Revista Brasileira de Paleontologia, 23(2):90–97, Abril/Junho 2020
A Journal of the Brazilian Society of Paleontology

doi:10.4072/rbp.2020.2.02

THE GENUS *CYPRIDEA* (CRUSTACEA, OSTRACODA) AND THE AGE OF THE QUIRICÓ FORMATION, SE BRAZIL: A CRITICAL REVIEW

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ABSTRACT – The non-marine ostracod *Cypridea* Bosquet is surprisingly diverse worldwide, especially in the Cretaceous. Due to their short temporal distribution, many *Cypridea* species together with other typical Pre-Salt ostracod genera, such as *Ilhasina* Krömmelbein, *Paracypridea* Swain, *Petrobrasia* Krömmelbein, *Reconcavona* Krömmelbein, and *Theriosynoecum* Branson, have provided a robust biostratigraphic framework for Brazilian and Western African basins. The Recôncavo-Tucano Basin, located in the Bahia State, was the first Brazilian oil basin. This huge Mesozoic paleolake has over a hundred of ostracod species, most of the genus *Cypridea*, which allowed the development of a biostratigraphic chart with nine biozones and several subzones. This biostratigraphic framework has been used for correlations with most of the non-marine sections of NE and SE Brazilian basins, including the Sanfranciscana Basin, whose lacustrine outcrops correspond to the Quiricó Formation. Nevertheless, in a recent publication on ostracods and the age of the Quiricó Formation, *Cypridea* species were erroneously identified. Consequently, a Valanginian age was wrongly proposed for the base of that formation, and the stratigraphic and geographical distributions of some species were erroneously extended. The present study reveals that none *Cypridea* species of the Quiricó Formation is conspecific with the Recôncavo-Tucano Basin species, including *Cypridea hystrix* Krömmelbein, and, consequently, a Valanginian age is discarded for the base of that formation.

Keywords: biostratigraphy, Cretaceous, Minas Gerais State, paleolimnology, Quiricó Formation.

RESUMO – O ostracode continental *Cypridea* Bosquet é incrivelmente diverso em todo o mundo, especialmente no Cretáceo. Devido à curta distribuição temporal, muitas espécies de *Cypridea*, juntamente com outros gêneros típicos de ostracodes das seções do Pré-Sal, como *Ilhasina* Krömmelbein, *Paracypridea* Swain, *Petrobrasia* Krömmelbein, *Reconcavona* Krömmelbein e *Theriosynoecum* Branson, permitiram a construção de um excelente arcabouço bioestratigráfico para bacias brasileiras e do oeste africano. A Bacia do Recôncavo-Tucano, localizada na Bahia, foi a primeira bacia petrolífera brasileira explorada economicamente. Esse enorme paleolago mesozoico possui mais de 100 espécies de ostracodes, a maioria do gênero *Cypridea*, que permitiram o desenvolvimento de uma carta bioestratigráfica com nove biozonas e várias subzonas. Este arcabouço bioestratigráfico tem sido usado para correlações com a maioria das seções não marinhas das bacias brasileiras do NE e SE, incluindo a Bacia Sanfranciscana, cujos afloramentos lacustres correspondem à Formação Quiricó. No entanto, em uma publicação recente sobre ostracodes e a idade da Formação Quiricó, espécies de *Cypridea* foram identificadas erroneamente. Em consequência disso, uma idade valanginiana foi proposta equivocadamente para a base dessa formação, e as distribuições estratigráficas e geográficas de algumas espécies foram incorretamente ampliadas. O presente estudo revela que nenhuma espécie de *Cypridea* da Formação Quiricó é coespecífica com qualquer espécie da Bacia do Recôncavo-Tucano, inclusive *Cypridea hystrix* Krömmelbein, e, portanto, uma idade valanginiana é descartada para a base dessa formação.

Palavras-chave: bioestratigrafia, Cretáceo, Minas Gerais, paleolimnologia, Formação Quiricó.

INTRODUCTION

The fossil genus *Cypridea* Bosquet, 1852 is well distributed in non-marine paleoenvironments around de world. Although it ranges from the Late Jurassic to the Eocene, *Cypridea* is much more diversified in the Early Cretaceous. Surprisingly, species of this genus have not yet been recorded in Australia and Antarctica, probably due to paucity of research in those regions rather than an actual absence of *Cypridea* species (Sames, 2011). Due to its high radiation rates, *Cypridea* is a very speciose genus largely used for biostratigraphic purposes.

In Brazil, seminal contributions to the study of *Cypridea* (and close relatives) and its use in the biostratigraphy of the NE Brazilian Lower Cretaceous basins were made mainly by Krömmelbein (1961, 1962, 1964, 1965, 1966), Viana (1966a, 1980, 1984), Schaller (1969), Krömmelbein & Weber (1971), Viana *et al.* (1971), Moura (1972, 1987, 1988), and Cunha & Moura (1979). Krömmelbein (1966), Viana (1966b) and Tambareau (1982) discussed the paleogeographic significance of the Early Cretaceous non-marine ostracods from NE Brazil and W Africa. In the SE Brazil, Moura & Praça (1985) and Moura (1987) provided a biostratigraphic framework of

the Lower Cretaceous non-marine sequence in the Campos Basin. Other studies on non-marine Cretaceous ostracods in Brazil have been published more recently, some dealing with *Cypridea* species, of which I highlight Dias-Brito *et al.* (2001), Coimbra *et al.* (2002), Do Carmo *et al.* (2004, 2008, 2013), Sousa *et al.* (2018), and Leite *et al.* (2018). Poporat & Colin (2012) reviewed the Early Cretaceous ostracod biozonation of Brazil and western Africa.

Barbosa (1965), Barbosa *et al.* (1970, 1997) and Delicio *et al.* (1998) registered some non-marine ostracods in the Quiricó Formation. More detailed analyses on this paleolacustrine unit of the Sanfranciscana Basin, however, were carried out by Do Carmo *et al.* (2004) and Leite *et al.* (2018). In the former, 15 species were identified from 11 outcrop samples in João Pinheiro and Carmo do Paranaíba municipalities, Minas Gerais State, although most species remained in open nomenclature, including *Cypridea* sp. 1 recorded in one sample as poorly preserved carapaces. Leite *et al.* (2018) sampled three outcrops, one in João Pinheiro and the other two in the Presidente Olegário municipalities, Minas Gerais State. Although they analyzed 168 samples, recovered only 16 species, most of which were not previously registered by Do Carmo *et al.* (2004).

Bittencourt *et al.* (2015) undertook an extensive bibliographical review of the fossils recorded in the São Francisco Craton sedimentary basins located in Minas Gerais State, including the Sanfranciscana Basin. In table 3, they listed a number of ostracod species registered by Do Carmo *et al.* (2004) in the Quiricó Formation, including *Cypridea* sp. 1.

Amaral *et al.* (2019) performed an analysis of the paleodrainage of the São Francisco Craton based mostly on the distribution of fossils previously studied by other authors in six basins, including the Sanfranciscana Basin. From the 15 species recorded by Do Carmo *et al.* (2004), they cited only four, as follows: *Harbinia symmetrica* (Krömmelbein & Weber, 1971), *Darwinula martinsi* Silva, 1978, *Wolburgiopsis plastica* (Musacchio, 1970), and *Wolburgiopsis chinamuertensis* (Musacchio, 1970). Amaral *et al.* (2019) did not consider the remaining 11 species of Do Carmo *et al.* (2004), probably because they were left in open nomenclature. Although the manuscript of Amaral *et al.* was submitted in June 2019 and published online in September of the same year, they were clearly unaware of the work of Leite *et al.* (2018).

Leite *at al.* (2018) identified four species of *Cypridea*: *C. hystrix* Krömmelbein, 1962, *C. conjugata* Krömmelbein & Weber, 1971, *C. infima* Krömmelbein & Weber, 1971, and *C. jequiensis* Krömmelbein and Weber, 1971. Moreover, *Cypridea hystricoides* Krömmelbein, 1962 was synonymized with *C. hystrix*. A more detailed analysis, however, reveals several incongruities, both in the identification of *C. hystricoides* and in its proposal as a junior synonym of *C. hystrix.* The misidentifications by Leite *et al.* (2018) as well as the incorrect synonymy above mentioned, have serious consequences for the paleobiogeography and biostratigraphy. The authors identified in the Quiricó Formation an interval attributed to the Valanginian, based on the presence of *C. hystrix*, a species originally described for the oil Recôncavo Basin, in the *Paracypridea brasiliensis* Biozone (coded NRT-004 by Petrobras). If this were true, this "can lead to a new age interpretation for the Quiricó Formation and, therefore, to a new interpretation for continental Cretaceous in Brazil" (Leite *et al.*, 2018, p. 676). It is noteworthy that in the same page they begin the 'Discussion' with the following sentence: "The species studied in the present work are important for future research on the geographic and stratigraphic distribution, as well as the correlation between Argentinian, African, and Brazilian continental and marginal basins".

Taking into account that *Cypridea* species led those authors to erroneous biostratigraphic interpretations, the present work focuses on a critical review of the species of *Cypridea* identified, redescribed and/or synonymized by Leite *et al.* (2018). I was motivated to perform this review due to the consequences of these misidentifications for the understanding of the geological evolution of the Sanfranciscana Basin, as well as the paleobiogeography of *Cypridea* species and the regional and supraregional biostratigraphic correlation. This study reveals that none *Cypridea* species of the Quiricó Formation is conspecific with any Cretaceous Brazilian species described so far.

GEOLOGICAL SETTING

The distensive efforts resulting from the opening of the Atlantic Ocean had important consequences in the interior of Brazil, including the São Francisco Craton, where the Sanfranciscana Basin lies (Campos & Dardenne, 1997a,b). The Areado (Lower Cretaceous), Mata da Corda (Upper Cretaceous) and Urucuia (Upper Cretaceous) groups contain the Mesozoic rocks of the Sanfranciscana Basin (Figure 1).

According to Zalán & Silva (2007), the Areado Group represents a lacustrine paleoenvironment silted up by fluvio-deltaic, fluvial, and eolian sandstones, under a distensional tectonic regime related to the Gondwana fragmentation. The group is subdivided in three formations, from the base to the top, as follows: Abaeté, Quiricó and Três Barras. Ostracods have been recorded only in the Quiricó, Formation, a paleolake with interstratified siltstones and sandstones at the base of the sequence, and shales and limestones at the top (Do Carmo *et al.* 2004; Leite *et al.*, 2018).

Bittencourt *et al.* (2015), mainly based on palynomorphs studied by Lima (1979) and Arai *et al.* (1995), accepted a Barremian age for the Quiricó Formation. However, as also discussed by Bittencourt *et al.* (2015), an Aptian age was proposed by Arai *et al.* (1995) for the upper portion of the Quiricó Formation outcropping in the municipality of Presidente Olegário, Minas Gerais State.

The regions sampled by Leite *et al.* (2018), Tereza Farm (João Pinheiro municipality) and the banks of the São José and Quiricó creeks (Presidente Olegário municipality) correspond to different lacustrine paleoenvironments and ages. The first, in the lower portion of the Quiricó Formation, is composed by siltstones and sandstones and was erroneously dated as Valanginian by those authors. The sampled region in the

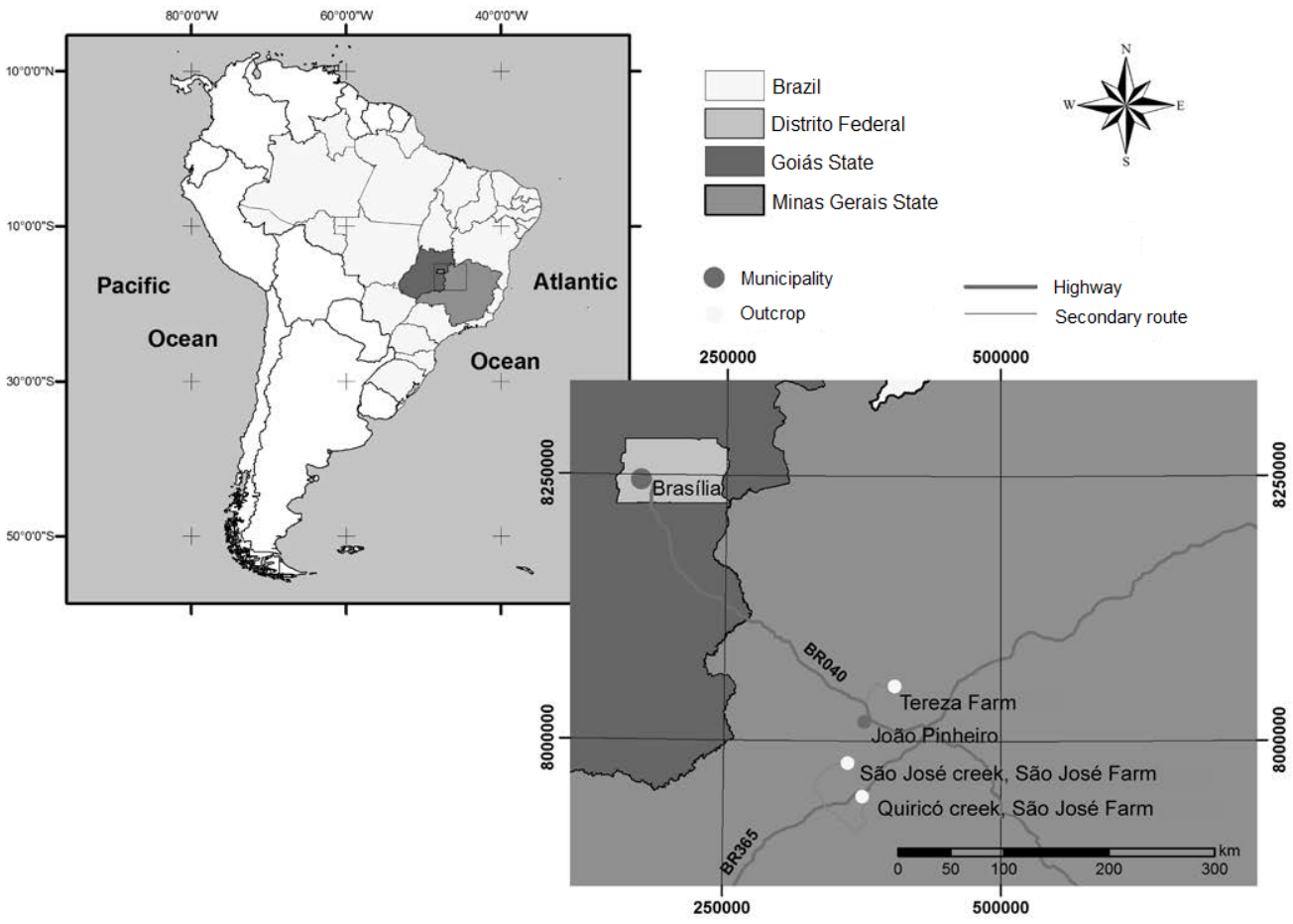

Figure 1. Location map of the Quiricó Formation outcrops (modified of Leite *et al.*, 2018).

Presidente Olegário municipality, as above already mentioned, is Barremian (Lima, 1979; Campos & Do Carmo, 2005) to Aptian in age (Arai *et al.*, 1995).

CYPRIDEA SPECIES AND THE AGE OF THE QUIRICÓ FORMATION

The non-marine genus *Cypridea* has successfully been used in biostratigraphy and correlation not only in Brazil but also around the world, including oil basins. As broadly accepted, however, a reliable biostratigraphic framework requires previously detailed taxonomic work. A suitable example of this is the taxonomic review of *Cypridea* species from the Lower Cretaceous of Europe and North America, which changed the ages for some important geological units at least in the latter region (Sames, 2011).

As previously discussed in the 'Introduction', the work by Leite *et al.* (2018) presents mistakes both in the identification of some species and in the proposition of new diagnoses, descriptions and/or synonymizations. In part, this is because the authors adopted some misconceptions regarding morphological terminology used in the original diagnoses and/or descriptions, employing terms which are nowadays unusual. Krömmelbein (1962, and other publications) used the term "Augen-Geged", correctly quoted, to indicate the region of the valve where the eye is normally located. However, *Cypridea* has no eye tubercle and, therefore, the reference to an ocular region, as did Leite *et al.* (2018), is uncommon. Likewise, the authors described punctate surfaces as "Porecanals spread throughout the surface of the carapace" (Leite *et al.*, 2018, p. 669) following again Krömmelbein's terminology. These are two examples of recurrent morphological misconception in the new diagnoses and/or descriptions proposed in that work. It would have been more appropriate if the authors had followed the terminology proposed by Sylvester-Bradley & Benson (1972) and, more specifically for the genus *Cypridea*, Sames (2011).

Below it is discussed the *Cypridea* species identified by Leite *et al.* (2018) according to the order presented in their paper: *Cypridea hystrix* Krömmelbein, 1962, *Cypridea hystricoides* Krömmelbein, 1962, *Cypridea conjugata* Krömmelbein & Weber, 1971, *Cypridea infima* Krömmelbein & Weber, 1971 and *Cypridea jequiensis* Krömmelbein & Weber, 1971.

Cypridea hystrix Krömmelbein, 1962

Although Leite *et al.* (2018) did not specify the dimensions of the figured carapace, the scale demonstrates that the

specimen of the figure 4.10 is approximately 0.81 mm length and 0.46 mm height. In turn, the holotype of *Cypridea hystrix* proposed by Krömmelbein (1962, pl. 55, fig. 18) is much larger: 0.94 mm length and 0.60 mm height. Regarding width, Krömmelbein (1962) did not assign it either. However, the holotype dorsal view (fig. 55.18c) is wider than the dorsal view of the specimen illustrated by Leite *et al.* (2018, fig. 4.12). It is also noteworthy that although the latter authors have stated in 'Description' that "In dorsal view, greatest width posteriorly", their figure 4.12 shows the greatest width immediately after half-length.

The new 'Diagnosis' of Leite *et al.* (2018) for *Cypridea hystrix* is less informative than that of Krömmelbein (1962) and does not address the morphology of *Cypridea hystricoides*, a species that the authors propose as a junior synonym of *C. hystrix*. There are also incongruities between the new 'Diagnosis' and the new 'Description'. For example, while the new 'Diagnosis' states "Medium-size carapace, with trapezoidal shape...", the new 'Description' says "Medium-size carapace, sub-oval to subrectangular...". In addition, primary ornamentation is described in different ways, consisting of "Porecanals spread throughout the surface of the carapace" in the new 'Diagnosis', and identified as "Reticulated ornamentation" in the new 'Description'. In similar way, about the anterior cardinal angle, the new 'Diagnosis' declares "Pronounced anterior cardinal angle", while the new 'Description' says "Dorsal margin nearly straight, with inconspicuous anterior hump".

In relation to the nodules, Krömmelbein's diagnosis states: "Strong spines; on each valve a generally multi-pointed, strong thorn in the 'eye area'; two more strong, superimposed thorns laterally behind the middle" (translated from original, in German). Now, let us see what Leite *et al.* (2018) comment about the larger nodules (= Krömmelbein spines/thorns): (i) in the new 'Diagnosis' they affirm "Pronounced nodules, mainly in the ocular region and posterior regions" (*sic*); (ii) and in the new 'Description' they describe "Two pronounced nodules in each valve, in posterior to mid-height region". Regarding the small nodules, both the diagnosis and description of Leite *et al.* (2018) differ from the original text. Furthermore, in their new 'Description' there are some confusion about these nodules, such as "Smaller nodules lined and concentrated on the anterior margin. Smaller nodules scattered throughout the surface".

Krömmelbein (1962), describing the beak-like structure (= 'rostrum' for him and other authors), wrote: "Rostral furrow deep, reaching far above, ending approximately before the 'eye' thorn" (translated from original, in German). Leite *et al.* (2018) had treated the beak-like structure in their new 'Diagnosis' and 'Description', but they did not even mention the beak furrow (= alveolar furrow for Sames, 2011). However, the specimens illustrated in their fig. 4.10–11 also present a deep beak furrow, but much shorter than the true *Cypridea hystrix*. Regarding intraspecific variability in this species, Krömmelbein (1962) reported that the carapace shape is relatively constant. Similarly, about the position, number, and development of the larger nodules, as well as the smaller and weaker ones, they stated that they vary little. Finally, it is worth mentioning in this context the specimens in fig. 4.13–14 also attributed to *C. hystrix*. They are somewhat poorly preserved, but their outline and ornamentation reveal important differences with numbers 10 and 11, and, therefore, they are probably other species.

From the above, I conclude that the specimens identified by Leite *et al.* (2018) as *Cypridea hystrix* belong to a different species, perhaps a new one. I also understand that there are misconceptions in the new 'Diagnosis' and 'Description', as well as incongruities between them. Biostratigraphically, the species of Leite *et al.* (2018) is not an index fossil of Valanginian age.

Is *Cypridea hystricoides* a junior synonym of *Cypridea hystrix*?

Leite *et al.* (2018) considered *Cypridea hystricoides* a junior synonym of *Cypridea hystrix*, as already mentioned above. In the 'Remarks' of *C. hystrix* they stated: "*Cypridea hystrix* has an outline and dimensions similar to *Cypridea hystricoides* Krömmelbein, 1962, however in dorsal view, *Cypridea hystrix* is broader. The nodules are similar in both species, as well as the outline and size. These similarities may indicate sexual dimorphism, and that both species are one and the same (*i.e. Cypridea hystrix* would be the female and *C. hystricoides*, the male)". However, according to the original descriptions of *C. hystrix* and *C. hystricoides*, the adult of the former species presents 0.94 mm length and 0.60 mm height, while the adult of *C. hystricoides* has 0.87 mm length and 0.54 mm height, being significantly shorter than *C. hystrix*. The length/height ratio of *C. hystricoides* illustrated by Leite *et al.* (2018), and which they consider males of *C. hystrix*, differs from that presented to *C. hystricoides* in Krömmelbein (1962). Furthermore, the length/height ratio is practically the same in the two Krömmelbein's species, even though *C. hystricoides* is smaller.

In addition, the detailed description of *Cypridea hystricoides*, together with the illustrations by Krömmelbein (1962, fig. 55: 19a–c), show that in both lateral and dorsal views this species has different outline, ornamentation and dimensions from *Cypridea hystrix*. In lateral view, *C. hystricoides* presents both cardinal angles more marked, especially the somewhat pointed anterior one. Regarding ornamentation, the general arrangement of nodules shows some similarity between the two species, but in *C. hystricoides* the surface is more finely punctate, the smaller nodules are much less numerous and the larger nodules much more developed, as already commented by Krömmelbein (1962). Additionally, the nodules position differs in both species.

Concerning their stratigraphic distribution, Krömmelbein (1962) restricted *Cypridea hystrix* to the upper stratum of the lower section of the Ilhas Formation, and *Cypridea hystricoides* to the upper stratum of the upper section of the same formation. The work of Viana *et al.* (1971), on the geology and micropaleontology of the Recôncavo/Tucano Basin, established independent lithostratigraphic, biostratigraphic and chronostratigraphic units, defining

numerous biozones and sub-biozones based on non-marine ostracods previously identified and described mainly by Krömmelbein. Nowadays, it is well known that *C. hystrix* occurs in the *Paracypridea brasiliensis* Biozone, *Paracypridea bicallosa* and *Paracypridea maacki* sub-zones, which chronostratigraphically are into the upper portion of the Rio da Serra local Brazilian Stage that is Valanginian–lower Hauterivian in age (see Arai *et al.*, 1989; Caixeta *et al.* 1994; Campos-Neto *et al.*, 2007). In contrast, *C. hystricoides* is restricted to the *Cypridea* (*Morinina*?) *bibullata bibullata* Biozone, chronostratigraphically into upper portion of the Aratu local Brazilian Stage, which is middle Barremian in age (see Arai *et al.*, 1989; Caixeta *et al.* 1994; Campos-Neto *et al.*, 2007).

Considering both morphology and biostratigraphy, the answer to the question that corresponds to the subtitle of this section is no. The ostracod *Cypridea hystricoides* is not the male of *Cypridea hystrix* and, therefore, it is not a junior synonym of this species. The carapace illustrated by Leite *et al.* (2018, fig. 4:13–14) is corroded and does not belong neither to *C. hystricoides* nor to *C. hystrix*. Biostratigraphically, this material of Leite *et al.* (2018) is not an index fossil of Valanginian age.

***Cypridea conjugata* Krömmelbein & Weber, 1971**

The holotype and paratype described and illustrated by Krömmelbein & Weber (1971, pl. 1:4–5) are clearly different in size, outline and ornamentation from the specimens studied by Leite *et al.* (2018, fig. 5:1–7). The original material has 1.03 mm length and 0.67 mm height, and a "rounded trapezoidal" outline in lateral view. Although Leite *et al.* (2018) did not specify the dimensions of their specimens, the scale of the figure 5 (images 1 and 2) demonstrate that they have approximately 1.12 mm length and 0.56 mm height. The outline is sub-rectangular in lateral view, as correctly described by those authors, but differs from the "rounded trapezoidal" outline described by Krömmelbein & Weber (1971) as above reported. Regarding length/height ratio, in the true *Cypridea conjugata* it is ~1.53, while in the more elongate specimens from the Quiricó Formation it is ~2.

In relation to the beak-like structure, in the true *Cypridea conjugata* it is strongly marked, with the end turned sharply back and down, clearly extending beyond the ventral margin. Beak notch conspicuous but few developed. Beak furrow moderately deep, reaching up to approximately half the height of each valve.

According to Krömmelbein & Weber (1971), in this species the ornamentation consists of punctae distributed on the entire carapace surface, two great nodules and, in larger number, smaller and more rounded nodules. One of the two great nodules occurs just below the anterior cardinal angle, while the other one is in the dorsomedian portion, immediately behind and above the region corresponding to the central muscle scars. The relatively numerous smaller nodules are more or less arranged in rows, as follows: a row of four at the posterior portion of each valve, and a ventrolateral row consisting of partly interconnected nodules. Two very small nodules occur above each of the two greater nodules. A few delicate nodules occur near the anterior margin, which also form not always conspicuous rows. On the other hand, the species of Leite *et al.* (2018) is very few ornamented when compared to *Cypridea conjugata*, presenting a punctate surface, but no well-developed nodule.

When comparing the above described morphological characteristics of the species of Krömmelbein & Weber (1971), it is concluded that the specimens attributed by Leite *et al.* (2018) to *Cypridea conjugata* are markedly different and should belong to an undescribed species. The ostracod from the Quiricó Formation has a larger size, show an elongated sub-rectangular shape in lateral view, and bear a somewhat dorsomedian depression and comparatively a very weaker ornamentation. The beak-like structure and the carapace outline also differ. For example, the posterior margin of the material of Leite *et al.* (2018) is not evenly rounded as in *C. conjugata* but is asymmetrically rounded being more projected posterodorsally.

Even though the identification of Leite *et al.* (2018) was correct, it is necessary to report that the 'Diagnosis' and 'Description' proposed by them are somewhat confusing, and much less detailed than those of Krömmelbein & Weber (1971). Finally, regarding stratigraphic distribution, the true *Cypridea conjugata*, a rare species, remains restricted to the lower section of the São Sebastião Formation (Recôncavo Basin, NE Brazil). Using the stratigraphic works of Arai *et al.* (1989), Caixeta *et al.* (1994) and Campos-Neto *et al.* (2007), I concluded that chronostratigraphically this section corresponds to the upper portion of the Aratu local Brazilian Stage, which is Barremian in age.

***Cypridea infima* Krömmelbein & Weber, 1971**

Concerning *Cypridea infima*, the 'Remarks' of Leite *et al.* (2018) reports: "Krömmelbein and Weber (1971) described only the porecanals through the carapace. In the present work, the good preservation of material allowed observation of a punctate ornamentation, and that the porecanals are present along the carapace and in the small nodules. For this reason, a new description and diagnosis are herein presented, emended from Krömmelbein and Weber (1971)". However, the material studied and illustrated by Krömmelbein & Weber (1971, pl. 1:3a–c) was also very well preserved and with conspicuous ornamentation. It is noteworthy that the conclusion of Leite *et al.* (2018) about the ornamentation of *C. infima* is a misconception. Why? Because in his descriptions Krömmelbein used the expression "Pore-Grübchen" (= pore cavities) to refer to punctate or even finely reticulate ornamentation. He was not referring to the normal porecanals. Therefore, different from the 'Remarks' of Leite *et al.* (2018), Krömmelbein & Weber (1971) described correctly the ornaments of *C. infima*, as follows: "Ornamentation: clearly salient, but only moderately strong pore cavities on the entire surface of the shell; other sculptural elements are completely missing". In addition, in the 'Diagnosis' they wrote "Ornamentation: moderately fine pore cavities on the entire surface of the carapace" (translated from original, in German).

Although the material figured by Leite *et al.* (2018) bears some similarity to *Cypridea infima*, a close examination reveals clear differences. Concerning the outline, only in the species of Krömmelbein & Weber (1971) the transition from the dorsal to the anterior and posterior margins is really rounded, that is, with indistinct cardinal angle. In the true *C. infima* LV overlaps RV solely in the anterior and posteroventral (cyathus) margins, while in the specimens of Leite *et al.* (2018), as described and illustrated by those authors, "Left valve larger than right valve, overlapping all the margins of the carapace, especially the ventral margin". The beak is much wider, and the beak furrow runs higher in the original species. Regarding ornamentation, it is only finely punctate in the 20 carapaces of *C. infima* examined by Krömmelbein & Weber (1971), while in the Sanfranciscana Basin the specimens are not only punctate, but have "small nodules present throughout the carapace" (Leite *et al.*, 2018).

Respecting its stratigraphic distribution, the true *Cypridea infima* occurs in the lower and median layers of the Candeias Formation (Recôncavo Basin, NE Brazil). Using the stratigraphic works of Arai *et al.* (1989), Caixeta *et al.* (1994) and Campos-Neto (2007), I concluded that chronostratigraphically this section corresponds to the lower half of the Rio da Serra local Brazilian Stage, which extends from the Berriasian to lower Valanginian in age.

***Cypridea jequiensis* Krömmelbein & Weber, 1971**

For this species, Leite *et al.* (2018) do not present a new 'Diagnosis' and 'Description' as they performed for the above discussed ones. However, the data provided in their 'Remarks' did not allow to allocate in *Cypridea jequiensis* any specimen of the Quiricó Formation. According to that, "After extensive revision of the *Cypridea* Bosquet, 1852 species occurring in Brazil, the species found in the Quiricó Formation are attributed to *Cypridea jequiensis* Krömmelbein and Weber, 1971 due to the smooth surface and trapezoidal shape. However, it must be noticed that in the São Francisco Basin, these occurrences are of Valanginian age".

Comparing the illustrated specimens of Leite *et al.* (2018) with the original 'Diagnosis', 'Description' and illustrations of Krömmelbein & Weber (1971), it is concluded that the Quiricó Formation fossils do not belong to *Cypridea jequiensis* Krömmelbein & Weber 1971. The holotype is 0.88 mm long and 0.60 mm high (although the holotype photos indicate a height around 0.56 mm), and 0.41 mm wide. In addition, in the 'Diagnosis' the authors sustain that the species can reach ~1.00 mm length. In turn, the material figured by Leite *et al.* (2018) is smaller, being approximately 0.76 mm long and 0.48 mm high, the carapace in dorsal view being 0.38 mm maximum wide.

Furthermore, (i) in lateral view, the anterior margin is more rounded in the Quiricó Formation specimens; (ii) in dorsal view, the holotype is more elongate and bears a more pronounced medium depression; (iii) the beak-like structure is more conspicuous in *Cypridea jequiensis* original material. Besides, it is noteworthy that Krömmelbein & Weber (1971) state that intraspecific variability in this species is insignificant.

Regarding stratigraphy, the true *Cypridea jequiensis* is known only for the Lower Cretaceous "Post-Bahia Series, Jiquiá layers" of the Sergipe-Alagoas and Campos basins, Brazil (Krömmelbein & Weber, 1971; Moura, 1987; Poporat & Colin, 2012). Based on Arai *et al.* (1989), Campos-Neto *et al.* (2007) and Winter *et al.* (2007), I concluded that chronostratigraphically in both basins the "Post-Bahia Series, Jiquiá layers" of Krömmelbein & Weber (1971) corresponds to the Jiquiá local Brazilian Stage, which extends from upper Barremian to lower Aptian.

FINAL REMARKS

The *Cypridea* species identified and illustrated by Leite *et al.* (2018) do not correspond to the species in which they were assigned. The new diagnoses and descriptions have inconsistencies between them or internally, and do not characterize the species originally described by Krömmelbein (1962) or Krömmelbein & Weber (1971). The proposal to consider *Cypridea hystricoides* male of *Cypridea hystrix*, and hence a junior synonym of *C. hystrix*, is another misconception presented by Leite *et al.* (2018). The specimens erroneously identified as *Cypridea conjugata* and *Cypridea jequiensis*, recorded together with the specimens wrongly attributed to *C. hystrix*, led to another mistake modifying the stratigraphic distribution of those three species. In turn, due to the misidentification of *Cypridea infima*, this relatively rare Berriasian (and/or early Valanginian) species had its stratigraphic distribution erroneously attributed to the Valanginian–Hauterivian/Aptian? age. Therefore, I concluded that all species of the genus *Cypridea* recorded in the Quiricó Formation require further morphological and taxonomic studies. They are likely new species, perhaps even endemic to the Quiricó Formation.

Regarding the chronostratigraphy of the Quiricó Formation, Leite *et al.* (2018) attributed a Valanginian age to the basal portion of the Tereza Farm outcrop, located in the João Pinheiro municipality. This age was based on a misidentification of *Cypridea hystrix*, a species that occurs in part of the upper portion of the *Paracypridea brasiliensis* Biozone, which chronostratigraphically is in the upper portion of the Rio da Serra local Brazilian Stage that is Valanginian–lower Hauterivian in age (see Viana *et al.*, 1971; Moura, 1972; Arai *et al.*, 1989; Caixeta *et al.* 1994; Campos-Neto *et al.*, 2007; Poporat & Colin, 2012). Surprisingly, at the end of the paper (p. 677), still dealing with the age of the Tereza Farm outcrop, Leite *et al.* (2018) affirm: "The middle portion of the sequence is of Hauterivian age, possibly up to Aptian age". The data that may indicate a Hauterivian age are unclear. In turn, they considered the São José creek Aptian in age and the Quiricó creek possibly Valanginian–Barremian in age, both located in the Presidente Olegário municipality.

The Valanginian–Hauterivian age, if correct, would change the geological history of the Quiricó Formation, as well as the stratigraphic and geographical distribution of many ostracod species recorded by Leite *et al.* (2018). In fact, apart from the Quiricó Formation, that and other mistakes

performed by them, if not herein discussed, would give rise to erroneous stratigraphic interpretations of other Brazilian Lower Cretaceous non-marine sequences.

ACKNOWLEDGEMENTS

I express my gratitude to the National Council for Scientific and Technological Development (CNPq) for Grant 305128/2017-5. C.T. Bergue, E.K. Piovesan and M. Arai are thanked for their useful comments and suggestions that significantly improve the quality of the manuscript.

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Received in 27 January, 2020; accepted in 16 May, 2020.