



CONULARIIDS FROM THE PONTA GROSSA FORMATION IN THE SOUTHWEST OF GONDWANA, MATO GROSSO DO SUL STATE, BRAZIL

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ABSTRACT – In the Mato Grosso do Sul State, there are outcrops of Paleozoic marine deposits of the Paraná Basin, which are characterized by the presence of a rich fauna of fossilized invertebrates (*i.e.*, conulariids, cnidarians), in the municipalities of Rio Negro, Rio Verde do Mato Grosso and Coxim. These fossils are from the Devonian (Pragian –Emsian) Ponta Grossa Formation and are very important for acquiring paleobiological and paleogeographical information on the Malvinokaffric Fauna. The conulariids analyzed were recorded in outcrops from the Rio Verde (P3), Fênix (P4) and Araras -Figueira (P6) mines. The conulariids belong to two species *Paraconularia africana* and *Conularia quichua*, with the latter predominating. Notably, the fossils are so well-preserved that the internal structures (*e.g.*, axial pillar and carina) in the basal region of the theca are visible. According to literature data, rocks of the Ponta Grossa Formation from the Rio Negro and Coxim regions (*e.g.*, outcrops MS 14 Estância Nhecolândia and MS65 Corredeira do Caeté) also revealed the presence of *Conularia quichua*, *Paraconularia africana*, *Paraconularia ulrichana* and *Reticulaconularia caetensis*. These species have been broadly paleobiogeographic distributed in the Andean-South African and Interior Gondwana seas bioregions.

Keywords: taxonomy, conulariids, Devonian, Southwest Gondwana, paleobiogeography.

RESUMO – No Estado do Mato Grosso do Sul ocorrem afloramentos de depósitos marinhos paleozoicos da Bacia do Paraná, caracterizados pela presença de uma rica fauna de invertebrados fossilizados (conularídeos, cnidários), nos municípios de Rio Negro, Rio Verde do Mato Grosso e Coxim. Esses fósseis são da Formação Ponta Grossa, Devoniano (Pragian –Emsiano), e são muito importantes para a aquisição de informações paleobiológicas e paleogeográficas sobre a Fauna Malvinocáfrica. Os conularídeos analisados foram registrados em afloramentos das minas Rio Verde (P3), Fênix (P4) e Araras -Figueira (P6). Os conularídeos pertencem a duas espécies *Paraconularia africana* e *Conularia quichua*, com predominância desta última. Notavelmente, os fósseis estão tão bem preservados que as estruturas internas (*e.g.*, pilar axial e carina) na região basal da teca são visíveis. Segundo dados da literatura, rochas da Formação Ponta Grossa das regiões Rio Negro e Coxim (*e.g.*, afloramentos MS 14 Estância Nhecolândia e MS65 Corredeira do Caeté), também revelaram a presença de *Conularia quichua*, *Paraconularia africana*, *Paraconularia ulrichana* e *Reticulaconularia caetensis*. Essas espécies possuem uma ampla distribuição paleobiogeográfica nas bioregiões dos mares Andino-Sul-Africano e do Interior de Gondwana.

Palavras-chave: taxonomia, conulários, Devoniano, Sudoeste Gondwana, paleobiogeografia.

INTRODUCTION

Conulariids are an extinct group of benthic marine cnidarians related to scyphozoans, which ranged from the late Ediacaran to the Late Triassic (Leme *et al.*, 2004, 2008, 2022; Van Iten *et al.*, 2006, 2014). The main characteristics of conulariids (Conulata; Van Iten, 1991a; Babcock *et al.*, 2005; Van Iten *et al.*, 2006, 2014; Leme *et al.*, 2008) are elongated pyramidal exoskeletons of calcium phosphate composition (Babcock & Feldmann, 1986), classified as sessile and benthic epifaunal organisms with four faces, although they can vary from three to six (Leme, 2006; Leme *et al.*, 2004, 2008).

The paleogeographic distribution of extinct taxa is essential for the construction of hypotheses and models of the paleoenvironments of a given region or period, which contributes to the understanding of relationships with the sedimentary basins of Andean-South Africa: Bolivian Chaco-Peru, Zorritas-NOA-South Bolivia, South Africa and Interior Gondwana: Alto Garças, Paraná and Parnaíba, during the Devonian (Ribeiro *et al.*, 2023). Although this period is mainly known for diversification and ecological expansion (Carvalho, 2010 a, b; Sedorko *et al.*, 2021), the Devonian Malvinokaffric biota of the Ponta Grossa Formation is predominantly formed by invertebrates. These organisms were common in the faunistic Devonian provinces of South America, being more abundant in Argentina, Bolivia, Brazil, Chile, Falkland Islands, Paraguay, Peru and Uruguay (Thomas, 1905; Clarke, 1913; Méndez-Alzola & Sprechmann, 1973; Babcock *et al.*, 1987; Babcock, 1993; Velazco, 2012; Leme *et al.*, 2004, 2015; Ribeiro *et al.*, 2023), occupying a marine environment of shallow and cold waters with high incidence of waves and varying rates of oxygenation (Montibeller *et al.*, 2017). Among these invertebrates, different taxa were present: Trilobitomorpha Walch (1771); Lingulida Waagen (1885); Orbiculoidea Biernat (1973); *Schuchertella* Girty (1904) and Conulariidae Walcott (1886).

This study aims to describe two species of conulariids from the municipalities of Rio Verde do Mato Grosso, *Paraconularia africana* and *Conularia quichua*. To understand the geographic paleodistribution in the Andean-South African and Interior Gondwana seas bioregions. Therefore contributing to the debate on the distribution of the Malvinokaffric Fauna of the Ponta Grossa Formation.

GEOLOGICAL SETTING

The Northwestern border of the Paraná Basin in the state of Mato Grosso do Sul (MS) exhibits an expressive Devonian outcrop NE-SW distribution, 300 km long and 35 km wide, containing fossils of marine invertebrates, plants, and fish fragments. The study area shows Paleozoic sedimentary sequences of the Paraná Group, comprising the following units: Furnas and Ponta Grossa formations (Figures 1–2; Milani *et al.*, 2007; Montibeller *et al.*, 2017). Previous surveys from 2010 onwards (Vilasboas *et al.*, 2022; Guedes

et al., 2023) have exhibited a paleontological heritage from the Lower Devonian. The fossil record of conulariids in the State of Mato Grosso do Sul shows discontinuous and irregular outcrops of the Ponta Grossa Formation, located in the central-north region of the state, encompassing the municipalities of Coxim, Pedro Gomes, Rio Negro and Rio Verde de Mato Grosso.

The field activities were carried out from 2019 to 2023 in order to obtain geological and paleontological information. The conulariids occur mainly in concretions from the dismantling of lithological materials performed by the ceramic industries, consisting of a package of gray to black shales and siltstones, with levels of clayey siltstones overlain by very fine micaceous feldspathic sandstones in cream, green, and reddish colors (Montibeller *et al.*, 2017). Field surveys were carried out in three mining fronts, located near the municipality of Rio Verde de Mato Grosso, MS, comprising the Rio Verde Mine (P3 – 18°56'19.56"S, 54°50'10.51"W, ~ 350 m above sea level (asl)), Fênix Mine (P4 – 18°55'33.94"S, 54°50'24.52"W ~ 366 m asl) and Araras Mine, formerly known as Figueira Mine (P6 – 18°55'3.04"S, 54°48'45.08"W, ~ 320 m asl) are close to each other and are part of the Ponta Grossa Formation (Figures 3–4, and Table 1). The surveys conducted by Guedes *et al.* (2023) in the cities of Rio Negro and Coxim provided significant evidence to support the biodiversity of conulariids in State of Mato Grosso do Sul, further corroborating the data collected in Rio Verde do Mato Grosso.

MATERIAL AND METHODS

After separating, treating, and labeling samples, 46 specimens were formally included in the Paleontological Collection, Faculdade de Engenharias, Arquitetura e Urbanismo e Geografia, Universidade Federal do Mato Grosso do Sul (GeoPalab/FAENG/UFMS). Among these, 24 samples were described and identified in this analysis, of which three don't have any identification. Based on the taxonomic, morphologic, and comparative revisions of the list of characters and considering criteria such as preservation of theca and clarity in visualizing the ornaments for the cladistic definition of the Conulariids group (Leme, 2006; Leme *et al.*, 2004, 2008), a sample classification was made possible. The samples were cleaned and prepared through submersion in water with a solution of 1/3 acetic acid, followed by a meticulous extraction to remove the fossils from the concretions. Mechanical preparation with chisels and brushes was used to remove the excess sediment.

Conulariids classification is based on 17 characters representing external and internal morphological structures, in addition to standardizing and revising descriptive terms previously used by Moore & Harrington (1956a, b), Babcock & Feldmann (1986), Leme (2002), Siviero (2002), Leme (2006) and Leme *et al.* (2004, 2008), taking into account the possible presence of taphotaxa (see Simões *et al.*, 2003), such as theca exfoliation or the bending by mechanical

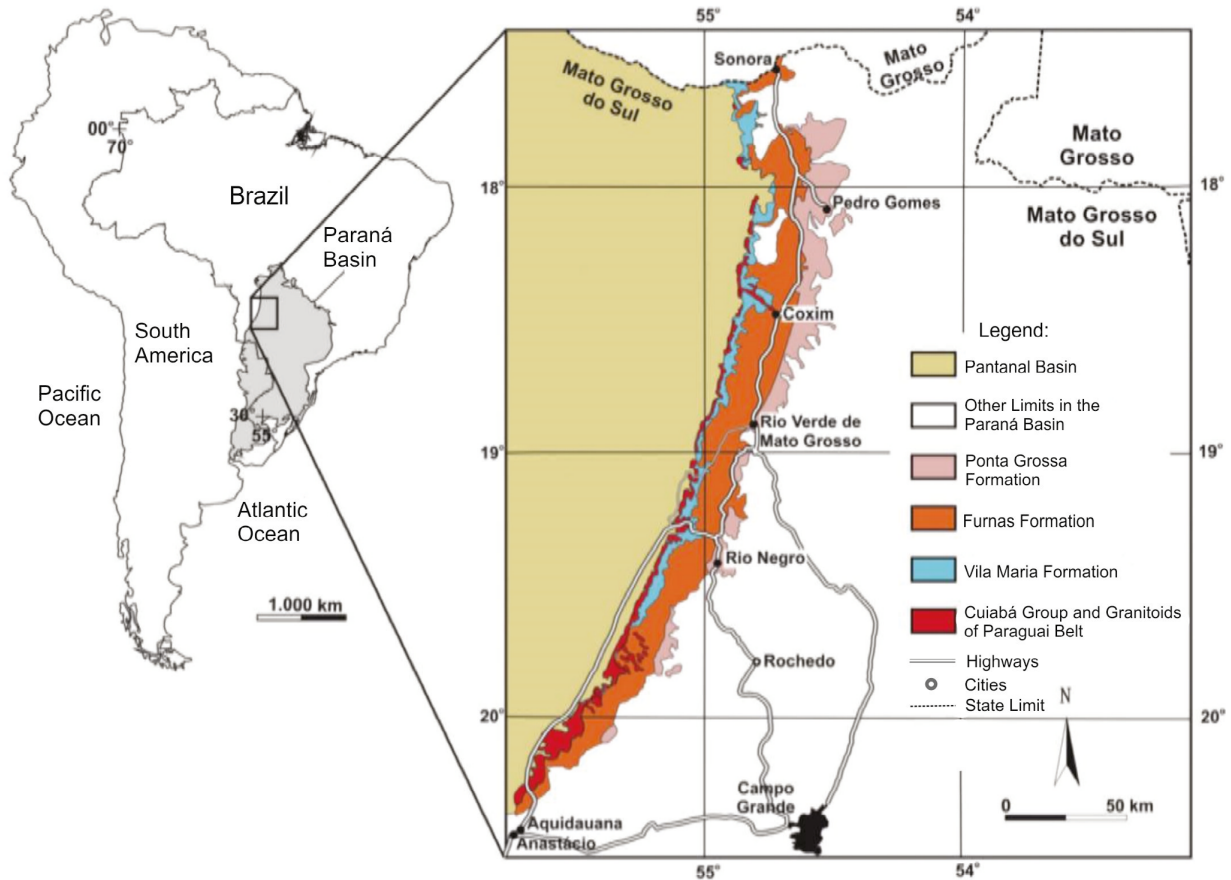


Figure 1. Outcrop area of the Devonian units of the Paraná Basin in the State of Mato Grosso do Sul. Montibeller *et al.* (2017).

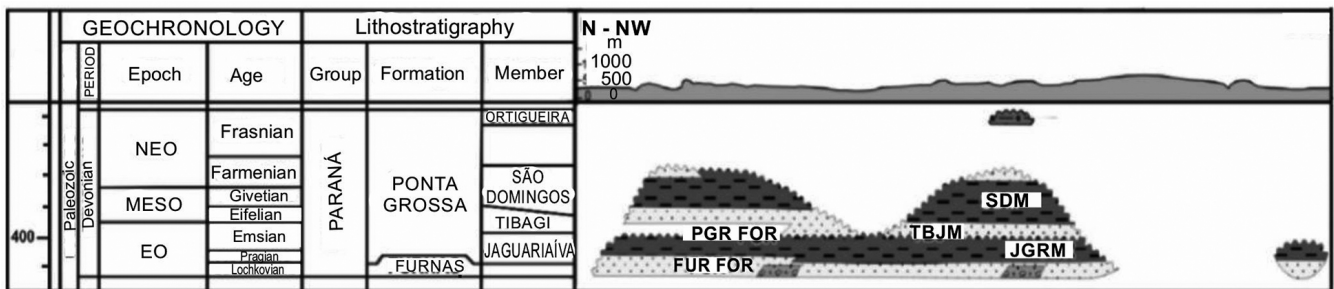


Figure 2. Chronostratigraphic chart of the Paraná Group. Scheffler *et al.* (2020, modified from Milani *et al.*, 2007).

deformation. At the Ecology Laboratory of the Biosciences Institute (INBIO/UFMS) the specimens were analyzed and photographed using a stereomicroscope model ZEISS StEREO Discovery.V20 (Figure 5 and Table 2).

The basic morphological structures for identification were all external (Figure 6), represented by the following items from the mentioned list: 1, 2, 3, 4, 5, 6, 7, 8, 9, 13. Items 10

to 12 are internal characters whose diagnosis requires a clean sample cross-section. Only one sample had a clean cross-section but did not indicate any of the mentioned structures. Items 14 to 17 are characters of identification and definition of the internal-external group of conulariids. Therefore, they were not used for morphological identification within the group.

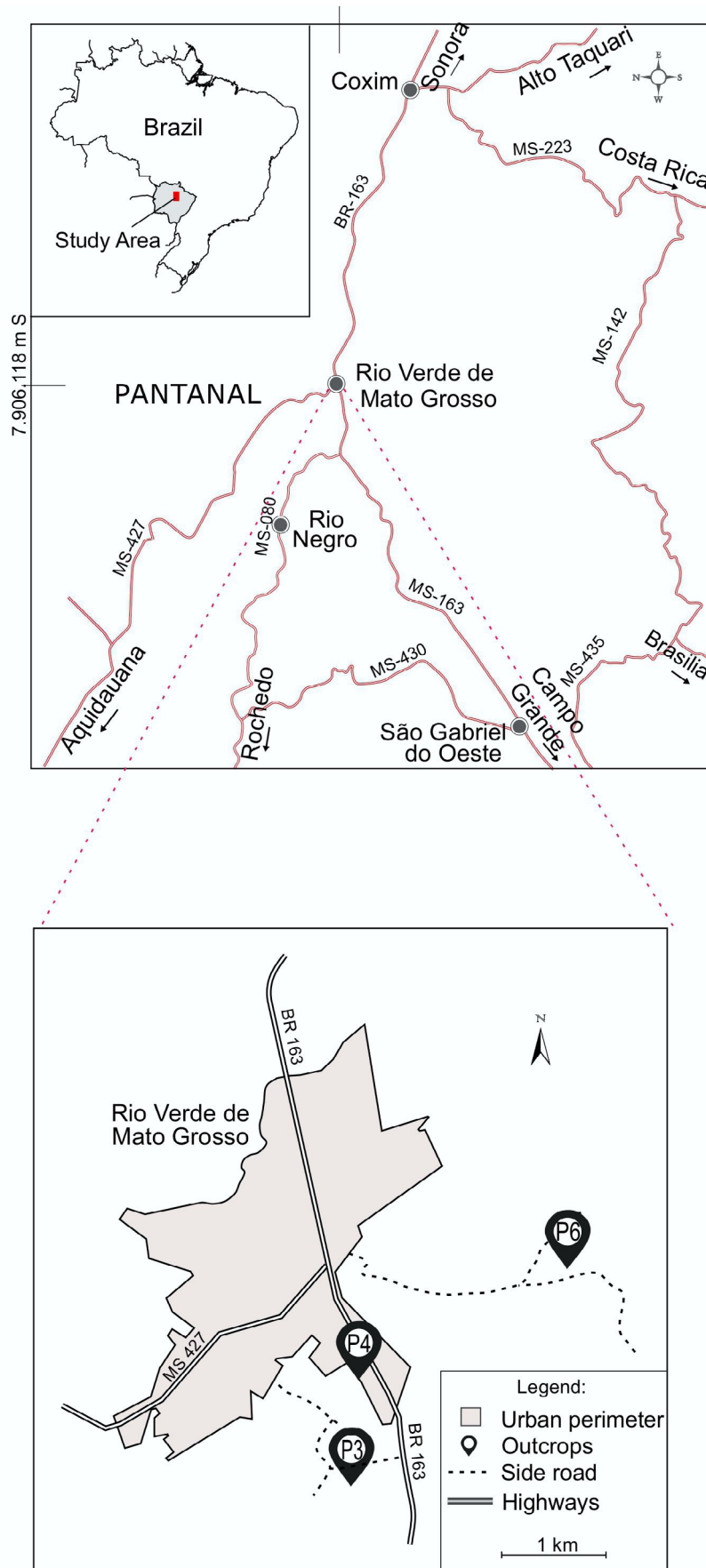


Figure 3. Location of sampled points in the description of the geological and fossiliferous unit. Map adapted from Montibeller *et al.* (2017) and Becker-Kerber *et al.* (2017).



Figure 4. Dismantling of siltstones, mudstones, and dark shales of the Ponta Grossa Formation. Figueira Mine (P6 – 18°55'3.04"S, 54°48'45.08"W, ~ 320 m above sea level), Rio Verde de Mato Grosso, MS.

Table 1. Analyzed samples from the mines in the region of Rio Verde de Mato Grosso, MS.

Specimen	Origin	Lithostatigraphic unit
CGP/1A- 169	Rio Verde Mine P3 18°56'19.56"S, 54°50'10.51"W	Ponta Grossa Formation
CGP/1A- 174		
CGP/1A- 180		
CGP/1A- 186		
CGP/1A- 195		
CGP/1A- 372		
CGP/1A- 173	Fênix Mine P4 18°55'33.94"S, 54°50'24.52"W	
CGP/1A- 163		
CGP/1A- 164		
CGP/1A- 165	Figueira Mine P6 18°55'3.04"S, 54°48'45.08"W	
CGP/1A- 166		
CGP/1A- 167		
CGP/1A- 168		
CGP/1A- 178		
CGP/1A- 179		
CGP/1A- 194		
CGP/1A- 198		
CGP/1A- 199		
CGP/1A- 368		
CGP/1A- 369		
CGP/1A- 370		
CGP/1A- 171	No mine identification	
CGP/1A- 172		
CGP/1A- 196		

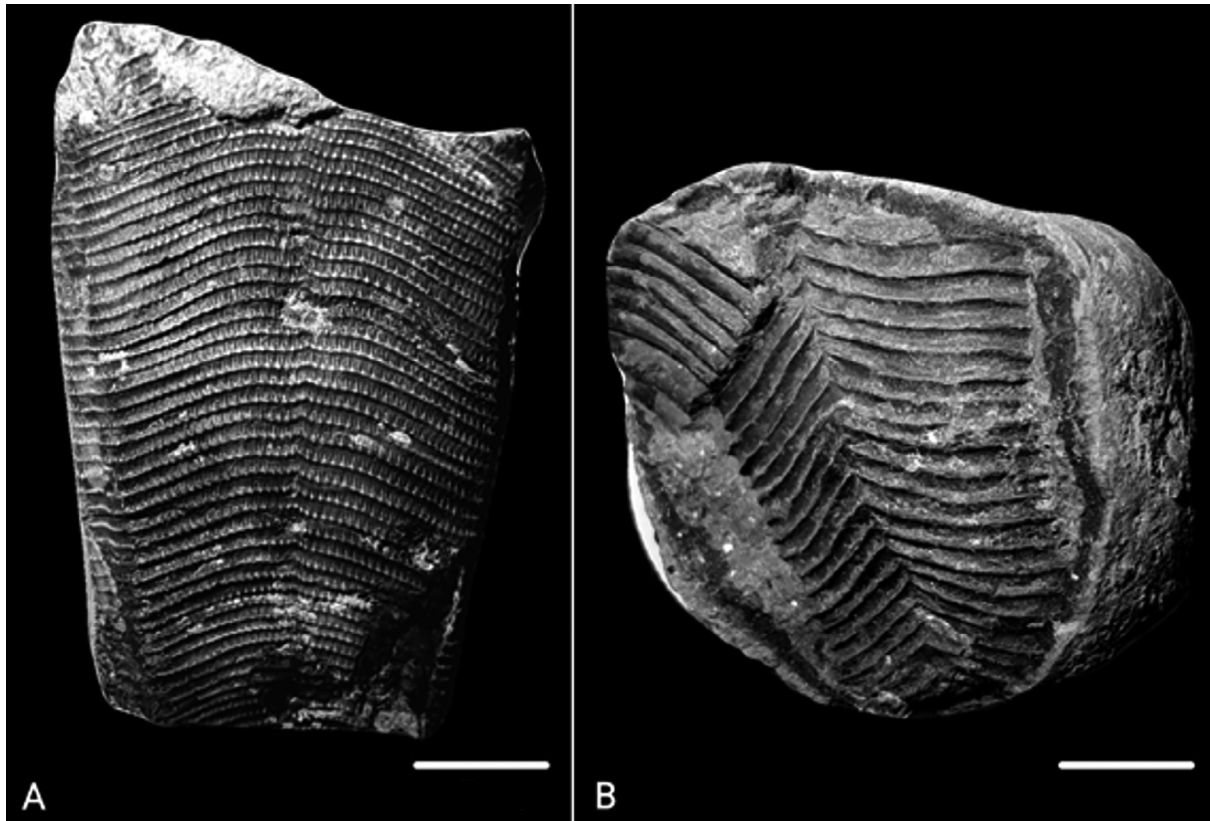


Figure 5. Specimens show the criteria of preservation and the ornaments. **A**, a specimen showing conservation of the theca and the types of articulation with apparent nodes and ridges; **B**, type of articulation and ornamentation, according to the criteria by Leme (2006) for their classification. Scale bars = 5 mm.

Table 2. Morphological characters refined by Leme (2006) and Leme *et al.* (2004, 2008).

Characters	Characters state		
1. Transverse cross-section of the oral region of the polyp	0 – Circular	1 – Quadrate	–
2. External ornamentation of the periderm	0 – Transverse ribs	1 – Nodes	2 – Tubercles
3. Longitudinal cross-section of the transverse ribs	0 – Sinusoidal	1 – Trochoidal	–
4. Inflection (adapertural arching) of the transverse ornament at the interradial (midline)	0 – Present	1 – Absent	–
5. Transverse ornament at the interradial (midline)	0 – Absent	1 – Present	–
6. Continuation of the transverse facial ornament across the perradial (corner)	0 – Present	1 – Absent	–
7. Nature of the transverse ornamentation at the perradial (corner)	0 – Continuous	1 – Disrupted	–
8. Transverse cross-section of the corner sulcus	0 – Rounded	1 – Angulated	2 – Angulated with fold
9. External peridermal ornamentation at the interradial (midline)	0 – Absent	1 – Present	–
10. Septa	0 – Absent	1 – Present	–
11. Morphology of the gastric septa	0 – Simple	1 – Bifurcated	–
12. Carina	0 – Absent	1 – Present	–
13. Crests	0 – Absent	1 – Present	–
14. Periderm	0 – Absent	1 – Present but limited to the basal area of the polyp	2 – Present and covering most of the polyp
15. Mineralized periderm	0 – Present	1 – Absent	–
16. Symmetry	0 – Radial tetramerous	1 – Biradial	–
17. Type of medusa formation	0 – Strobilation	1 – Metamorphosis without transverse fission	–

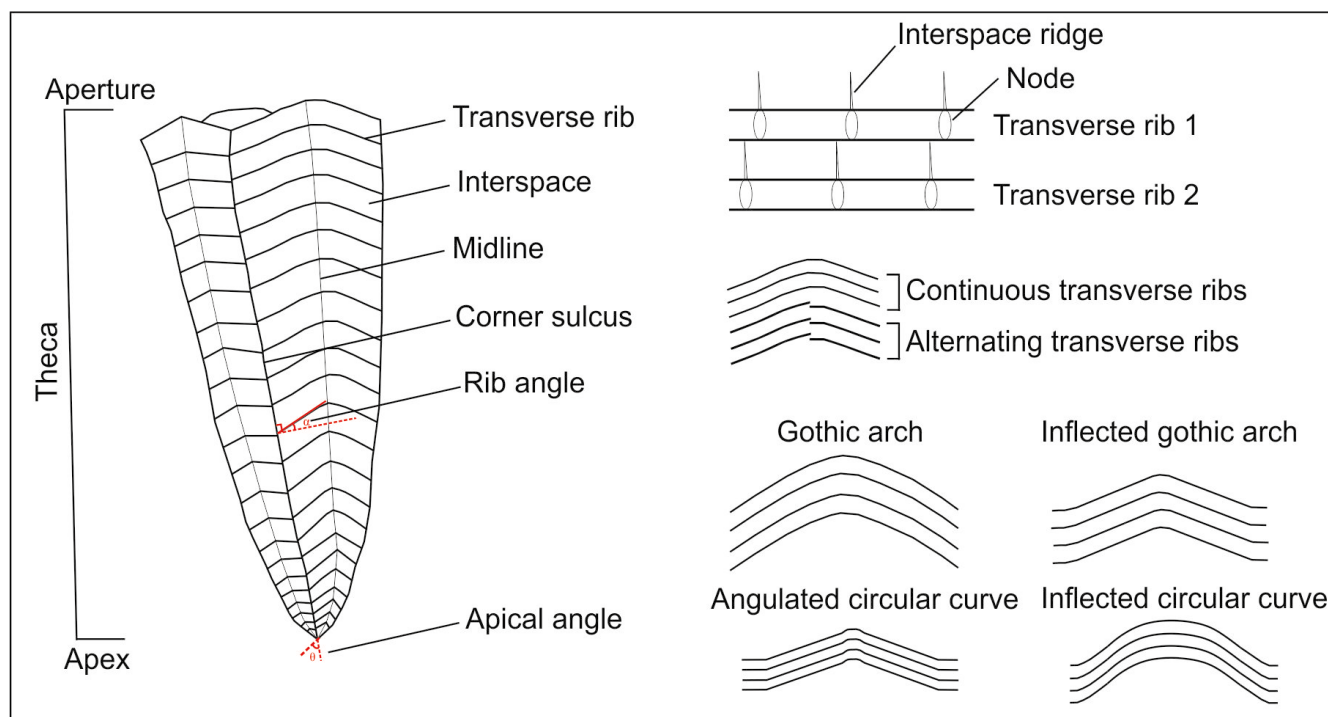


Figure 6. Conulariidae group morphology with the main characters used in the descriptions, modified from Babcock & Feldmann (1986), Van Iten *et al.* (1996), Leme *et al.* (2004), and Guedes *et al.* (2023). Adapted from Guedes *et al.* (2023).

RESULTS

The systematic study of the conulariid fauna of the Paraná Basin in its northwestern part, State of Mato Grosso do Sul, showed the presence of at least two species: *Conularia quichua* (Ulrich, 1890) and *Paraconularia africana* (Sharpe, 1856). The morphological terminology of the conulariid theca was presented by Babcock & Feldman (1986), emphasizing its external features (midline, corner sulcus, rib angle). The preservation method was followed to determine and describe these morphological features, mainly of the morphometric characters. In this way, the recommendations made by Leme (2002), Rodrigues (2002), and Rodrigues *et al.* (2003) were followed, namely: (i) the study of the collection (GeoPaLab-Faeng-UFMS) was based to identify the largest possible spectrum of morphological variations resulting from taphonomic changes; (ii) priority was given to examine slightly deformed (well-preserved) specimens; and (iii) the descriptions were based on complete specimens. Regarding the nomenclature of morphological terms, we used those applied by Sinclair (1940, 1942, 1948, 1952); Moore & Harrington (1956a, b); Bischoff (1978); Van Iten (1991a, b); Van Iten *et al.* (1996) and Leme *et al.* (2004, 2008).

The 24 collected samples were identified (with listing number following sequences between CGP/1A: 163, 164, 165, 166, 167, 168, 169, 174, 179, 178, 180, 186, 194, 195, 198, 199, 368, 369, 370 and 372. However, three samples, CGP/1A: 171, 172, 196, did not contain their identified provenance mine locations, but they come from the same

lithological materials, deposited within the GeoPaLab/FAENG/UFMS. Two types of conulariids were identified: *Conularia quichua* and *Paraconularia africana* (Table 3).

SYSTEMATIC PALEONTOLOGY

Subclass CONULATAE Collins *et al.*, 2000
Family CONULARIIDAE Walcott, 1886

Conularia Sowerby, 1820

Type species. *Conularia quadrisulcata* (Sowerby, 1820).

Conularia quichua Ulrich, 1890
(Figures 7–8)

1890 *Conularia quichua*: Ulrich in Steinmann & Döderlein, p. 343, fig. 395d–e; Ulrich, 1892:34–36, pl. 3, fig. 7a–b; Bernard, 1895, fig. 265c; Reed, 1904:248, pl. 30, figs. 10–10a; Clarke, 1913:163; Douglas, 1920:37–38, pl. 1, fig. 3; Kozłowski, 1923:69–70, pl. 7, fig. 6; Reed, 1925:107; Ulrich in Steinmann, 1930, figs. 21d–e; Kiderlen, 1937, fig. 10; Ahlfeld & Branisa, 1960, pl. 4, figs. 4, 10–10a; Hasman *et al.*, 1962:21; Branisa, 1965, pl. 43, figs. 1, 3–4, pl. 45, figs. 2–4, 6–12; Babcock *et al.*, 1987:218, fig. 4; Leme, 2002:33, pl. 1, 2.; Leme *et al.*, 2004, fig. 4.

1897 *Conularia quichua*: Ulrich? Kayser: p. 288, pl. 11, figs. 1–2; Thomas, 1905:254–255, pl. 12, fig. 19.

Table 3. List of conulariid samples identified in relation to morphological characters. Due to their preservation, the characters represented by “?” couldn’t be identified within the specimens. The characters are listed in Table 2.

Specimen	Characters												Identification
	1	2	3	4	5	6	7	8	9	10-12	13	14-17	
CGP/1A 163	1	0	0	0	0	0	0	0	0	X	1	X	<i>Conularia quichua</i>
CGP/1A 164	1	0	0	0	0	0	0	0	0	X	1	X	<i>Conularia quichua</i>
CGP/1A 165	1	0	0	0	0	0	0	0	0	X	1	X	<i>Conularia quichua</i>
CGP/1A 166	1	0	?	1	?	?	1	?	?	X	?	X	<i>Paraconularia africana</i>
CGP/1A 167	1	0	?	1	1	0	1	?	0	X	?	X	<i>Paraconularia africana</i>
CGP/1A 168	1	0	?	1	?	0	1	?	?	X	?	X	<i>Paraconularia africana</i>
CGP/1A 169	1	0	0	0	0	0	0	0	0	X	1	X	<i>Conularia quichua</i>
CGP/1A 171	1	0	?	1	?	?	?	?	0	X	0	X	<i>Paraconularia sp.</i>
CGP/1A 172	1	0	1	1	?	0	1	1	0	X	0	X	<i>Paraconularia sp.</i>
CGP/1A 173	1	0	1	1	1	0	1	1	0	X	0	X	<i>Paraconularia sp.</i>
CGP/1A 174	1	0	?	1	?	0	1	1	0	X	0	X	<i>Paraconularia sp.</i>
CGP/1A 178	1	0	1	1	1	?	?	?	0	X	0	X	<i>Paraconularia sp.</i>
CGP/1A 179	1	0	0	0	0	0	0	0	0	X	1	X	<i>Conularia quichua</i>
CGP/1A 180	1	0	1	1	1	0	1	1	0	X	0	X	<i>Paraconularia sp.</i>
CGP/1A 186	1	0	1	1	1	?	1	1	0	X	0	X	<i>Paraconularia sp.</i>
CGP/1A 194	1	0	0	0	0	0	0	0	0	X	1	X	<i>Conularia quichua</i>
CGP/1A 195	1	0	?	0	0	?	0	0	0	X	?	X	<i>Conularia quichua</i>
CGP/1A 196	1	0	?	0	0	0	0	0	0	X	?	X	<i>Conularia quichua</i>
CGP/1A 198	1	0	0	0	0	0	?	?	0	X	1	X	<i>Conularia quichua</i>
CGP/1A 199	1	0	1	1	1	0	?	?	0	X	0	X	<i>Conularia quichua</i>
CGP/1A 368	1	0	0	0	0	0	0	1	0	X	0	X	<i>Conularia quichua</i>
CGP/1A 369	1	?	?	?	?	?	?	?	?	X	?	X	<i>Conularia quichua</i>
CGP/1A 370	1	0	0	0	0	?	?	?	0	X	0	X	<i>Paraconularia africana</i>
CGP/1A 372	1	0	1	0	0	0	0	1	1	X	0	X	<i>Conularia quichua</i>

1939 *Conularia (Mesoconularia) quichua* Ulrich: Boucek, fig. 3e.

1948 *Mesoconularia quichua* Ulrich: Sinclair, p. 119.

1904 *Conularia cf. undulata* Conrad: *sensu* Reed, p. 248–249, pl. 31, figs. 1–1a; Hansman *et al.*, 1962:21–22.

1960 *Conularia cf. quichua* Ulrich: Ahlfeld & Branisa, pl. 4, fig. 9; Lof, 1985.

1965 *Conularia quichua* var. nov.: Branisa, pl. 43, fig. 2.

1965 *Conularia* sp.: Branisa, pl. 43, figs. 5–6.

Diagnosis. conulariids with angulated circular curve articulation in the adaperatural and middle regions (Figure 7A–C) and gothic arch articulation in the basal region (Figure 7A); crests present in the interspaces (Figure 7B–C). Axial pillar present (Figure 8C–D).

Type material. Holotype lost (Babcock *et al.*, 1987). YPFB 3432 and USNM 409818 (Neotypes).

Material. Specimen preserved in concretions: CGP/1A 163; CGP/1A 164; CGP/1A 165; CGP/1A 169; CGP/1A 179; CGP/1A 194; CGP/1A 195; CGP/1A 196; CGP/1A 198; CGP/1A 199; CGP/1A 368; CGP/1A 369; CGP/1A 372.

Occurrence. Ponta Grossa Formation, Devonian (Pragian–Emsian), Alto Garças Sub-basin, Paraná Basin, City of Rio Verde de Mato Grosso, State of Mato Grosso do Sul, Brazil. Figueira Mine (P6 – 18°55'3.04"S, 54°48'45.08"W, ~ 320 m high).

Description. Complete conulariids (CGP/1A 199; CGP/1A 372). Lacking the base of the theca (CGP/1A 163; CGP/1A 164; CGP/1A 165; CGP/1A 179; CGP/1A 194; CGP/1A 195; CGP/1A 368; CGP/1A 369). Theca partially fragmented (CGP/1A 169; CGP/1A 196; CGP/1A 198). All specimens have four similar faces, with lengths varying from 2,50 to 7,00 cm. Round axial pillar with the same constitution as the theca, interconnected by the carinae, present in two specimens (CGP/1A 195 and CGP/1A 199), highlighting the high degree of basal preservation without the flattening process, corresponding to Figure 8. Transverse ribs articulation of Gothic arch type, ridges and nodes present and schematized in Figures 6 and 7. Midline with opposed ornamentations and angulated corner sulcus with continuous transverse ribs (Figure 8A).

Comments. *Conularia quichua* distinguishes from all described species of conulariids; it has thickened edges in the basal region, extending to a “central pillar” and structures related to longitudinal septa united in this region (Leme *et al.*, 2004). These individuals can occur isolated or forming groups of two or three specimens, with a paleogeographic distribution in the Malvinokaffric region, in the Devonian terrains of Peru, Bolivia, Chile, Argentina, Paraguay, Uruguay, Brazil and South Africa (Leme *et al.*, 2004, 2008). The taxonomic proposal by Ulrich (1890) underwent revisions due to divergences. The specimens present striking characteristics of *Conularia quichua*, exhibiting structures that are easy to visualize and classify. The evaluation of the samples reaffirms the conclusion of Leme *et al.* (2004) about the dominance of this species in the fauna of the northwestern border of the Paraná Basin.

All the specimens present in this contribution have four faces, but *Conularia quichua* stands out for being able to present up to five true faces. Due to the remarkable fossil preservation, it became possible to examine the inner region of this conulariids species, called axial pillar, at the base of the theca and in the apical angle. This analysis allowed the observation of straight septa and carinae. The occurrence of this characteristic is rare, being the first record of this structure in conulariids specimens of the northwestern border of the Paraná Basin, with circular features. Only two specimens of *C. quichua* sampled in this paper, CGP/1A 195 and CGP/1A 199 (Figure 8), show this feature. In fact, new occurrences and information about the anatomy of thecas exhibiting internal structures supply subsidies for a better understanding about the anatomic variation and the morphological complexity of the Conulatae. This structure has not been examined for the remaining conulariids genus yet, being an exclusive structure of *C. quichua*.

Paraconularia Sinclair, 1940

Type species. *Conularia inaequicostata* Koninck (1883).

Paraconularia africana (Sharpe, 1856) (Figure 9)

1856 *Conularia africana*: Sharpe, p. 214, pl. 27, figs. 13a–b; Ulrich, 1892, p. 29–31, pl. 3, fig. 4; Reed, 1904, p. 247–248; Schwarz, 1906, p. 362–363, pl. 7, figs. 13, 15; Reed, 1925, p. 103; Kiderlen, 1937, figs. 15, 26; 1–2; Moore & Harrington, 1956b, p. F60–F61, figs. 46, 11; Ahlfeld & Branisa, 1960, pl. 4, fig. 13; Hansman *et al.*, 1962, p. 21; Branisa, 1965, pl. 44, figs. 1–3, 6, 12, 14–16; Méndez-Alzola & Sprechmann, 1973, p. 130, pl. 1, fig. 1; Babcock *et al.*, 1987, figs. 4a–d, 8c, tab. 1.

1923 *Conularia africana* var. *striatula*: Kozłowski, p. 67–68, pl. 7, figs. 1–3.

1948 *Paraconularia africana* (Sharpe): Sinclair, p. 187–188; Babcock *et al.*, 1987, p. 221, fig. 7; Leme, 2002, p. 42, pl. 3.; Leme *et al.*, 2004, p. 218, fig. 5.

1948 *Conularia* s.l. *striatula* Kozłowski: Sinclair, p. 285.

1960 *Conularia africana striatula* Kozłowski: Ahlfeld & Branisa, pl. 4, fig. 3; Branisa, 1965, pl. 44, figs. 5, 7, 10.

1965 *Conularia* sp.: Branisa, pl. 44, fig. 4, pl. 78, fig. 5.

1906 *Conularia baini* Ulrich: *sensu* Schwarz, p. 362, pl. 8 fig. 14; Branisa, 1965, pl. 44, figs. 14–16.

Diagnosis. Conulariids with theca ornamented by trochoidal transverse ribs, frequently alternating in the midline; discontinuous, alternating and interlaced in the corner sulcus; articulation of gothic type or inflected circular curve; the corner sulcus is angled, while the midline is traced by the flexion of the transverse ribs or by external bending; nodes and interspace ridges are rarely observed, and tubercles are absent. **Type material.** Holotype lost (Babcock *et al.*, 1987). BM (NH) 4279 (lectotype) and BM (NH) 4278 (paralectotype).

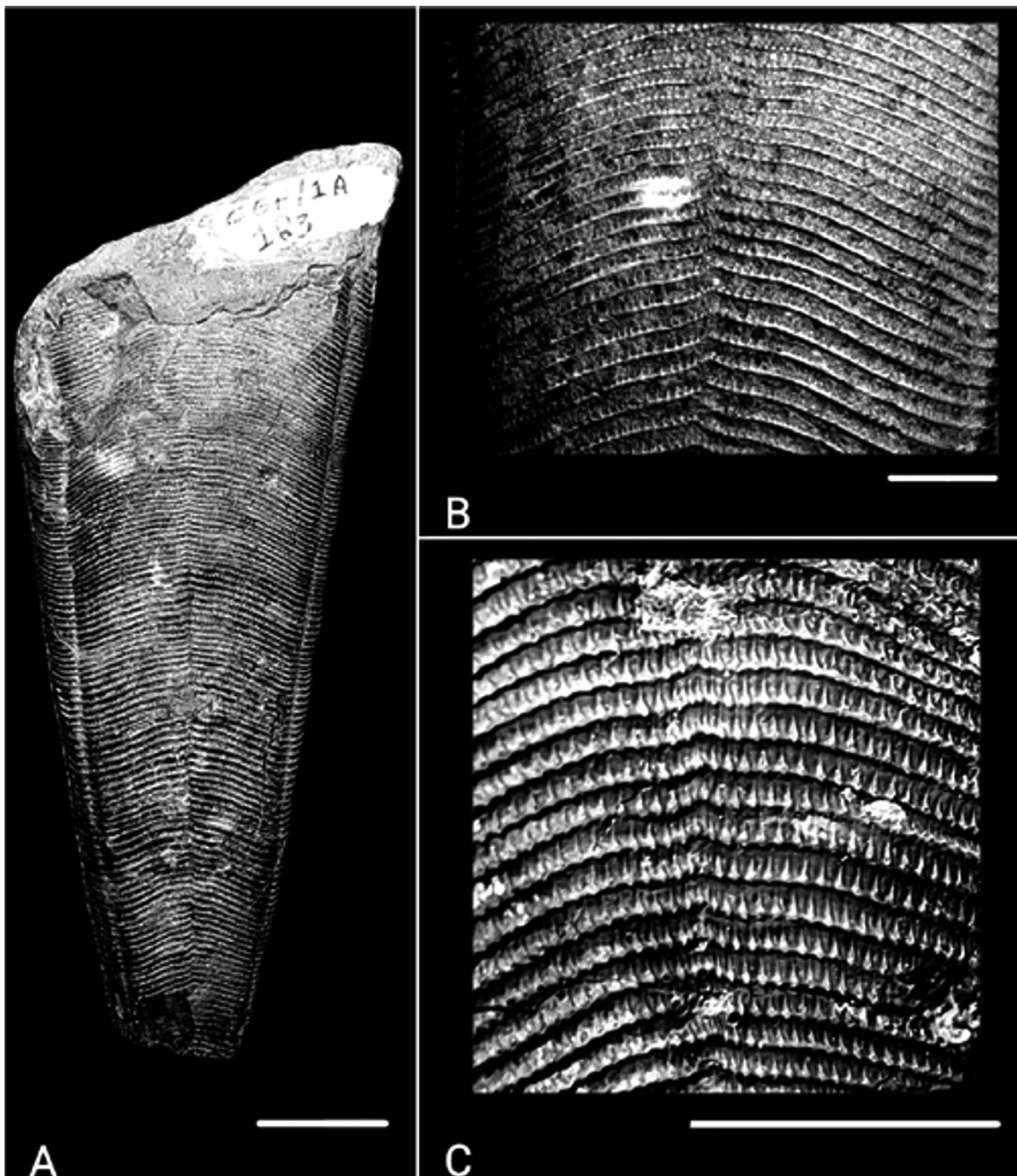


Figure 7. *Conularia quichua*. A–B, CGP/1A 163, tetrameric radial symmetry, general view of the specimen (A); angulated circular curve articulation (B). C, CGP/1A 194, nodes and interspace ridges present. Scale bars: A–B = 10 mm; C = 5 mm.

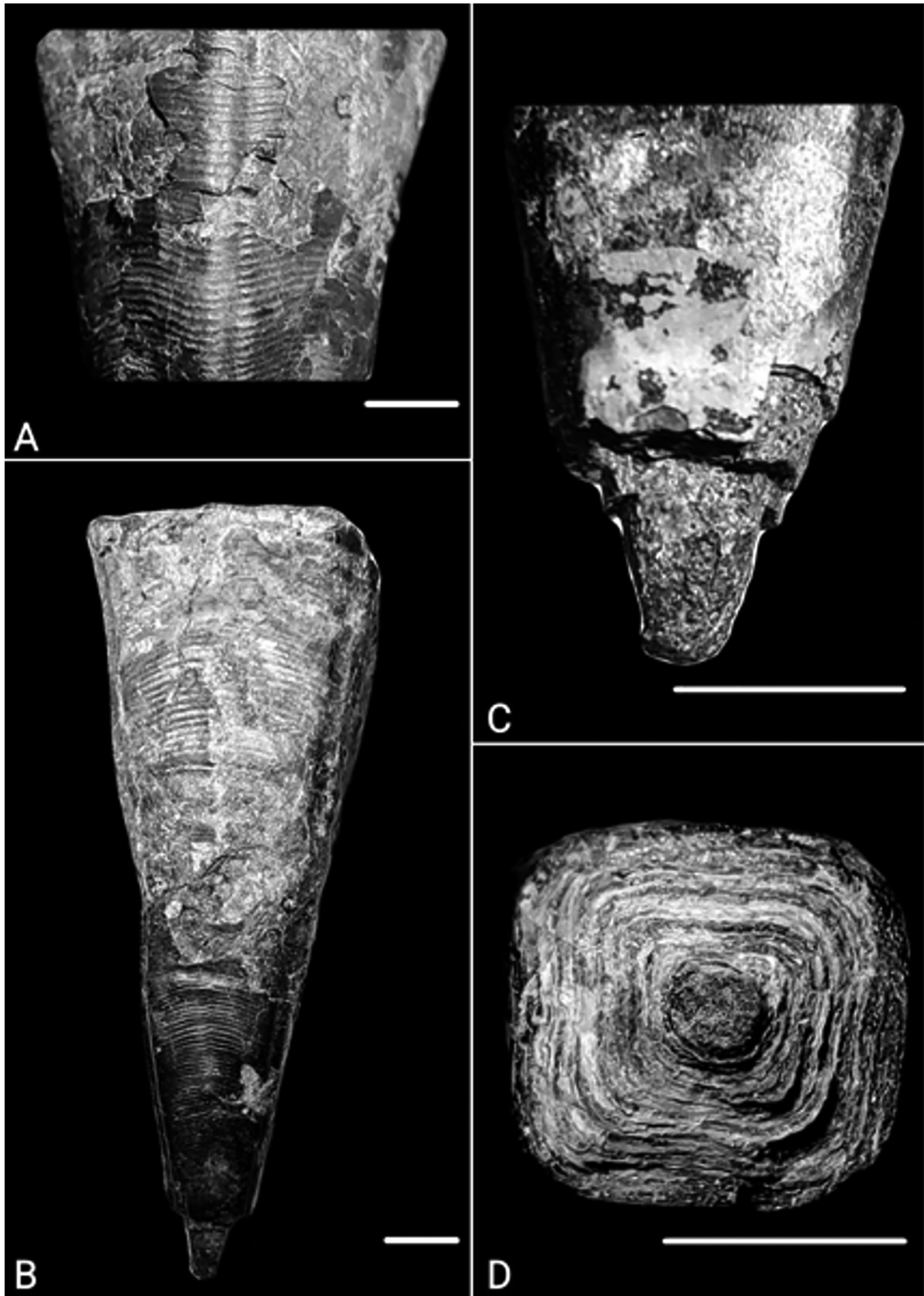


Figure 8. *Conularia quichua*. A–C, CGP/1A 199, corner sulcus with continuous transverse ribs (A); complete external theca (B); axial pillar, internal structure (C). D, CGP/1A 195, axial pillar, internal structure. Scale bars = 5 mm.

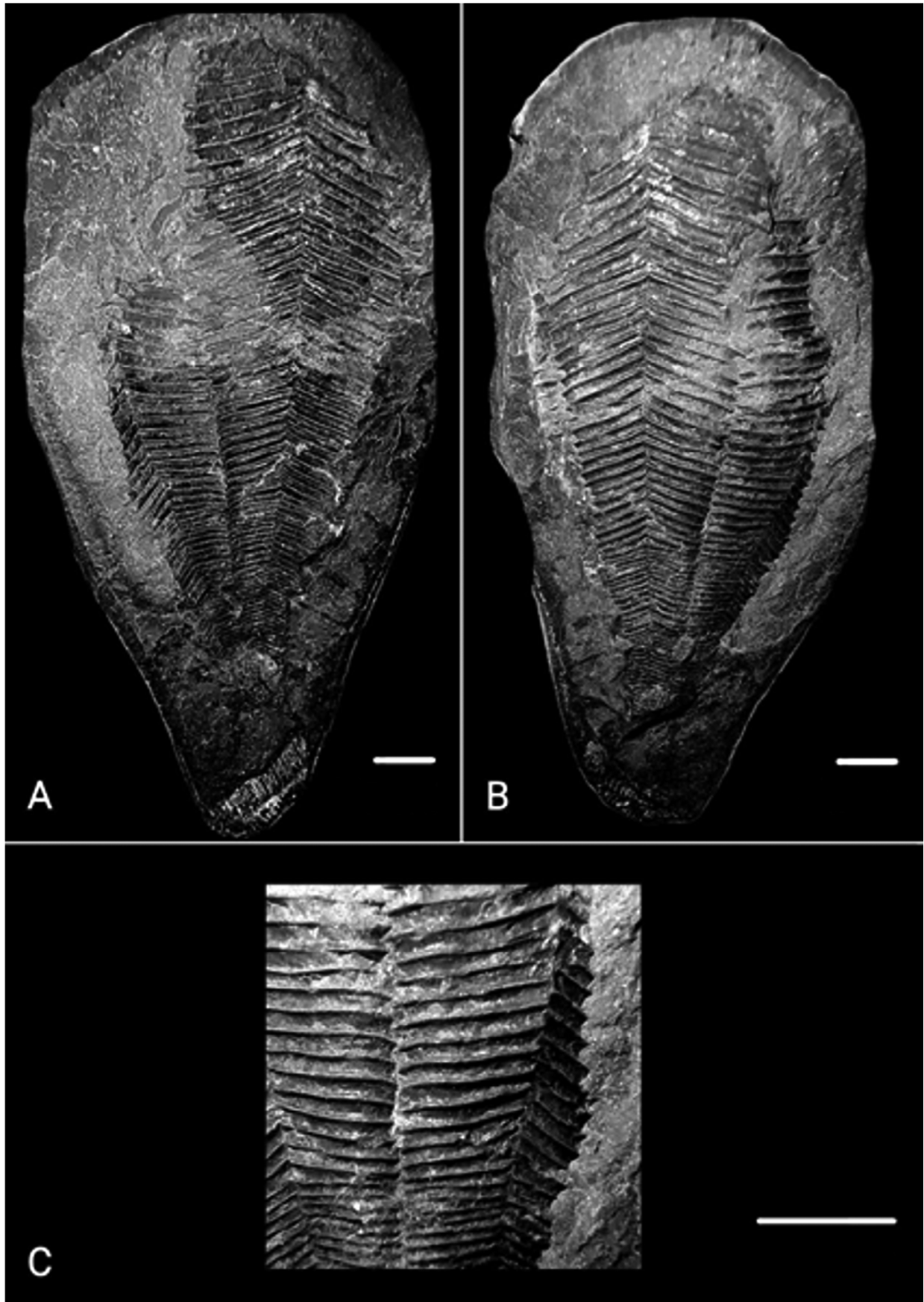


Figure 9. *Paraconularia africana*. A–C, CGP/1A 180, cut in frontal plane with two corresponding parts A and B (A); revealing the face of the theca of the conulariid (B); detail of the inflected gothic arch ornamentations (C). Scale bars = 5 mm.

Material. Specimen preserved in concretions: CGP/1A 166; CGP/1A 167; CGP/1A 168; CGP/1A 171; CGP/1A 172; CGP/1A 173; CGP/1A 174; CGP/1A 178; CGP/1A 180; CGP/1A 186; CGP/1A 370.

Occurrence. Devonian outcrops of the Ponta Grossa Formation, Devonian (Pragian–Emsian), Alto Garças Sub-basin, Paraná Basin, City of Rio Verde de Mato Grosso, State of Mato Grosso do Sul, Brazil. Rio Verde Mine (P3 – 18°56'19.56"S, 54°50'10.51"W, ~ 350 m high).

Description. *Paraconularia africana*, partially preserved, theca ornamentation composed by smooth trochoidal inflected gothic arch and midline with external fold. Angulated corner sulcus. Midline outlined by the ridges or by external bending. Nodes and ridges are rarely present. Tubercles absent.

Comments. *Paraconularia africana* stands out as one of the most abundant species on the northwestern edge of the Paraná Basin. Its diagnostic characteristic is the gothic ornamentation (see Leme *et al.*, 2004). However, the presence of morphological variation is also observed, with the predominance of the curved gothic type ornamentation, as pointed out by Vilasboas *et al.* (2022) and Guedes *et al.* (2023). They may also exhibit well-preserved internal structures, such as carinae along the edges and septa (Leme *et al.*, 2004). The presence of a curved/inflected gothic ornamentation is predominant in the examined specimens, as exemplified in Leme *et al.* (2004, fig. 12). *Paracolunaria africana* (Sharpe) is the single conulariid known from the Bolivian Devonian that only has inflected gothic articulation (Babcock *et al.*, 1987), which is distinct of the Brazilian region.

DISCUSSION AND CONCLUSIONS

The specimens of *Conularia quichua* display excellent integrity and well-preserved ornamentation, without signs of flattening. This exceptional preservation enabled the detailed observation of the conulariid internal structure, revealing a rarely documented rounded axial pillar. These are the first reported specimens from the northwestern margin of the Paraná Basin to exhibit this structure, contributing to a better understanding of the paleoecology of conulariid fauna. Leme *et al.* (2004) initially described the axial pillar in *C. quichua* specimens from the Ponta Grossa Formation, Paraná State. As noted by Leme *et al.* (2004), a similar structure is also present in the theca of *Circonularia eosilurica* (Bischoff, 1978). Additionally, comparable morphological features are found in extant species of Stauromedusae, such as *Craterolophus tethys*, although the axial pillar in *C. tethys* is not mineralized (Jerre, 1994). The comparison of internal morphological structures strengthens the interpretation of phylogenetic affinities between Conulatae and Cnidaria (Van Iten *et al.*, 2006; Leme *et al.*, 2008). Furthermore, new occurrences and anatomical data from thecae with internal structures provide deeper insights into the anatomical variation and morphological complexity of the Conulatae (Van Iten, 1991b; Jerre, 1994; Leme *et al.*, 2004).

On the Southwest Gondwana, in the northeast portion of the Paraná Basin, Alto Garças Sub-basin, it is possible to identify the presence of *Paraconularia africana*, *Conularia quichua*, *P. ulrichana* and *Reticulaconularia caetensis* in the Ponta Grossa Formation (Guedes *et al.*, 2023). These same species are also observed in the intracratonic basins of the Interior Gondwana (Alto Garças and Apucarana sub-basins of the Paraná and Parnaíba basins) and Andean-South African (Bolivian Chaco-Peru, Zorritas-NOA-South Bolivia, South Africa) revealing a clear paleogeographical correlation between the two regions. This connection suggests possible environmental similarities between the colder and warmer zones and depths of this marine context, confirming the cosmopolitan character of those species, being *Conularia quichua* and the distribution of conulariid recorded in the outcrops of the Ponta Grossa Formation, Devonian (Pragian–Emsian). The changes in diversity were influenced by the position of the continents during the Lower–Middle Devonian.

DECLARATION OF COMPETING 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.

ACKNOWLEDGMENTS

The authors are grateful to Thematic Project 16-06144-6 (São Paulo State Research Support Foundation - FAPESP), Foundation to Support the Development of Education, Science and Technology of the State of Mato Grosso do Sul - Fundect-UFMS (project no. 29-2021) and Carlos Chagas Filho Foundation for Research Support in the State of Rio de Janeiro (FAPERJ; E-26/202.047/2020 and E-26/202.048/2020). To I.S. Carvalho, from Federal University of Rio de Janeiro, and Gilmar Kerber, from the Post Graduation Program in Animal Biology of the Biosciences Institute of the Federal University of Mato Grosso do Sul, for participating in the gathering of samples on the field. The authors are also grateful for the valuable suggestions sent by reviewers in the initial version of the paper.

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Received: 15 July 2024. Accepted: 24 October 2024.

Associated editor: Sergio Martínez
Editor-in-chief: Matias do Nascimento Ritter