juvenile.

Guzmán *et al.* (2022) discussed mistakes made by Tomé *et al.* (2014) in the diagnosis and description of *Damonella grandiensis*. They also discussed the supposed sexual dimorphism present in this species. For Guzmán *et al.* (2022), paratypes number 1.175 to 1.184 of table 5 by Tomé *et al.* (2014) can be separated into two morphogroups, as follows: (i) the smallest, represented in drawings 1 to 5 as if they were females; and the (ii) larger ones, represented in drawings 6 to 10 as if they were males. Differences in outline and the position of the greatest height and width also occur between the two morphogroups.

For Guzmán *et al.* (2022), the differences between the two morphotypes of *Damonella grandiensis* would be related to ontogeny and not to sexual dimorphism as proposed by Tomé *et al.* (2014). However, we are not sure if this would be the correct proposal. Why? Because considering the holotype and the illustrated paratype (see Tomé *et al.*, 2014, figures 10A–F and 11A–M), we have the following: (i) both are very juvenile and with almost equal length; (ii) the central muscle scars of the holotype are different from those of the paratype; and (iii) the outline and positioning of the greatest height and width are different, as already recorded in the last paragraph.

Damonella grandiensis was proposed by Tomé *et al.* (2014) to formalize a species known only as Ostracode 207, which is an important index fossil. Tomé *et al.* (2014, figure 12A–F) compared the holotype with the specimen Ostracod 207 number SMF Xe-22592 from the Krömmelbein & Weber's collection, which was also recovered from the NE Brazil, deposited at the Research Institute of the Senckenberg Museum, located in Frankfurt am Main, Germany. These two specimens have practically the same length; however, some differences occur in lateral and dorsal views, but they may be due to preservation. Anyway, this must be further discussed in a review of the material studied by Tomé *et al.* (2014).

Tomé *et al.* (2022), in a new contribution to the study of ostracods from the Araripe Basin, removed the paratype number DGEO-CTG-UFPE-1157 from the species *Damonella grandiensis*, which was illustrated in figures 10D–F and 11G–M by Tomé *et al.* (2014). It is worth remembering that in the captions of figures 10D–F and 11G–M the paratype number DGEO-CTG-UFPE-1157 appears erroneously with the holotype number DGEO-CTG-UFPE-1158. Tomé *et al.* (2022, p. 543) present the following observation: *"Tomé et al. (2014) emphasize the sexual dimorphism of this species and describe the male form, however in the present study these forms are described as distinct species, mainly due to the different outlines, since both specimens are smooth"*. Additionally, Tomé *et al.* (2022, p. 543) state that the carapace number DGEO-CTG-UFPE-1513, which is illustrated in figures 3P–R, shows the same outline and posterodorsal and ventral overlapping of the *D. grandiensis* holotype (number DGEO-CTG-UFPE-1158). This is very strange, because both the outline in lateral view and in dorsal view of the carapace number DGEO-CTG-UFPE-1513 are very different from the holotype of *D. grandiensis*.

Finally, when checking the synonymy lists and the geographic and stratigraphic distribution of *Damonella grandiensis*, we also found many discrepancies between different authors. In fact, the "history" of this species is very complex and full of misconceptions. Only a detailed morphological and taxonomic review will reveal the Kafkaesque scenario in which *D. grandiensis* finds itself. This implies that we still do not have an identity for Ostracode 207, a species so crucial for the characterization of the *Harbinia* spp. 201/218 Biozone.

***Candonopsis alagoensis* Tomé *et al.*, 2014.** According to the original description of this species, the holotype (DG-CTG-UFPE number 1167) is 0.830 mm long, 0.498 mm height and 0.401 mm wide. However, considering that Tomé *et al.* (2014) measured and drew the outline of another ten specimens, obtaining lengths ranging from 0.754 mm to 0.936 mm, it is certain that the holotype does not represent an adult carapace.

In turn, the material by Barros *et al.* (2022), as indicated in the caption of figure 4D, is a juvenile measuring 0.582 mm in length and 0.360 mm in height. Although it presents outline differences when compared with the specimens studied by Tomé *et al.* (2014), it is believed that the material by Barros *et al.* (2022) is a much younger specimen of this taxon.

It is also worth mentioning the work by Guzman *et al.* (2022, figures 3A–C) on ostracods from the Santana Group, Araripe Basin, that identified a juvenile A-1 of this species and placed a question mark after the generic epithet. The authors discussed the attribution of this species to the genus

Candonopsis Vávra, 1891, and concluded that in further studies it should be assigned to a new genus. In the same remarks, some corrections were proposed regarding the stratigraphic distribution of the species.

?*Theriosynoecum colini* Do Carmo *et al.*, 2013. Although Barros *et al.* (2022, figure 4F) recovered only one poorly preserved specimen of this ostracod, they tentatively identified it as being conspecific with *T. colini*, a species described by Do Carmo *et al.* (2013) in the Alagamar Formation, Potiguar Basin, NE Brazil. However, even though the specimen from the Codó Formation has the same length as the adult male of *T. colini*, the morphological features of these two ostracods are quite different. In this scenario, it is surprising to see Barros' work report that the geographic and stratigraphic distribution of this left valve (identified in the Codó Formation) is identical to the distribution of *T. colini*, a species recorded in Brazil and Africa.

***Theriosynoecum silvai* (Silva, 1978a) emend. Do Carmo *et al.*, 2004.** The species in question was erected by Silva (1978a) and assigned to the genus *Bisulcocypris* Pinto & Sanguinetti, 1958. Later, Berthou *et al.* (1994) transferred it to the genus *Theriosynoecum* Branson, 1936. Since (i) the original description was made based only on the male, (ii) the sexual dimorphism in this species is very marked, and (iii) the drawings presented by Silva (1978a) were of poor quality, Do Carmo *et al.* (2004) redescribed this species and illustrated adults of both sexes together with juvenile stages. Considering that the material analyzed by Silva (1978a) was lost, Do Carmo *et al.* (2004) erected neotypes based on specimens collected in the type locality.

Regarding another species also originally proposed for the genus *Bisulcocypris* by Silva (1978a), *B. quadrinodosa*, Do Carmo *et al.* (2004) recorded it as a juvenile of *T. silvai*. However, this proposal was not accompanied by a discussion, which caused strangeness. Why? Because *Theriosynoecum silvai* and *T. quadrinodosa* are very different, not only in size but also in outline and ornamentation. Other works, such as Do Carmo *et al.* (2018) and Guzmán *et al.* (2022), follow this same synonymization, while the synonym list of *T. silvai* presented by Souza *et al.* (2017) does not include *T. quadrinodosa*.

A similar situation occurs with the third species of *Bisulcocypris* erected by Silva (1978a), *B. munizi*. Do Carmo *et al.* (2004, p. 155), wrote: "Theriosynoecum munizi *(Silva, 1978a) and* T. quadrinodosa *(Silva, 1978a), species proposed with material-type from the same type locality, are here considered as juvenile forms of* T. silvai." However, comparing specimen number MP-O-1802, illustrated by Do Carmo *et al.* (2004) as the A-3 of *T. silvai*, with the holotype illustrated by Silva (1978a), both of which have the same length, it appears that they must not belong to the same species. Furthermore, subsequent authors (*e.g.*, Souza *et al.*, 2017; Guzmán *et al.*, 2022), who assumed the synonymization performed by Do Carmo *et al.* (2004), also did not present any argument that would allow the reader to accept (or not) this proposal.

As if the problems discussed in the last paragraphs were not enough, when we compare the female specimens of *Theriosynoecum silvai* studied and illustrated by Do Carmo *et al.* (2004) with the illustrations present in subsequent works (*e.g.*, Syrio & Rios-Netto, 2002; Souza *et al.*, 2017; Guzmán *et al.*, 2022), it is verified that the specimens differ in outline, ornamentation, and size. Noteworthy is that any author presents no discussion. In this context, the work by Barros *et al.* (2022) is no exception, unfortunately. Therefore, what is happening is that ostracods from different species are being attributed to *T. silvai*, requiring a new morphological and taxonomic revision of the species, including the proposal of a revised synonymic list.

Finally, the geographic and stratigraphic distribution of *Theriosynoecum silvai* presented by Barros *et al.* (2022) is identical to what was proposed by Do Carmo *et al.* (2004). The authors appropriated conclusions that were obtained by Do Carmo *et al.* (2004), as follows: "*In Africa, considering the material figured by Colin and Depeche (1997), here considered as a junior synonym of* T. silvai*, the occurrences of this species are extended to the Bongor, Doba and Doseo basins, in strata that were tentatively attributed by those authors to Aptian-Albian.*" From the above it seems that Barros *et al.* (2022) proposed the material illustrated by Colin & Depeche (1997) as conspecific to *T. silvai*; however, this proposal is from Do Carmo *et al.* (2004).

***Aracajuia* sp. 1.** The presence of this ostracod in Barros' material is probably due to laboratory contamination. The figured right valve belongs to a recent male marine loxoconchid, which was first illustrated by Machado *et al.* (2020, figure 6C) as *Loxocorniculum* sp., occurring on the continental shelf of Northeastern Brazil (see Appendix 2 in Machado *et al.*, 2020). In turn, Luz & Coimbra (2022, figures 4:1–10), studying benthic ostracods from the Vitória-Trindade Chain, Southwestern Atlantic, erected and richly illustrated this species, naming it *Loxocorniculum micropapillosum*.

***Darwinula martinsi* Silva, 1978b emend. Do Carmo *et al.*, 2004.** The authors illustrated a juvenile that, following Do Carmo *et al.* (2004) proposal, would correspond to ontogenetic stage A-3. However, the fossil in figure 4J is poorly preserved, not allowing a secure identification. Notably, the species under discussion has been changed to the genus *Alicenula*, at least since Tomé *et al.* (2014).

With regard to geographic and stratigraphic distribution, the text presented by Barros *et al.* (2022) is not only outdated, but also quite similar to Do Carmo *et al.* (2004, p. 156). By comparison, see the distribution of *Alicenula martinsi* proposed by Guzmán *et al.* (2022, p. 22). In this scenario, it should be noted that comparing the illustrations by Do Carmo *et al.* (2004, figures 3:21–27) and Guzmán *et al.* (2022, figures 13:S–U), it is evident that the Guzmán specimens are significantly more elongated. Does this difference mean intraspecific variation, or does *A. martinsi* need a taxonomic revision? This is an important question that goes beyond this work's scope.

Ostracod indet. sp. 1. Considering the poor state of conservation and what remains of the morphology of the specimens photographed by Barros *et al.* (2022, figures 4:K–M), it is surprising that the authors considered all to be adults of the same species, which was informally identified as Ostracode indet. sp. 1. Besides, contrary to expectations, there is no discussion of how the authors arrived at this conclusion.

Ostracod indet. sp. 2. In Ostracode indet. sp. 2, the authors also grouped specimens (see figures 4:N–O) with different outlines and dimensions, both being considered adults. In addition, according to the legend, they would be two right valves, which if true would make them even more distinct from each other. Once again, it is not clear how they arrived at this taxonomic proposal.

On the ostracod taxonomy by Ramos *et al.* (2006)

In that work the authors identified *Candona* sp., *Harbinia micropapillosa* (Bate), *Harbinia angulata* (Krömmelbein & Weber), *Harbinia sinuata* (Krömmelbein & Weber), *Harbinia* sp. aff. *H. symmetrica* (Krömmelbein & Weber), *Harbinia salitrensis* (Krömmelbein & Weber), and *Harbinia* sp. The illustrations of the material assigned to the genus *Harbinia* are indicated in the work as being juvenile forms, except for two photos of *H. micropapillosa*. However, according to Smith (2000), in a detailed study on the morphology and ontogeny of this species, which he classified under the genus *Pattersoncypris* Bate, 1972, the adult length ranges from 1.122 mm to 1.244 mm, while the height ranges from 0.756 mm to 0.842 mm. Therefore, the material considered an adult by Ramos *et al.* (2006) should be A-1 and not the adult stage. In fact, the outline of the carapaces illustrated by Ramos *et al.* (2006) in lateral view is very similar to the outline of stage A-1 presented by Smith (2000).

Antonietto *et al.* (2012) included the specimens of *Harbinia angulata* depicted by Ramos *et al.* (2006, figures 4:E–H) in the synonymic list of the new species *Harbinia alta*, a proposal followed by Guzmán *et al.* (2022). In turn, the ostracods identified as *Harbinia* sp. aff. *H. symmetrica* by Ramos *et al.* (2006, figures 4:M–P) probably do not belong to this species, as already proposed by Guzmán *et al.* (2022).

The specimens of *Candona* sp. illustrated by Ramos *et al.* (2006, figure 4:Z–Z") were assigned to *Damonella grandiensis* by Tomé *et al.* (2014), a suggestion followed by Guzmán *et al.* (2022). However, as discussed in the topic above, where we dealt with *D. grandiensis*, the proposal of this species by Tomé *et al.* (2014) has inconsistencies and requires revision, as previously noted by Guzmán *et al.* (2022). In this context, we understand that the material illustrated by Ramos *et al.* (2006) may not be compatible with the species informally known at the time as Ostracode 207, although it is listed as a synonym of *Candona* sp.

Bioevents based on the Codó Formation ostracods

Ecostratigraphy, a stratigraphy based on bioevents, uses methods to identify short-term changes – on a geological scale – in the composition of fossil communities. Such events become significant for stratigraphy if they can be recognized regionally, supraregionally, or even globally, facilitating stratigraphic correlation. Due to the nature of the event, the record left in the rock may correspond to a time span of a few thousand or several million years. As discussed in the studies of Boucot (1982, 2005), ecostratigraphy is understood as an integrative analysis associated with accurate biostratigraphy. Each layer must be seen under its lithological, taphonomic, and paleoecological aspects in the search for the identification of events with potential for stratigraphic correlation.

The works by Olóriz *et al.* (1993, 2012) offer a fruitful discussion of ecostratigraphy as an efficient tool to characterize and correlate system tracts. The integration of sequence stratigraphy and ecostratigraphic analysis facilitates the identification of bioevents within the scope of "High-Resolution Event Stratigraphy - HiRES" (see Kaufmann, 1988), grouping all stratigraphic data carefully to accurately find out within each section all event-stratigraphic units and surfaces. According to Kauffman (1988, p. 610), "*Each surface or unit so documented is regarded as a hypothetical isochronous deposit for short-term events to be tested by correlation (standard or graphical techniques) with various other sections*". For a critical review of the application of HiRES in basin analysis, together with a discussion on the precision and quantification of uncertainties in the process of deciphering the stratigraphic record, the work of Cramer *et al.* (2015) is recommended.

Within this frame of reference, it is important to discuss the following excerpt from Barros *et al.* (2022): "*Analysing the distribution of ostracod species for the studied well (Figs. 5,7), it was possible to identify bioevents based not only on first and last occurrences of the identified taxa, but also on changes in abundance and diversity of the ostracod fauna*" (p. 8). They applied some classic statistical analysis looking for bioevents into the *Harbinia* spp. 201/218 Biozone, which probably encompasses the interval studied by them. Notably, the core preservation was precarious, not allowing a systematic sampling. Consequently, only 24 samples were recovered along a profile of 105.50 m in length, three of which did not have their microfossils identified. Why? Because in these three samples "*no recovered specimens could be classified due to the bad preservation*" (p. 4). In fact, according to the authors, merely 38% of the total recovered ostracods were identified at the genus and/or species level, being the only ones used in the statistical analyses. The number of specimens per species was low, with the most abundant species, *Harbinia micropapillosa*, having only 146 specimens, which contrasts with other occurrences of this species, always much more numerous (*e.g.*, Ramos *et al.*, 2006 recorded about 200 specimens in only two samples also collected at Codó Fm.). *Harbinia salitrensis* (107 specimens) and *H. symmetrica* (88 specimens) were the other two most abundant species. The other figured species computed from 1 to a maximum of 28 specimens each. To conclude this paragraph, it is necessary to highlight the methodology used by the authors for the statistical analysis, as follows: "*In case of samples containing less than 300 specimens, the whole samples were picked;*

those which displayed high abundance were splitted until a fraction containing approximately that amount, and the abundance values were normatized taking that fraction into account. Carapaces, valves (including juveniles) and molds were counted as one specimen each" (p. 3).

Given what was said above, added the numerous misidentifications of only 38% of the ostracods analyzed and the occurrence of most carapaces/valves (or molds?) that were not studied (= 62% of recovered ostracods), the fossil material and the methodology do not corroborate the bioevents proposed by Barros *et al.* (2022). Thus, it is surprising that the authors stated (p. 13, "Interpretation and discussion") the following: "*The alteration mechanisms identified in this study do not seem to have modified the original composition of the assemblages*"; remembering, also, that in the "Results" (p. 4) they informed: "*Sometimes taxonomic identifications were limited to the generic level, or even to the family level, as is the case of the internal molds corresponding to specimens included in the families Cyprididae, Candonidae, Limnocytheridae, Darwinulidae and Cytheridae.*"

Returning to the first paragraph of "Interpretation and discussion" (p. 13), they also wrote: "*The abundance of closed carapaces in some assemblages also indicates limited transportation, a soft substratum and a relatively high rate of sedimentation (Oertli, 1971; Boomer et al., 2003), although disarticulated shells were also obtained in the studied samples. Cabral and Colin (1998) and Boomer et al. (2003) interpreted the dominance of closed carapaces in the non-marine Aptian ostracods of Portugal as taphonomic marker of an in-situ fauna, being a good indicator of environmental conditions in which the ostracods lived.*" These assertions are contrary, at least in part, to what was stated in the first paragraph of the "Results" (p. 4), as follows: "*Most assemblages were characterized by a high proportion of disarticulated valves and juvenile specimens.*" It should also be noted that Boomer *et al.* (2003) did not study Aptian ostracods from Portugal but presented an overview of ostracod applications for marine and non-marine ecosystems, as well as a case study on the Quaternary ostracods from the Aral Sea, Central Asia. In turn, Cabral & Colin (1998) presented a work whose objective was the description of two new Aptian species of ostracods, one from a mesohaline environment and the other from freshwater to oligohaline. Of the mesohaline species, the authors recovered more than 700 well-preserved carapaces and very few valves, which made them suggest an *in situ* fossilization.

Finally, although the search for synchronous bioevents that allow the refinement of the *Harbinia* spp. 201/218 Biozone for stratigraphic correlation purposes is praiseworthy, the results presented by Barros *et al.* (2022) do not contribute to this subject, unfortunately. The main mistakes present in the work are the following: (i) the ostracod fauna studied by them, in addition to being restricted to only 38% of the recovered specimens, is predominantly made up of very poorly preserved microfossils; and (ii) the taxonomic study proved to be unreliable due to numerous misidentifications made by the authors. These facts triggered the other problems of this work, whether related to paleoenvironmental proposals or chronostratigraphic markers.

FINAL REMARKS

A suitable taxonomic identification underpins the establishment of chronological frameworks, the disclosure of paleoecological scenarios, the resolution of taxonomic uncertainties, and the discovery of evolutionary and paleobiogeographical patterns. Through meticulous observation, interdisciplinary collaboration, and the application of various analytical techniques, researchers can unravel the secrets preserved in fossil ostracods, making them powerful tools for understanding the evolution of sedimentary basins. Taxonomy, a discipline that serves as a prerequisite for all other research in the field of zoology, is therefore equally crucial in the study of fossil ostracods and their applications to the geosciences.

Concerning ostracods, Lord (2020) brings us an interesting discussion on the definition of species in fossil ostracods, especially those with smooth or poorly ornamented carapaces, as is the case of most species of the Codó Formation. Lord exemplified this matter mainly using the fossil genera *Bairdiacypris* Bradfield, 1935 and *Fabalicypris* Cooper, 1946, which are morphologically similar. Authors have assigned species to these genera without a morphological and taxonomic discussion, raising problems in paleontological systematics and, consequently, in its application to stratigraphy and reconstruction of evolutionary processes through time. Reading Lord's work (2020), it is noted that with regard to fossil material, there are relatively numerous cases similar to these, unfortunately. The author stresses that in addition to a detailed morphological study based on good images of different views of carapaces and valves, paleontologists should also consider the geological distribution to define fossil ostracod species consistently.

Bringing this discussion to the scope of this work, the pioneering study on ostracods from the Codó Formation, coordinated by ostracodologist Maria Inês Feijó Ramos, was a milestone in the knowledge of the taxonomy and paleoenvironmental application of these microfossils in the Cretaceous of the Parnaíba Basin. Different opinions regarding the determination of two species in no way detract from the quality of the work by Ramos *et al.* (2006). It should be noted that at the time, the taxonomy of Aptian/Albian ostracods from the Brazilian basins was poorly known.

On the other hand, the work carried out by Barros *et al.* (2022), whose main objective was the application of the Codó Formation ostracods to biostratigraphy, correlation, and paleoecology, including the proposal of potential chronostratigraphic markers, is weakened mainly as a result of the numerous incorrect taxonomic identifications. They admit that the core and the microfossils were poorly preserved, with ostracods represented mainly by juveniles and molds, causing only 38% of the recovered material to be analyzed, with most taxa represented by very few specimens. Given this, it is surprising that despite abundant taphonomic biases, they have refrained from presenting a meaningful discussion for the specific assignments. Contamination of the samples is also evident by the presence of an extant species of the marine genus *Loxocorniculum* misidentified as belonging to the Cretaceous genus *Aracajuia*.

Finally, although it is understood that the refinement of *Harninia* spp. 201/218 Biozone is a prerequisite for understanding the evolution of the Aptian section of many Brazilian basins, it can only be achieved with a robust taxonomic framework. In this scenario, as shown in the present work, even the identification of frequently abundant species in this biozone, such as *Harbinia micropapillosa*, *H. symmetrica*, *Damonella grandiensis* and *Candonopsis alagoensis*, has not reached a consensus in the literature. Although the recent study by Guzman *et al.* (2022) made significant progress in this regard, our analysis reveals crucial questions that are still unanswered.

ACKNOWLEDGMENTS

The authors are indebted to C.T. Bergue and M. Arai for their suggestions that improved the quality of the manuscript. The editors are thanked for their comments and recommendations. The senior author is grateful to the National Council for Scientific and Technological Development (CNPq) for grant 309394/2021-0.

REFERENCES

Almeida, F.F.M. & Carneiro, C.D.R. 2004. Inundações marinhas fanerozóicas no Brasil e recursos minerais associados. *In*: V. Mantesso-Neto; A. Bartorelli; C.D.R. Carneiro & B.B. Brito-Neves (orgs.) *Geologia do continente sul-americano: evolução da obra de Fernando Flávio Marques de Almeida*, Beca, p. 43–58.

Antonietto, L.S.; Do Carmo, D.A.; Viviers, M.C.; Neto, J.V.Q. & Hunt, G. 2016. Ostracoda (Arthropoda, Crustacea) from the Riachuelo formation, Sergipe-Alagoas Basin, Brazil, Upper Aptian-Albian. *European Journal of Taxonomy*, **244**:1–57. *doi:10.5852/ejt.2016.244*

Antonietto, L.S.; Gobbo, S.R.; Do Carmo, D.A.; Assine, L.M.; Castanheira, M.A.M. & Silva, J.E.L. 2012. Taxonomy, ontogeny and paleoecology of two species of *Harbinia* Tsao, 1959 (Crustacea, Ostracoda) from the Santana formation, Lower Cretaceous, Northeastern Brazil. *Journal of Paleontology*, **86**:659–668. *doi:10.1666/11-012R.1*

Antonioli, L. & Arai, M. 2002. O Registro da Ecozona Subtilisphaera na Formação Codó (Cretáceo Inferior da Bacia do Parnaíba, Nordeste do Brasil): seu Significado Paleogeográfico. *In*: SIMPÓSIO SOBRE O CRETÁCEO DO BRASIL, 6, 2002. *Boletim*, São Pedro – SP, p. 1–6.

Arai, M. 2014. Aptian/Albian (Early Cretaceous) paleogeography of the South Atlantic: a paleontological perspective. *Brazilian Journal of Geology*, **44**:339–350. *doi:10.5327/Z2317-4889201400020012*

Arai, M. & Assine, M.L. 2020. Chronostratigraphic constraints and paleoenviron-mental interpretation of the Romualdo Formation (Santana Group, Araripe Basin, Northeastern Brazil) based on palynology. *Cretaceous Research*, **116**:104610. *doi:10.1016/j.cretres.2020.10461*

Araripe, R.C.; Lemos, F.A.P.; Prado, L.A.C.; Tomé, M.E.T.R.; Oliveira, D.H.; Pereira, P.A.; Nascimento, L.R.; Asakura, Y.; Ng, C.; Viviers, M.C. & Barreto, A.F. 2022. Upper Aptian–lower Albian of the southern-central Araripe Basin, Brazil: Microbios-tratigraphic and paleoecological inferences. *Journal of South American Earth Sciences*, **116**:103814. *doi:10.1016/j.jsames.2022.10381*

Araripe, R.C.; Oliveira, D.H.; Tomé, M.E.; Mello, R.M. & Barreto, A.M.F. 2021. Foraminifera and Ostracoda from the Lower Cretaceous (Aptian–lower Albian) Romualdo Formation, Araripe Basin, northeast Brazil: Paleoenvironmental inferences. *Cretaceous Research*, **122**:104766. *doi:10.1016/j.cretres.2021.104766*

Bahniuk, A.M.; Anjos, S.; França, A.B.; Matsuda, N.; Eiler, J.; Mckenzie, J.A. & Vasconcelos, C. 2015. Development of Microbial Carbonates in the Lower Cretaceous Codó Formation (north-east Brazil): implications for interpretation of microbialite facies associations and palaeoenvironmental conditions. *Sedimentology*, **62**:155–181. *doi:10.1111/sed.12144*

Barros, C.L.; Silva, S.C.; Machado, L.L.; Rios Netto, A.M.; Sames, B.; Alves, T.D. & Silva Júnior, R.P. 2022. Non-marine ostracods of the Codó Formation (upper Aptian, Lower Cretaceous), Parnaíba Basin, NE Brazil: new biostratigraphic and paleoecological insights. *Cretaceous Research*, **133**:105125. *doi:10.1016/j.cretres.2021.105125*

Bastos, L.P.H.; Jagniecki, E.A.; Holanda dos Santos, W.; da Cavalcante, D.C.; Jorge de Menezes, C.; Alferes, C.L.F.; da Silva, D.B.N.; Bergamaschi, S.; Rodrigues, R. & Pereira, E. 2022. Organic geochemical evidence for the transition of Aptian-Albian hypersaline environments into marine restricted seas: The South Atlantic oceanic northern gateway and its implications for the pre-salt deposits. *Marine and Petroleum Geology*, **140**:105632. *doi:10.1016/j.marpetgeo.2022.105632*

Bastos, L.P.H.; Pereira, E.; Cavalcante, D.D.C. & Rodrigues, R. 2014: Estratigrafia química aplicada à Formação Codó nos furos de sondagem UN-24-PI e UN-37-PI, Aptiano/Albiano da Bacia do Parnaíba. *Boletim de Geociências da Petrobras*, **22**:289–312.

Bate, R.H. 1972. Phosphatized ostracods with appendages from the Lower Cretaceous of Brazil. *Palaeontology*, **15**:379–393. *doi:10.1038/230397a0*

Bate, R.H.; Horne, D.J.; Horne, S.E.; Douglas, L.; Miller, C.G. & Lord, A.R. 2022. Non-marine Ostracoda (Crustacea) of the Early Cretaceous 'Pre-Salt' sediments of Brazil: an illustrated catalogue of the type specimens of Wicher, Krömmelbein, Krömmelbein & Weber, and Bate. *Zootaxa*, **5098**:1–84. *doi:10.11646/zootaxa.5098.1.1*

Berthou, P.Y.; Dépêche, F.; Colin, J.P.; Filgueira, J.B. de M. & Teles, M. do S.L. 1994. New data on the ostracods from the Crato lithologic units (lower member of the Santana Formation, latest Aptian–lower Albian) of the Araripe Basin (Northeastern Brazil). *Acta Geologica Leopoldensia*, **XVII**:539–554.

Bobco, F.E.R.; Trombetta, M.C.; Ferreira, L.O.; Silveira, L.F.; Kroth, M.; Mendonça, J.O.; Mendonça Filho, J.G.; Sedorko, D.; Araújo, B.C. & Borghi, L. 2023. Alternations of open and closed lakes in the Lower Aptian Codó Formation (Parnaíba Basin, Brazil). *Sedimentary Geology*, **455**:106478. *doi10.1016/j.sedgeo.2023.106478*

Boomer, I.; Horne, D.J. & Slipper, I.J. 2003. The use of ostracods in palaeoenvironmental studies, or what can you do with an ostracod shell? *Paleontological Society Papers*, **9**:153–180. *doi:10.1017/S1089332600002199*

Boucot, A.J. 1982 Ecostratigraphic framework for the Lower Devonian of the North American Appo himchi Subprovince. *Neues Jahrbuch für Geologie und Paläontologie*, **163**:81–121.

Boucot, A.J. 2005. Ecostratigraphy's Basis, using Silurian and Devonian Examples, with Consideration of the Biogeographic Complication. *In*: E.A.M. Koutsoukos (ed.) *Applied Stratigraphy*, Springer, p. 55–71.

Cabral, M.C. & Colin, J.P. 1998. Nouvelles espèces de Limnocytheridae (ostracodes limniques) dans l'Aptien du Portugal: systématique et paléoécologie. *Revue de Micropaléontologie*, **41**:269–279.

Coimbra, J.C. 2020. The genus *Cypridea* (Crustacea, Ostracoda) and the age of the Quiricó Formation, SE Brazil: a critical review. *Revista Brasileira de Paleontologia*, **23**:90–96. *doi:10.4072/rbp.2020.2.02*

Coimbra, J.C.; Arai, M. & Carreño, A.L. 2002. Biostratigraphy of Lower Cretaceous microfossils from the Araripe Basin, northeastern Brazil. *Geobios*, **35**:687–698. *doi:10.1016/s0016-6995(02)00082-7*

Coimbra, J.C. & Freire, T.M. 2021. Age of the Post-rift Sequence I from the Araripe Basin, Lower Cretaceous, NE Brazil: implications for spatio-temporal correlation. *Revista Brasileira de Paleontologia*, **24**:37–46. *doi:10.4072/rbp.2021.1.03*

Colin, J.P. & Depèche, F. 1997. Faunes d'ostracodes lacustres des bassins intra-cratoniques d'âge Albo-Aptian en Afrique de l'Ouest (Cameroun, Tchad) et au Brésil: considérations d'ordre paléoécologiques et paléobiogéographiques. *African Geoscience Review*, **4**:431–450.

Cramer, B.D.; Vandenbroucke, T.R.A. & Ludvigson, G.A. 2015. High-Resolution Event Stratigraphy (HiRES) and the quantification of stratigraphic uncertainty: Silurian examples of the quest for precision in stratigraphy. *Earth-Science Review*, **151**:136–153. *doi:10.1016/j.earscirev.2014.11.011*

Do Carmo, D.A.; Coimbra, J.C.; Whatley, R.C.; Antonietto, L.S. & Citon, R.T.P. 2013. Taxonomy of limnic Ostracoda (Crustacea) from the Alagamar Formation, Middle–Upper Aptian, Potiguar Basin, Northeastern Brazil. *Journal of Paleontology*, **87**:91–104. *doi:10.1666/11-108R.1*

Do Carmo, D.A.; Rafael, R.M.L.; Vilhena, R.M. & Tomassi, H.Z. 2004. Redescrição de *Theriosynoecum silvai* e *Darwinula martinsi*, Membro Crato (Formação Santana), Cretáceo Inferior, bacia do Araripe, NE, Brasil. *Revista Brasileira de Paleontologia*, **7**:151–158.

Do Carmo, D.A.; Spigolon, A.L.D.; Guimarães, E.M.; Richter, M.; Mendonça-Filho, J.G.; Dangpeng, X.; Caixeta, G.M. & Leite, A.M. 2018. Palaeoenvironmental assessment of Early Cretaceous limnic ostracods from the Alagamar Formation, Potiguar Basin, NE Brazil. *Cretaceous Research*, **85**:266e279. *doi:10.1016/j.cretres.2018.01.009*

Do Carmo, D.A.; Whatley, R.; Queiroz Neto, J.V. & Coimbra, J.C. 2008. On the validity of two Lower Cretaceous nonmarine ostracode genera: biostratigraphic and paleogeographic implications. *Journal of Paleontology*, **82**:790–799. *doi:10.1666/07-008.1*

Fauth, G. *et al.* 2023. Early Aptian marine incursions in the interior of northeastern Brazil following the Gondwana breakup. *Scientific Reports*, **13**:6728. *doi:10.1038/s41598-023-32967-w*

Góes, A.M.O. & Feijó, F.J. 1994. Bacia do Parnaíba. *Boletim de Geociências da Petrobras*, **8**:57–68.

Góes, A.M. & Rossetti, D.F. 2001. Gênese da Bacia de São Luís-Grajaú, Meio-Norte do Brasil. *In*: D.F. Rossetti; A.M. Góes & W. Truckenbrodt (eds.) *O Cretáceo na Bacia de São Luís-Grajaú*, Museu Paranaense Emílio Goeldi, p. 15–29.

Guzmán, J.; Piovesan, E.K.; Almeida-Lima, D.S.; Sousa, A.J. & Neumann,V.H.M.L. 2022. Aptian ostracods from the Santana Group, Araripe Basin, Brazil. *Revue de Micropaléontologie*, **77**:100694. *doi:10.1016/j.revmic.2022.100694*

Guzmán, J.; Piovesan, E.K.; Melo, R.M.; Almeida-Lima, D.S.; Sousa, A.J. & Neumann, V.H.M.L. 2023. Ostracoda and Foraminifera biostratigraphy and palaeoenvironmental evolution of the Aptian Santana Group, post-rift of the Araripe Basin, Brazil. *Gondwana Research*, **124**:18–38. *doi:10.1016/j.gr.2023.06.014*

Kauffman, E.G. 1988. Concepts and methods of high-resolution event stratigraphy. *Annual Review of Earth and Planetary Sciences*, **16**:605–654. *doi:10.1146/annurev.ea.16.050188.003133*

Krömmelbein, K. & Weber, R. 1971. Ostracoden des Nordostbrasilianischen Wealden. *Beihefte zum Geologischen Jahrbuch*, **115**:3–93.

Leite, A.M. 2017. *Ostracodes da Formação Quiricó, Cretáceo inferior, Bacia do São Francisco, estado de Minas Gerais, região Sudeste do Brasil.* Programa de Pós-graduação em Geologia, Universidade de Brasília, M.Sc. thesis, 98 p.

Leite, A.M.; Do Carmo, D.A.; Ress, C.B.; Pessoa, M.; Caixeta, G.M.; Denezine, M.; Adorno, R.R. & Antonietto, L.S. 2018. Taxonomy of limnic Ostracoda (Crustacea) from the Quiricó Formation, Lower Cretaceous, São Francisco Basin, Minas Gerais State, Southeast Brazil. *Journal of Paleontology*, **92**:661–680. *doi:10.1017/jpa.2018.1*

Lindoso R.M; Maisey, J.G. & Carvalho, I.S. 2016. Ichthyofauna from the Codó Formation, Lower Cretaceous (Aptian, Parnaíba Basin), Northeastern Brazil and their paleobiogeographical and paleoecological significance. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **447**:53–64. *doi:10.1016/j.palaeo.2016.01.045*

Lord, A. 2020. Towards objectivity in Ostracoda species definition. *BSGF-Earth Sciences Bulletin*, **191**:27. *doi:10.1051/bsgf/2020029*

Luz, N.C. & Coimbra, J.C. 2022. Ostracods (Crustacea: Ostracoda) of the Vitoria-Trindade Chain, Southwestern Atlantic. *Zootaxa*, **5188**:301–329. *doi:10.11646/zootaxa.5188.4.1*

Machado, C.P.; Coimbra J.C. & Bergue, C.T. 2020. Provinciality of Ostracoda (Crustacea) in the Northeastern and Eastern Brazilian shelves based on neontological and paleontological analyses. *Revista Brasileira de Paleontologia*, **23**:3–31. *doi:10.4072/rbp.2020.1.01*

Maizatto, J.R.; Neto, J.V.Q.; Ferreira, E.P. & Bahniuk, A. 2011. Palinomorfos e ostracodes não-marinhos de afloramentos da Formação Codó, Bacia do Parnaíba. *In*: I.S. Carvalho; N.K. Srivasatava; O.S. Strohschoen Jr. & C.C. Lana (eds.) *Paleontologia: Cenários de Vida*, Interciência, p. 367–377.

Mazzini, I.; Gliozzi, E.; Rossetti, G. & Pieri, V. 2014. The *Ilyocypris* puzzle: A multidisciplinary approach to the study of phenotypic variability. *International Review of Hydrobiology*, **99**:395–408. *doi:10.1002/iroh.201301729*

Melo, R.M.; Guzmán, J.; Almeida-Lima, D.; Piovesan, E.K.; Neumann, V.H.M.L. & Sousa, A.J. 2020. New marine data and age accuracy of the Romualdo Formation, Araripe Basin, Brazil. *Scientific Reports*, **10**:15779. *doi:10.1038/s41598-020-72789-8*

Merton, R.K. 1973. *The Sociology of science. Theoretical and empirical investigations.* Chicago, University of Chicago Press, 638 p.

Moura, J.A. 1987. Biocronoestratigrafia da sequência não marinha do Cretáceo Inferior da Bacia de Campos, Brasil: ostracodes. *In*: CONGRESSO BRASIL DE PALEONTOLOGIA, 10, 1987. *Anais*, Rio de Janeiro, p. 716–731.

Moura, J.A. 1988. Ostracods from Non-marine Early Cretaceous Sediments of the Campos Basin, Brazil. *Developments in Palaeontology and Stratigraphy*, **11**:1207–1216.

Neale, J.W. 1984. The Ostracoda and uniformitarianism. II. The earlier record: Cretaceous to Cambrian. *Proceedings of the Yorkshire Geological Society*, **44**:443–478.

Oertli, H.J. 1971. The aspect of ostracode faunas – A possible new tool in petroleum sedimentology. *Bulletin du Centre de Recherches de Pau-SNPA*, **5**:137–151.

Olóriz, F.; Reolid, M. & Rodriguez-Tovar, F.J. 2012. Palaeogeography and relative sea-level history forcing eco-sedimentary contexts in Late Jurassic epicontinental shelves (Prebetic Zone, Betic Cordillera): an ecostratigraphic approach. *Earth-Science Reviews*, **111**:154–178. *doi:10.1016/j.earscirev.2011.11.004*

Olóriz, F.; Rodriguez-Tovar, F.J.; Marques, B. & Caracuel, J.E. 1993. Ecostratigraphy and sequence stratigraphy in high frequency sea level fluctuations: examples from Jurassic macroinvertebrate assemblages. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **101**:131–145. *doi:10.1016/0031-0182(93)90156-D*

Paz, J.D.S. & Rossetti, D.F. 2001. Reconstrução paleoambiental da Formação Codó (Aptiano), borda leste da Bacia do Grajaú, MA. *In*: D.F. Rossetti; A.M. Góes & W. Truckenbrodt (eds.) *O Cretáceo na bacia de São Luís-Grajaú*, Museu Paraense Emílio Goeldi, p. 77–100.

Paz, J.D.S. & Rossetti, D.F. 2005. Linking lacustrine cycles with syn-sedimentary tectonic episodes: an example from the Codó Formation (late Aptian), northeastern Brazil. *Geology Magazine*, **142**:269–285. *doi:10.1017/S0016756805000488*

Paz, J.D.S.; Rossetti, D.F. & Macambira, M. 2005. An Upper Aptian saline pan/lake system from the Brazilian equatorial margin: Integration of facies and isotopes. *Sedimentology*, **52**:1303–1321. *doi:10.1111/j.1365-3091.2005.00744.x*

Piovesan, E.K.; Nicolaidis, D.D.; Fauth, G. & Viviers, M.C. 2013. Ostracodes from the Aptian-Santonian of the Santos, Campos and Espírito Santo basins, Brazil. *Journal of South American Earth Sciences*, **48**:240–254. *doi:10.1016/j.jsames.2013.09.012.*

Ponte, F.C. & Ponte Filho, F.C. 1996. Evolução tectônica e classificação da Bacia do Araripe. *In*: SIMPÓSIO SOBRE O CRETÁCEO DO BRASIL, 4, 1996. *Boletim*, Águas de São Pedro, UNESP, p. 123–133.

Poropat, S.F. & Colin, J.P. 2012 Early Cretaceous ostracod biostratigraphy of eastern Brazil and western Africa: an overview. *Gondwana Research*, **22**:772–798. *doi:10.1016/j.gr.2012.06.002*

Ramos, M.I.F.; Rossetti, D.F. & Paz, J.D.S. 2006. Caracterização e significado Paleoambiental da fauna de ostracods da Formação Codó (Neoaptiano), Leste da Bacia de Grajaú, MA, Brasil. *Revista Brasileira de Paleontologia*, **9**:339–348. *doi:10.4072/rbp.2006.3.09*

Regali, M.S.P. 1990. Biocronoestratigrafia e paleoambiente do Eocretáceo das bacias do Araripe (CE) e Rio do Peixe (PB), NE Brazil. *In*: SIMPÓSIO SOBRE A BACIA DO ARARIPE E BACIAS INTERIORES DO NORDESTE, I, 1990. *Anais*, Crato, DNPM, p. 163–172.

Rossetti, D.F. & Góes, A.M. 2000. Deciphering the sedimentological imprint of paleoseismic events: an example from the Aptian Codó Formation, northern Brazil. *Sedimentary Geology*, **135**:137–156. *doi:10.1016/S0037-0738(00)00068-3*

Rossetti, D.F.; Góes, A.M. & Arai, M. 2001. A passagem Aptiano-Albiano na Bacia do Grajaú, MA. *In*: D.F. Rossetti; A.M. Góes & W. Truckenbrodt. (eds.) *O Cretáceo na Bacia de São Luís-Grajaú*, Museu Paraense Emilio Goeldi, p. 101–117.

Schaller, H. 1969. Revisão estratigráfica da Bacia de Sergipe/Alagoas. *Boletim Técnico da Petrobras*, **12**:21–86.

Silva, D.M. 1978a. Ostracodes da Formação Santana (Cretáceo Inferior) e Grupo Araripe. Nordeste do Brasil I: novas espécies do gênero *Bisulcocypris*. *In*: CONGRESSO BRASILEIRO DE GEOLOGIA, 30, 1978. *Anais*, Recife, SBG, p. 1014–1022.

Silva, D.M. 1978b. Ostracodes da Formação Santana (Cretáceo Inferior) e Grupo Araripe. Nordeste do Brasil III: Nova espécie do gênero *Darwinula* Brady, Robertson 1985. *In*: CONGRESSO BRASILEIRO DE GEOLOGIA, 30, 1978. *Anais*, Recife, SBG, p. 1028–1031.

Silva-Telles Jr., A.C. & Viana, M.S.S. 1990. Paleoecologia dos ostracodes da Formação Santana (Bacia do Araripe): um estudo ontogenético de populações ([Ostracoda paleoecology of the Santana Formation (Aptian–Albian), Araripe Basin: an ontogenetic study of populations]). *In*: SIMPÓSIO SOBRE A BACIA DO ARARIPE E BACIAS INTERIORES DO NORDESTE, I, 1990. *Atas*, Crato, DNPM, p. 309–327.

Smith, R.J. 2000. Morphology and ontogeny of Cretaceous ostracods with preserved appendages from Brazil. *Palaeontology*, **43**:63–98. *doi:10.1111/1475-4983.00119*

Sousa, C.S.; Klein, E.L.; Vasquez, M.L.; Lopes, E.C.S.; Teixeira, S.G.; Oliveira, J.K.M.; Moura, E.M. & Leão, M.H.B. 2012. Mapa Geológico e Recursos Minerais do Estado do Maranhão. *In*: E.L. Klein & C.S. Sousa (orgs.) *Geologia e Recursos Minerais do Estado do Maranhão: Sistema de Informações Geográficas – SIG, Escala 1:750.000*, Belém, CPRM.

Sousa, E. da S.; Sousa Júnior, G.R.; Silva, A.F.; Reis, F. de A.M.; Sousa, A.A.C. de; Cioccari, C.M.; Capilla, R.; Souza, I.V.A.F.; Imamura, P.M.; Rodrigues, R.; Lopes, J.A.D. & Lima, S.G. 2019. Biomarkers in Cretaceous sedimentary rocks from the Codó Formation - Parnaíba Basin: Paleoenvironmental assessment. *Journal of South American Earth Sciences*, **92**:265–281. *doi:/10.1016/j.jsames.2019.03.025*

Souza, D.M.; Piovesan, E.K. & Neumann, V.H.M.L. 2017. Ostracodes do Aptiano-Albiano da Bacia do Araripe: implicações paleoambientais e bioestratigráficas. *Estudos Geológicos*, **27**:3–18.

Syrio, V.N. & Rios-Netto, A.M. 2002. Ostracodes from the Rio da Batateira Formation (Lower Cretaceous, Araripe Basin): preliminary results on systematics, biostratigraphy and paleoecology. *Anais da Academia Brasileira de Ciências*, **74**:369.

Teixeira, M.C.; Mendonça Filho, J.G.; de Oliveira, A.D. & Assine, M.L. 2017. Faciologia orgânica da Formação Romualdo (Grupo Santana, Cretáceo Inferior da Bacia do Araripe): caracterização da matéria orgânica sedimentar e interpretação paleoambiental. *Geologia USP*, **17**:19–44. *doi:10.11606/issn.2316-9095.v17-347*

Tomé, M.E.; Araripe, R.; Oliveira, D.; Barreto, A.; Prado, L.; Pedrosa, F.; Pereira, P.; Nascimento, L.R. & Ng., C. 2022. Early Cretaceous Ostracoda (Crustacea) from south-central Araripe Basin, Brazil, with descriptions of seven new species. *Zootaxa*, **5159**:535–557. *doi:10.11646/zootaxa.5159.4.4*

Tomé, M.E.R. & Lima Filho, M.F. 2010. Ostracodes da Bacia de Cedro, Andar Alagoas, Estado de Pernambuco, NE, Brasil: Implicações Paleoambientais e Bioestratigráficas. *Estudos Geológicos*, **20**:49–63.

Tomé, M.E.T.R., Lima Filho, M.F. & Neumann, V.H.M.L. 2014. Taxonomic studies of non-marine ostracods in the Lower

Cretaceous (Aptian-lower Albian) of post-rift sequence from Jatobá and Araripe basins (Northeast Brazil): Stratigraphic implications. *Cretaceous Research*, **48**:153–176. *doi:10.1016/j.cretres.2013.12.007*

Vaz, P.T.; Rezende, N.G.A.M.; Wanderley Filho, J.R. & Travassos, W.A.S. 2007. Bacia do Parnaíba. *Boletim de Geociências da Petrobras*, **15**:253–263.

Viana, C.F.; Gama Júnior, E.G.; Simões, I.A.; Moura, J.A.; Fonseca, J.R. & Alves, R.J. 1971. Revisão estratigráfica da Bacia do Recôncavo/Tucano. *Boletim Técnico da Petrobras*, **14**:157–192.

Received in 28 August, 2023; accepted in 30 November, 2023.