



## GEOSCIENCES

# Response to Coimbra (2023) 'Rebuttal of Leite and Do Carmo, 2021'

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This article is a response to the comments raised by Dr. Coimbra (2023) published in this journal, regarding the ostracod taxonomy used by Leite & Do Carmo (2021) as support for the age determination of the Lower Cretaceous Quiricó Formation. After the discussion raised by Coimbra (2020), the four species of *Cypridea* Bosquet, 1852 recovered from the Quiricó Formation were carefully revised with focus on their taxonomy and now are classified as: *Cypridea hystrix* Krömmelbein, 1962; *Cypridea* sp.; *Cypridea* aff. *Cypridea infima* Krömmelbein & Weber, 1971; *Cypridea* aff. *Cypridea jequiensis* Krömmelbein & Weber, 1971.

### ***Cypridea hystrix* Krömmelbein, 1962**

**Non 1962 *Cypridea hystricoides* Krömmelbein, p. 507, pl. 55, fig. 19.**

**Non 2018 *Cypridea hystrix* Krömmelbein; Leite et al. (2018), p. 8, fig. 4 13-14.**

### **Remarks**

Leite et al. (2018) proposed an emend on diagnosis and description for *Cypridea hystrix* Krömmelbein, 1962 based on the occurrence of sexual dimorphism, and considered *Cypridea hystricoides* Krömmelbein, 1962 a junior synonym of *C. hystrix*, which was also endorsed by Leite & Do Carmo (2021). Considering the comments made by Coimbra (2020) regarding the differences between *C. hystricoides* and *C. hystrix* and further analysis on the specimens recovered from the Quiricó Formation, it is agreed that *C. hystricoides* is not a junior synonym of *C. hystrix*.

Because of that, and due to the comments made by Coimbra (2020), the emend in diagnosis and description by Leite et al. (2018) is incorrect. It is concluded that *C. hystricoides* does not occur in the Quiricó Formation, *C. hystrix* does not present sexual dimorphism and the specimen thought to be the male of *C. hystrix* in figure 4.13-14 of Leite et al. (2018) is an unidentified species. Coimbra's (2020) interpretation that the specimen illustrated in figure 4.10-12 of Leite et al. (2018) is not *C. hystrix* was firstly based on carapace size. However, variability in carapace size can occur within a population (Boomer et al. 2003), and within the same species, in different locations (Ramos et al. 2015). Then, Coimbra (2020) argued that in dorsal view, the holotype of *C. hystrix* is wider than the specimen from the Quiricó Formation. Notwithstanding, the specimen illustrated in figure 4.12 of Leite et al. (2018) is slightly tilted, not showcasing the true width. Moreover, there are specimens in the

Quiricó Formation that present a wider width in dorsal view. Also, when comparing the outline in dorsal view, of the specimen illustrated in figure 4.12 of Leite et al. (2018), enlarged to the same length as the holotype of *C. hystrix*, both specimens present almost the same outline (Fig. 1a). Coimbra (2020) also pointed out that in the specimen illustrated in figure 4.10-12 of Leite et al. (2018), the greatest width was erroneously described to be posteriorly, whereas it is in fact immediately after half-length, just like the holotype of *C. hystrix*, and in both specimens, the greatest width is emphasized by the spine in the “eye region”, as described by Krömmelbein (1962). Regarding the beak furrow, Coimbra (2020) pointed out that it was described by Krömmelbein (1962) as deep, reaching far above, ending approximately before the “eye thorn”, and the same occurs in the specimen illustrated in Leite et al. (2018). In the original description by Krömmelbein (1962), it is stated that, in each valve, there is a strong multi-pointed spine in the “eye region”, and two further strong spines superimposed just behind the middle. In the specimen illustrated in figure 4.10-12 of Leite et al. (2018), those characteristics are present, along with the smaller nodules described by Krömmelbein (1962), although somewhat

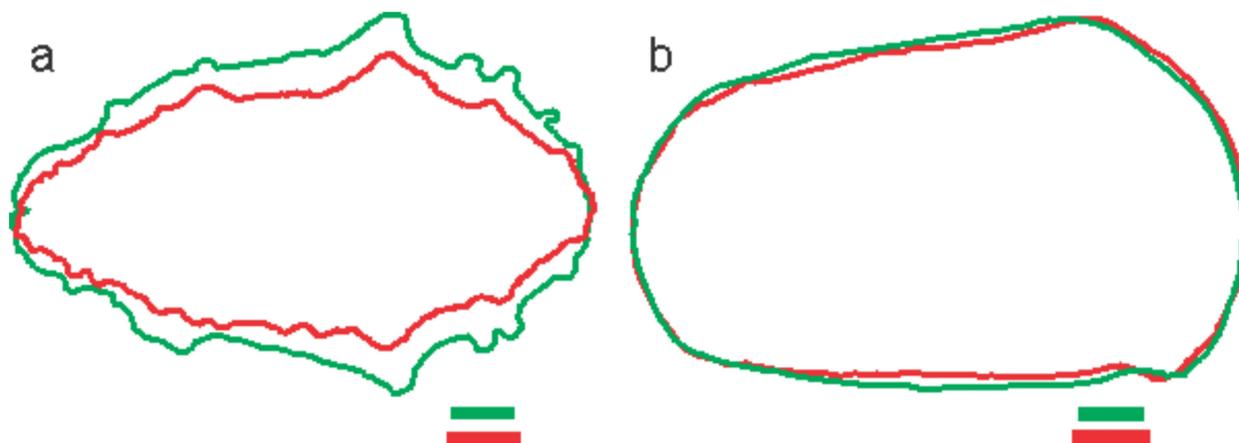
less developed than the holotype, which can be attributed to a phenotypic control. Other specimens from the Quiricó Formation present better developed nodules. It is important to point out that in lateral view, when enlarging the specimen illustrated in figure 4.10-12 of Leite et al. (2018) to the same length as the holotype of *C. hystrix*, and comparing both outlines, the general shape of the carapace of both specimens is almost the same (Fig. 1b). Due to the similarities between the specimen illustrated in figure 4.10-12 of Leite et al. (2018), along with other specimens recovered from the Quiricó Formation, and the holotype of *C. hystrix*, the specimens from the Quiricó Formation remain as *C. hystrix*.

### *Cypridea* sp.

### Non 2018 *Cypridea conjugata* Krömmelbein & Weber; Leite et al. (2018), p. 10, fig. 5 1-7.

### Remarks

Leite et al. (2018), identified the species in figure 5.1-7 as *Cypridea conjugata* Krömmelbein & Weber, 1971, and proposed an emend on diagnosis and description due to nodule variability within the species. Coimbra (2020) argued that several characteristics of the



**Figure 1.** Outline of the holotype of *Cypridea hystrix* Krömmelbein, 1962, in green, and of the *Cypridea hystrix* illustrated in figure 4.12 of Leite et al. (2018), in red, enlarged to the same size as the holotype: a, Outline of the dorsal view; b, Outline of the right lateral view. Scale bar = 100  $\mu$ m.

specimen illustrated in figure 5.1-3 of Leite et al. (2018) are different from the holotype of *C. conjugata*. These characteristics are mainly the length/height ratio and the beak extending beyond the ventral margin in the holotype. The specimen illustrated in figure 5.1-3 of Leite et al. (2018) presents an elongation more pronounced than other specimens from the same sample, with an inconspicuous hump on the anterodorsal margin and a more narrowly rounded posterior end. It is worth mentioning that in the specimen illustrated in figure 5.1-3 the nodules are far less when compared to the specimens illustrated in Leite et al. (2016), and the discussion for that matter is explored in Leite et al. (2018). The nodules that are developed in the specimens from Leite et al. (2018) and Leite et al. (2016) are in positions similar to the holotype of *C. conjugata*. Also, there are more elongated specimens and more rounded trapezoidal specimens in the Quiricó Formation, with similar position of nodules as the holotype of *C. conjugata*, and with nodule variability. However, in the specimens illustrated in figure 5.1-5 of Leite et al. (2018), the posterodorsal region is slightly more pronounced than the posteroventral region, making up an uneven subrounded outline, different from the holotype of the species, which is evenly rounded. Moreover, especially in the specimen illustrated in figure 5.1-3 of Leite et al. (2018), the beak-like structure does not extend beyond the ventral margin, which is a characteristic in the holotype of *C. conjugata*. With that, it is important to consider that although the specimens in the Quiricó Formation can be compared to *C. conjugata*, due to the similar nodule pattern, the differences between them justify the classification of the specimens from the Quiricó Formation as *Cypridea* sp., instead of *C. conjugata*.

### ***Cypridea* aff. *Cypridea infima* Krömmelbein & Weber, 1971**

#### **Remarks**

Leite et al. (2018) proposed an emend on diagnosis and description based on punctate ornamentation and porecanals. Coimbra (2020) drew attention to the mistranslation applied by Leite et al. (2018), in which Krömmelbein & Weber (1971) used the expression “Pore-Grübchen” translated as pore cavities, to refer to a punctate or finely reticulate ornamentation, meaning that the authors were not referring to normal porecanals. Therefore, Krömmelbein & Weber (1971) described correctly the ornamentation of *Cypridea infima*, and the emend on diagnosis and description presented by Leite et al. (2018) is incorrect. Additionally, Coimbra (2020), although affirming that the *C. infima* illustrated by Leite et al. (2018) and the holotype bear similarities, also states that there are differences. First, the transition from the dorsal to the anterior and posterior margins of the holotype is really rounded, with indistinct cardinal angles. This is also true for the *C. infima* illustrated by Leite et al. (2018), in which it is possible to observe a small deformation in the mid to posterodorsal area in left lateral and dorsal views, probably caused by diagenetic factors, creating the false impression of a slightly marked posterior cardinal angle in lateral view. Regarding ornamentation, other than the finely punctate all through the carapace, the *C. infima* illustrated by Leite et al. (2018) also presents small nodules. However, *Cypridea* seems to present a phenotypical control for nodules. Regarding the beak and the beak furrow, the holotype presents a wide beak, and the beak furrow is not very deep, reaching up to about half the height. The beak in the *C. infima* illustrated by Leite et al. (2018) appears to be similar in width, although not so wide as the holotype, and the height of the beak furrow is

not easily determined in the illustration. As for the overlap of the left valve over the right valve, in the holotype, this overlap occurs only in the anterior and posteroventral margins, and in the *C. infima* illustrated by Leite et al. (2018), the left valve also overlaps the right valve in the ventral margin. This overlap is present in the illustrated specimen, but not in other specimens attributed to the species, and could be attributed to factors such as diagenesis. All characteristics of the specimen illustrated by Leite et al. (2018) seem to indicate that the species is indeed *C. infima*, however, due to the valve overlap and the small differences in the beak and beak furrow, the species from the Quiricó Formation will be left in affinity.

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

**Remarks**

Coimbra (2020), while comparing the specimen illustrated in Leite et al. (2018) and the holotype by Krömmelbein & Weber, 1971, pointed out some differences. Regarding the size of the carapace, the holotype is much larger than the *Cypridea jequiensis* illustrated in Leite et al. (2018). However, as already mentioned, variability in carapace size can occur within a population (Boomer et al. 2003), and within the same species, in different locations (Ramos et al. 2015). Regarding the anterior margin, Coimbra (2020) pointed out that the specimens from the Quiricó Formation are more rounded than the holotype. However, when comparing specimens from the Quiricó Formation and the holotype of *C. jequiensis*, it is possible to see that both anterior margins are broadly rounded and very similar. In relation to the beak, Coimbra (2020) argues that it is more pronounced in the holotype, and that difference is not evident in the specimen illustrated by Leite et al. (2018).

When comparing both specimens, the beak structure is very similar, even the beak furrow, which is just as described by Krömmelbein & Weber (1971). As for the dorsal view, in which the holotype is more elongated and bears a more pronounced sulcus, some specimens of the Quiricó Formation are similar to the holotype, others, such as the one illustrated by Leite et al. (2018) are not, and for that reason, the species from the Quiricó Formation will be left in affinity.

**CONCLUSIONS**

In addition to the taxonomic revision reported herein, it is important to clarify the comment presented by Coimbra regarding the chronostratigraphic column used by Leite et al. (2018) and Leite & Do Carmo (2021), in which the Quiricó Formation was not updated to encompass the Valanginian. That is an inconsistency, since the data in table II of Leite & Do Carmo (2021) indicate that the base of the Quiricó Formation might be attributed to the Valanginian. The chronostratigraphic column in question should indeed present a Valanginian-Albian interval, which will be addressed in future biostratigraphic and chronostratigraphic studies.

As for the coelacanth *Mawsonia* Mawson & Woodward, 1907, the hypothesis that the record of *Mawsonia* in South America consists of *Mawsonia gigas* Mawson & Woodward, 1907, which has occurrences recorded in the Quiricó Formation by Carvalho & Maisey (2008), is validated by Toriño et al. (2021). The species in question is the best one to characterize the genus, and presents patterns of morphology and ornamentation that vary, with a wide range of sizes, due to intraspecific variability (Toriño et al. 2021). The stratigraphic range of *Mawsonia gigas* Mawson & Woodward, 1907, is from Upper Jurassic and Neocomian

(Berriasian-Valanginian-Hauterivian) to Cenomanian (Toriño et al. 2021). So, it is important to point out that the occurrence of this species alone would not date the Quiricó Formation in the hypostratotype section of the Tereza Farm as Valanginian-Hauterivian. However, when associated with the ostracod fauna, especially with *Cypridea hystrix* and *Cypridea* aff. *C. infima*, it might corroborate the hypothesis of a Valanginian-Hauterivian interval for the lower and middle portions of the section. Regarding the geochronology of this section, studies are planned in order to evaluate the relative dating.

Lastly, the chronostratigraphic attribution of the lower and middle portions of the hypostratotype section of the Tereza Farm is based mainly on ostracod occurrence. The stratigraphic range of *Cypridea* Species, especially *Cypridea hystrix* Krömmelbein, 1962 and *Cypridea* aff. *C. infima* Krömmelbein & Weber, 1971, as well as the occurrence of *Brasacypris ovum* Krömmelbein, 1965, indicate that the lower and middle portions of the Quiricó Formation might be attributed to the Valanginian-Hauterivian interval. However, it is important to point out that biostratigraphic studies are being conducted in order to determine the chronostratigraphic attribution of the Quiricó Formation in the hypostratotype section of the Tereza Farm.

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