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Article

FIRST OCCURRENCE OF LINGULIDAE (?*GLOTTIDIA* DALL, 1870: BRACHIOPODA) IN THE PARANÁ FORMATION (LATE MIOCENE, ARGENTINA) AND ITS IMPLICATIONS

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ABSTRACT – The brachiopod *Glottidia bravardi*? is first described from the Paraná Formation (Late Miocene, Argentina). The species was known from other deposits of the "Entrerriense or Paranense" transgression (Puerto Madryn Formation in Argentina and Camacho Formation in Uruguay), and its absence in the Paraná Formation was noteworthy. Finally, two specimens collected around a century ago were found in the Paleoinvertebrate Collection of the Museo Argentino de Ciencias Naturales. One of them was intended to be the holotype of the species, but *Glottidia bravardi* was formally described just in 1995, by Figueiras & Martínez, based on Uruguayan type specimens. *G. bravardi* lived in warm, subtropical waters, and its presence in this latitude reflects a northward withdrawal of the genus range in the Atlantic waters during the Paleogene/Neogene, in accordance with other brachiopod examples (*i.e.*, *Bouchardia*).

Keywords: Brachiopoda, Lingulidae, *Glottidia*, Late Miocene, Paraná Formation, Argentina.

INTRODUCTION

The occurrence of lingulids in Paleogene/Neogene deposits of the South American subcontinent and its austral projection has been known since the beginning of the XX century when Buckman (1910, p. 9, pl. 1, fig. 7) described as *Lingula antarctica* some specimens collected during the Swedish South Pole Expedition (1901–03) in Antarctica. Further illustrations of that species were provided by Owen (1980, fig. 10), Wiedman *et al*. (1988, figs. 2.18–20), Bitner (1996a, pl. 18, figs. 1a–b, 2a–b; 1996c, pl. 2, figs. 1a–b; 1997, fig. 2a) from the Eocene La Meseta Formation *s.l* exposed at various localities in Marambio (= Seymour) Island, Antarctic Peninsula (Figure 1). Nearly two decades ago, the taxonomic assignment was revised to *Glottidia antarctica* (Buckman), based on well-preserved material (Emig & Bitner, 2005b, text-figs. 1–4) from Telm 6 and Telm 7 (*i.e*., Submeseta Formation; late Eocene–Oligocene?).

The Late Miocene "Entrerriense/Paranense" transgression covered a considerable part of the present Argentina, Uruguay, and southern Brazil, leaving rich fossiliferous deposits that have been extensively studied since the middle of the XIX century (see the syntheses of del Río & Martínez, 1998 and Pérez *et al*., 2013). Nevertheless, new and significant findings still occur (*e.g.*, Martínez *et al*., 2022).

The presence of Lingulidae in these deposits was reported in the same year by Teisseire (1927: 52), who mentioned *Lingula* sp.? in Uruguay, at Barranca de los Loros (Camacho Formation), and by Frenguelli (1927) in Argentina, who published a photograph of *Lingula* sp. n.?, from the basal section of Puerto Madryn Formation exposed at Puerto San José (Chubut Province, the so-called "Aonikense beds") (Figure 1). Unfortunately, no additional lingulids were subsequently found, or at least reported, for the Puerto Madryn Formation, but Frenguelli (1930) stated that these specimens were identical to "*Lingula Bravardi* Doello-Jurado (*in litteris*)", a new species from Uruguayan deposits that would be described in the future by M. Doello-Jurado. The mentioned Uruguayan deposits and the shells sent to M. Doello-Jurado were apparently the same as those referred to by Teisseire (1927). However, the intended description of the new species never happened, thus becoming *Lingula bravardi* a

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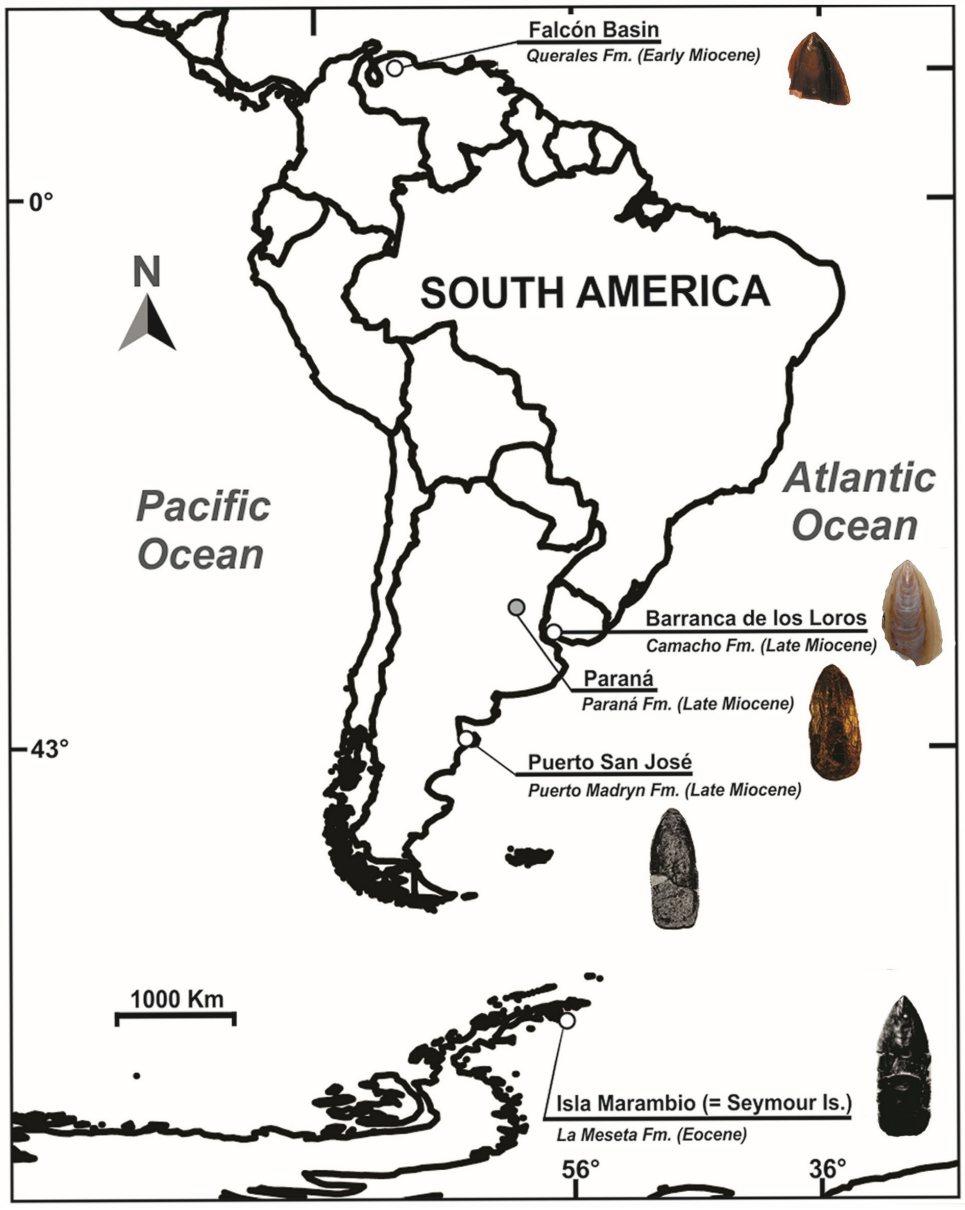

Figure 1. Paleogene/Neogene records of *Glottidia* in South America. **Abbreviation: Fm.**, Formation.

nomen nudum, even though that species' name was quoted again by others (Lambert, 1941, p. 72, 1942, p. 575; Francis, 1975, p. 565). Figueiras (1980), based on the presence of the typical septa, stated that those specimens from Uruguay belonged to *Glottidia*, and Figueiras & Martínez (1995) finally formally described *Glottidia bravardi* as new, without uttering an opinion about the Patagonian exemplars, which, incidentally, according to the figures provided by Frenguelli (1927, fig. 9), also show evidence of divergent septa, characteristic of the genus *Glottidia*.

Pérez *et al*. (2013) stated that Frenguelli (1927, 1930) indicated the presence of lingulids in Uruguay, as well as in the Patagonian and Mesopotamian regions of Argentina. With regard to the surmised occurrence in the last area, it should be recalled that Frenguelli was in direct contact with Doello-Jurado, and he would presumably have been aware of all the material available to the latter. In any case, the Paraná and Camacho formations are correlated units, a fact recognized by authors since the early observations of Darwin (1839, 1846) and d'Orbigny (1842), to the isotopic dating of del Río *et al*. (2018), or the latest news about invertebrate fossils of Martínez *et al*. (2022). In consequence, it was reasonable to expect the presence of lingulids in the Paraná Formation.

At last, a couple of specimens turned up in the collections of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", which possess a considerable paleontological interest and historical value and help to corroborate the presence of lingulids for the three main lithostratigraphic units of the Entrerriense/Paranense transgression.

SYSTEMATIC PALEONTOLOGY

The classification follows Holmer & Popov (2000).
Phylum BRACHIOPODA Duméril, 1805
Class LINGULATA Williams, Carlson, Brunton, Holmer & Popov, 1996
Order LINGULIDA Waagen, 1885
Family LINGULIDAE Menke, 1828

Glottidia Dall, 1870

Glottidia bravardi? Figueiras & Martínez, 1995
(Figure 2)

Material. MACN-Pi 4083; a shell with conjoined valves and only the outer surface visible. MACN-Pi 4084; a bivalved shell with both valves rotated about the umbo and anteriorly damaged.
Geographic and stratigraphic provenance. Paraná, Argentina; Paraná Formation, Late Miocene.
Description. Shell thin, gently convex, spatuliform, smooth, surface only with gentle commarginal growth lines. Lateral margin smoothly convex anteriorly and subparallel posteriorly. Posterior margins nearly straight convergent. Umbonal area pointed.
Dimensions. MACN-Pi 4083: length (L): 35,2 mm; width (W): 15,5 mm; thickness (both valves conjoined) (T): 6,1 mm; umbonal angle: 60.3º; L/W: 2.27; T/L: 0.17; T/W: 0,39. MACN-Pi 4084: umbonal angle: 59.0º.

Remarks. Two genera of Lingulata are recognized nowadays for the Entrerriense/Paranense transgression: *Discinisca* Dall, 1871 (Pérez *et al*., 2013) and *Glottidia* Dall, 1870. The latter is known from the Puerto Madryn Formation (Frenguelli, 1927 as *Lingula* Bruguière, 1791; Figueiras & Martínez, 1995) and from the Camacho Formation (Kraglievich, 1928 as *Lingula*; Figueiras & Martínez, 1995). The shells under consideration undoubtedly belong to Lingulidae, being most probably a representative of *Glottidia*. Indeed, an old label handwritten by Martín Doello-Jurado himself states, "*Lingula* (*Glottidia*) *bravardi* D.J.", a *nomen nudum* for *Glottidia bravardi* (Figure 3). Another label states, "*Lingula pennula*," an even earlier *nomen nudum* by Bravard (Figure 3). Unfortunately, mostly only the outer surface is visible; nevertheless, the shell MACN-Pi 4083 is cracked and partly decorticated, and the internal presence of a pair of divergent septa is insinuated. Consequently, the present material may be identified (albeit with some reservation) with *Glottidia bravardi* Figueiras & Martínez, the holotype of which is herein illustrated (Figure 4) for objective comparison. Yet, adoption of open nomenclature, as *Glottidia bravardi*? seems prudent at this time.

The matrix is still adhered to one of the specimens (MACN-Pi 4084), consisting of a fine-grained, friable sandstone. The precise level(s) where these specimens come from is unknown, but it can be safely assumed that they belong to the Paraná Formation since this is the only marine unit that crops out around Paraná City.

In addition, this material is quite similar to *Glottidia antarctica* (Buckman) from the late Eocene Submeseta Formation (updated

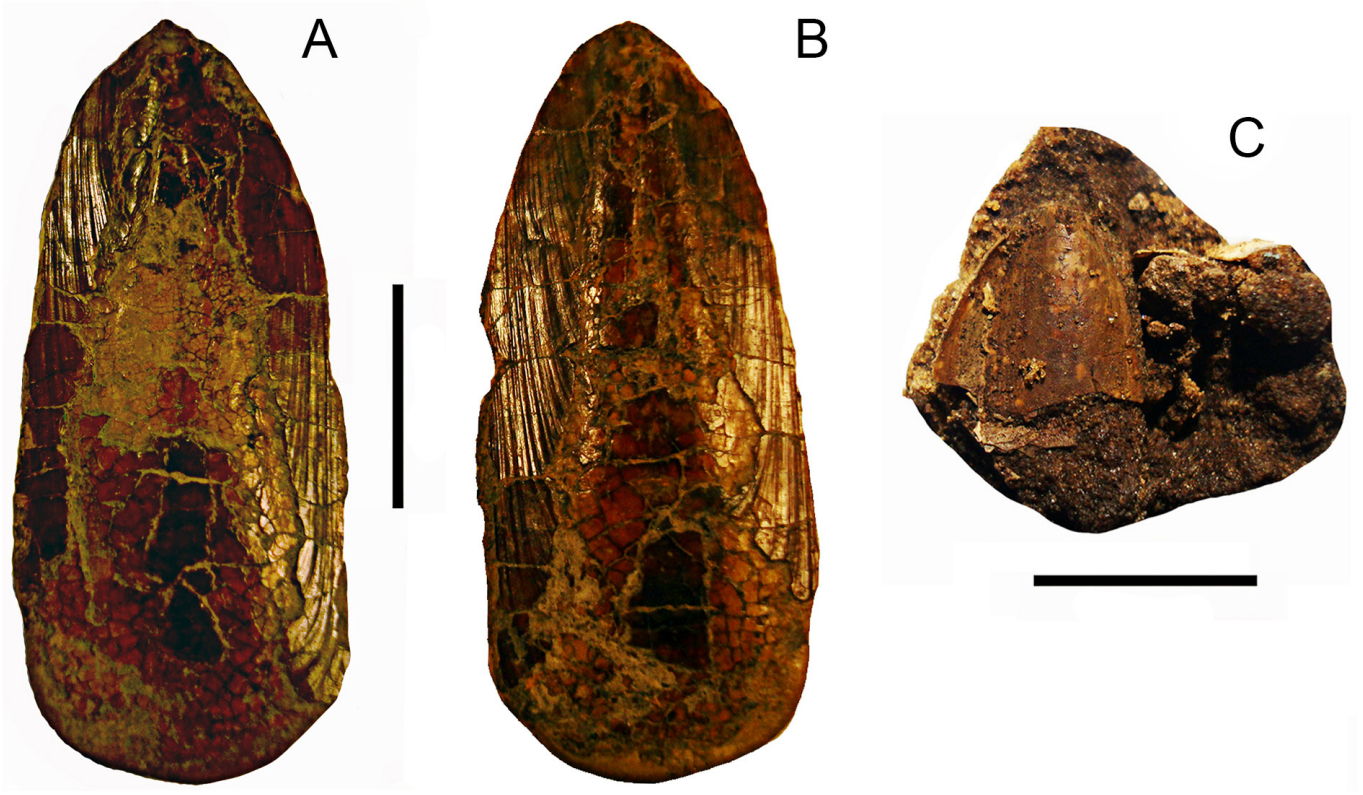

Figure 2. *Glottidia bravardi*? from Paraná. **A**, **B**, MACN-Pi 4083. **C**, MACN-Pi 4084. Scale bars = 10 mm.

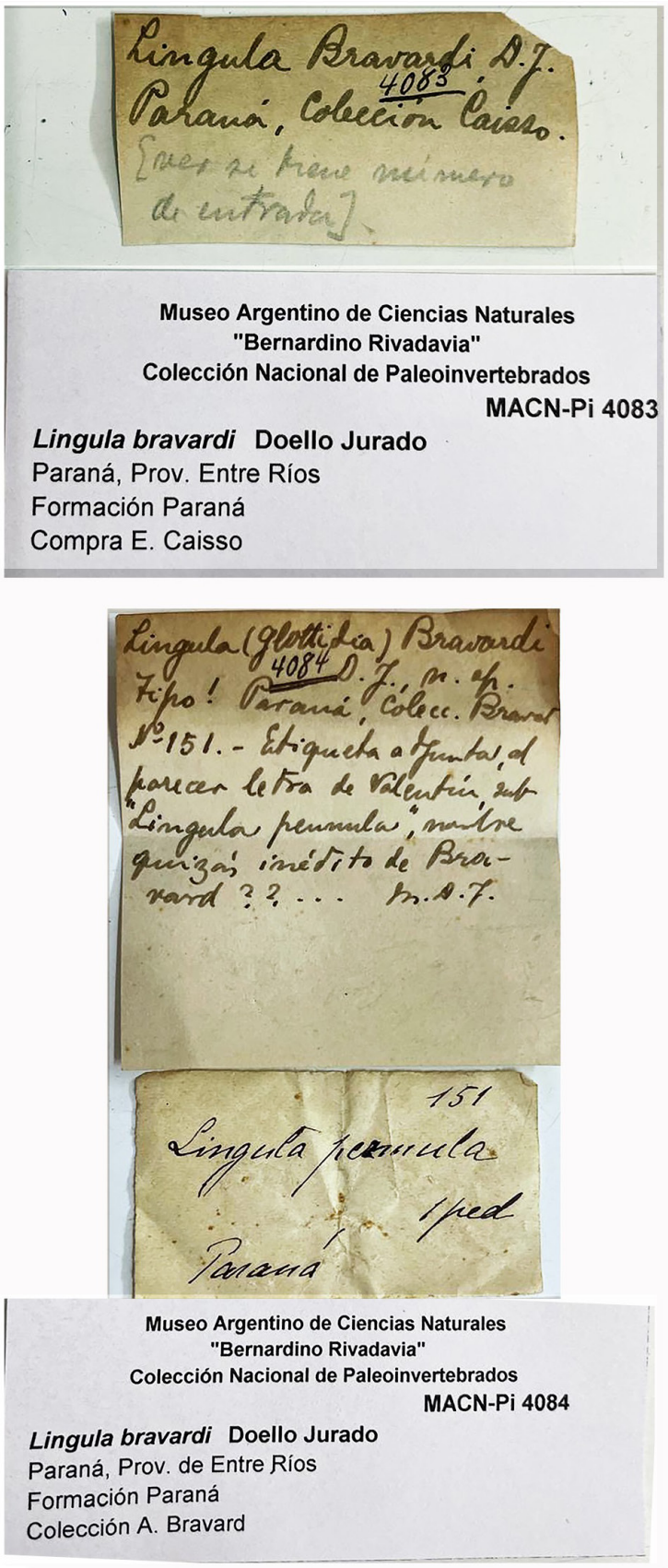

Figure 3. Original and modern labels of specimens (prior to this study). MACN-Pi 4083 and MACN-Pi 4084.

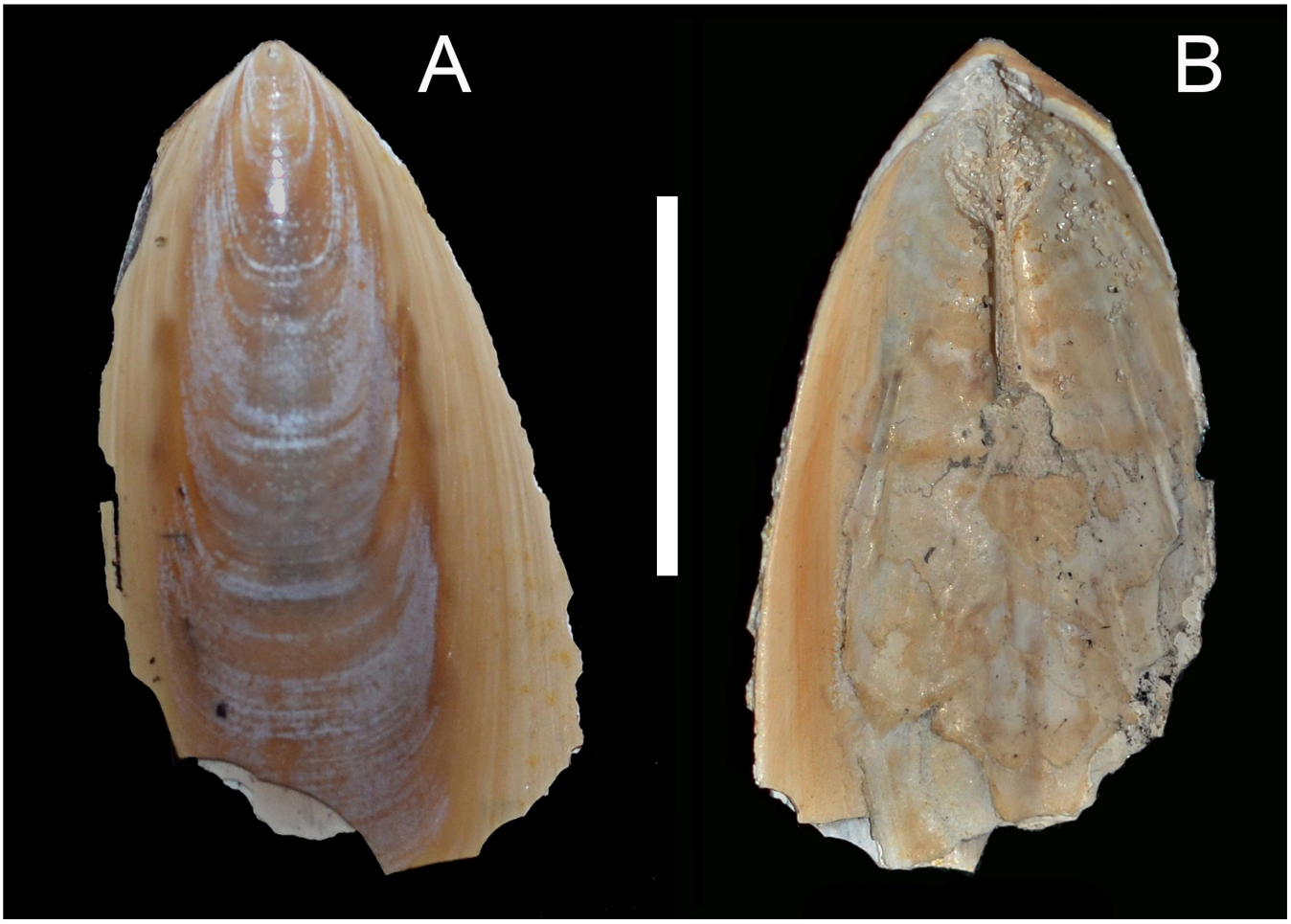

Figure 4. *Glottidia bravardi* from Camacho Formation, Barranca de los Loros. Holotype. **A**, **B**, FCDP 2554. Scale bar = 10 mm.

denomination of the bearing unit) of the Antarctic Peninsula (Buckman, 1910; Owen, 1980; Wiedman *et al*., 1988; Bitner, 1996a,c, 1997; Emig & Bitner, 2005b), which has a narrower umbonal angle (43.5º–52.2º, compared with 59º–60º), is proportionately longer than wide, with a L/W ratio 2.27–2.85, average 2.56, compared with 2.27, and the T/W ratio is greater than 0.20 (0.21 to 0.27) instead of 0.19 (*cf.* Emig & Bitner 2005b).

Quite recently, an indeterminate species of *Glottidia* has been documented in the Early Miocene Querales Formation from the Falcón Basin in northern Venezuela (Pérez *et al*., 2016, fig. 6.l) (Figure 1). This material shows a resemblance to the known specimens from Argentina and Uruguay, but it is too scanty for further comparison.

Other species with known fossil occurrences are: *Glottidia glauca* Chuang from the Lower Claiborne (Eocene) of La Salle Co., Texas, USA, with a L/W ratio 2.3–2.7 (Chuang, 1964c; Emig & Bitner 2005b, as a synonym of *G. antarctica*); *Glottidia albida* (Hinds), from Eocene to Pliocene strata of San Diego, California, USA , with a L/W ratio 1.86–2.27 (Hertlein & Grant, 1944, 1960); *Glottidia inexpectans* Olsson from the Yorktown Formation (Pliocene) of Hampton, Virginia, USA, with a L/W ratio 2.5–2.6 (Olsson, 1914; Chuang, 1964a; Cooper 1988); *Glottidia dumortieri* (Nyst) recorded from various Pliocene deposits of northwestern Europe (Belgium, England, Netherlands), with a L/W ratio 2.08 (Davidson, 1852, 1874; Chuang, 1964b) but absent from the Paratethys (Emig & Bitner, 2005a).

PALEOENVIRONMENTAL AND PALEOBIOGEOGRAPHIC SIGNIFICANCE

It is generally accepted that just two lingulid genera (*i.e.*, *Lingula* and *Glottidia*) have been recognized since early Paleogene times to the present (Emig, 1997b, 2003; Williams *et al*., 2000; Emig & Bitner 2005a, b). The separate distribution of extant taxa (widespread from the Indo-Pacific to Africa for *Lingula* with seven known species, whereas exclusively around the Americas, for the two or three of *Glottidia*) has been clearly depicted by them (Emig, 1997b, text-fig. 416; Williams *et al*., 2000, text-fig. 1). The latter authors have also stated that this situation most likely reflects an ancient dichotomy and further conjectured about possible migratory routes since the Late Cretaceous (Williams *et al*. 2000,

text-fig. 6). In such context, the findings described herein may offer a supplementary Paleogene/Neogene perspective for these paleobiogeographic interpretations. It is likewise known that living lingulids are roughly restricted within a latitudinal belt from 40º S to 40º N (Emig, 1997b, text-figs. 415, 417), which has been repeatedly blamed on limitations by cold winter temperatures (Paine, 1963; Rudwick, 1970, p. 158). Although temperature alone should not be regarded as the only limiting factor responsible for such latitudinal extension (due to the variable range of temperature tolerance among various populations, Emig, 1997a, Emig & Bitner, 2005b), it is evident that northernmost occurrences may be influenced by warm oceanic currents (such as Gulf Stream, Kuro Shio). All in all, it is remarkable that, in earlier times, *Glottidia* inhabited Antarctic waters, which by the Eocene were definitely warmer than those at present (Owen, 1980; Bitner, 1996b; Emig & Bitner, 2005b), and the progressive location of known fossil records along the Atlantic coast of South America reported is strongly reminiscent of the paleoceanographic scenario inferred for successive species of the terebratulide brachiopod *Bouchardia* after the onset of the Circum-Antarctic current system (Manceñido & Griffin, 1988, text-figs. 1–3). As a whole, the results from studying these fossil occurrences provide additional support to the interpretation that the brachiopod faunas of the Paraná and Camacho formations inhabited warm, tropical–subtropical seas (Sprechmann, 1978, 1980; Figueiras & Martínez, 1995) and may bear witness to a long-term northwards retraction through time (Manceñido & Griffin, 1988). This is consistent with assertions propounded on the basis of taxa from other phyla (*e.g.*, del Río, 1990; Martínez & del Río, 2002; Pérez *et al*., 2015).

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article.

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AUTHOR CONTRIBUTIONS

Sergio Martínez: writing - initial draft, editing, research. Miguel Oscar Manceñido: writing - advanced version, detailed research. Leandro Martín Pérez: review, investigation. Claudia J. Del Río: review, data curation. All authors gave final approval for publication and agreed to be held accountable for the work performed therein.

DECLARATION OF AI USE

We have not used AI-assisted technologies to create, review, or any part of this article.

ETHICS

This work did not require ethical approval, collecting licenses, or previous authorizations.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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