

New Occurrences of Ordovician, Devonian, and Carboniferous
Conulariids from North America,
South America, and Asia

A Thesis

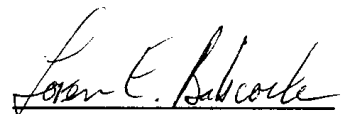
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ABSTRACT

Four new occurrences of Paleozoic conulariids are reported. A species of *Climacoconus* is reported from the Ordovician of Korea. *Conularia quichua* Ulrich (*in* Steinmann & Döderlein, 1890) is reported for the first time from Chile. It occurs in the Zorritós Formation. (Devonian). A new species of *Paraconularia* occurs in the Woodford Shale (Devonian) of Oklahoma. Another species of *Paraconularia* is reported from the Carboniferous (Pennsylvanian) of the Kansas-Oklahoma border area.

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INTRODUCTION

Conulariids are a group of problematic fossils whose phylogenetic affinities have been argued about for about 200 years. They have been described as mollusks, cnidarians, worms, vertebrates, and as an independent phylum. The heart of the problem lies in the fact that their morphology does not seem to fit well into any one group. Also, problems arise from the fact that few well preserved specimens have been found with soft parts intact. Soft part morphology is one of the best tools for classifying the group of organisms. The modern consensus view is that conulariids are an extinct group of cnidarians or have close affinities with cnidarians (Van Iken, 1992a, 1992b; Babcock, 1993).

Conulariids secreted an elongate, four-sided pyramidal exoskeleton having a phosphatic composition and a subtle bilateral symmetry. Bilateral symmetry is indicated by different apical angles between the major (larger) and minor (smaller) faces. It is also evident in differences in the pattern of rod articulation between the major and minor faces; commonly a species is characterized by a right-superior pattern of articulation on one type of face, and a left-superior pattern of articulation on the other type of face. The weakly rectangular (almost square) outline of its exoskeleton, as viewed from the apertural end along the long axis, has given rise to the misconception that conulariids had a radial (tetrameral) symmetry (Babcock, 1993).

The exoskeleton was open at the wider end, or aperture, and closed at the narrower end, or apex. The exoskeleton, which was moderately flexible, is composed of numerous, thin phosphatic laminae. It was thickened in part by transverse thickenings that have been called rods. Although made up of numerous laminae, similar to the

adjacent integument, the rods seem to be sufficiently thickened so as to have a different taphonomic history from the integument. Conulariids have a known stratigraphic range of Cambrian to Triassic. Conulariids apparently have affinities with

In this thesis I report four new occurrences of Paleozoic conulariids. One, *Conularia quichua*, is from the Devonian of Chile. Previously, the species was reported from elsewhere in South America and Africa. A species of *Climacoconus* is from the Ordovician of Korea. A new species of *Paraconularia* is from the Devonian of Oklahoma. Finally, another new species of *Paraconularia* is from the Carboniferous of the Kansas-Oklahoma border area.

SYSTEMATIC PALEONTOLOGY

Genus *Climacoconus* Sinclair, 1940

Remarks. – *Climacoconus*, as described by (Sinclair, 1948), is a small, narrow, conulariid characterized by unornamented ridges. It is nearly square in cross section. The genus has distinct corner grooves and rounded, or even ridged corner angles. Carinae interval to the midline are ubiquitous in species assigned to this genus.

Climacoconus new species

Figure 1

Material. – Ten specimens on nine rock slabs. Specimens, collected by Duck Keun Choi, are repositied in the paleontology collection of Seoul National University (SNU 890603, 890605, 890606, 890608, 890611, 890612, 890617, 890620, 890626).

Diagnosis. – A new species of *Climacoconus* is defined by distinctly incised corner grooves, two rows of internal carinae, and a wider apical angle (17-19°), as well as a closely spaced rods, 20-32/cm.

Description. – Exoskeleton up to 11 mm in length, and nearly square in cross section. Apical angle 17–19 °. Ridge articulation of circular curve style apically and gothic arch style elsewhere. Ridges usually abut at the midline, ridge angle up to 14° (decreasing towards apex). 20–24 ridges/cm near the aperture, increasing to 28–32/cm toward the apex; nodes and spines absent. Apical wall not observed.

Occurrence. – Yeongheung Formation of the Joseon Supergroup (Middle Ordovician), Yeongweol area, along Route 38, Samgeori, Korea. The Yeongheung Formation consists of two major lithologies; massive thick-bedded dolostone at its base, and bluish-gray limestone in its upper part. Lithofacies represent a supratidal to subtidal environment. The formation is poorly fossiliferous, containing relatively uncommon trilobites, brachiopods, cephalopods, conulariids, stromatoporoids, and conodonts (Choi and Chough, 2005). The illustrated specimens are black in color against a gray shale matrix, preserved from the upper part of the Yeongheung Formation.

Remarks. – *Climacoconus* n. sp. is the first Ordovician conulariid to be identified from Korea. Specimens reported here were previously noted (Choi and Jeong 1990), but not described. Aside from this species of *Climacoconus*, only one other conulariid species, *Paraconularia geumcheonensis*, has been reported from Korea (Choi, 1988). That species is from the Geumcheon Formation (Carboniferous) of the Sangdong area, Korea.

Climacoconus n. sp. is similar to *C. quadratus* (Sinclair, 1942), which has apical angles ranging from 12° to 19°. It is also similar to *C. clermontanus* and *C. mollis* (Sinclair, 1948) in the number of ridges/cm (20 to 40). *C.* n. sp. is unique within the genus *Climacoconus* by the combination of a wide apical angle (17° to 19°) and closely spaced rods, as well as distinctly incised corner grooves and two rows of internal carinae.

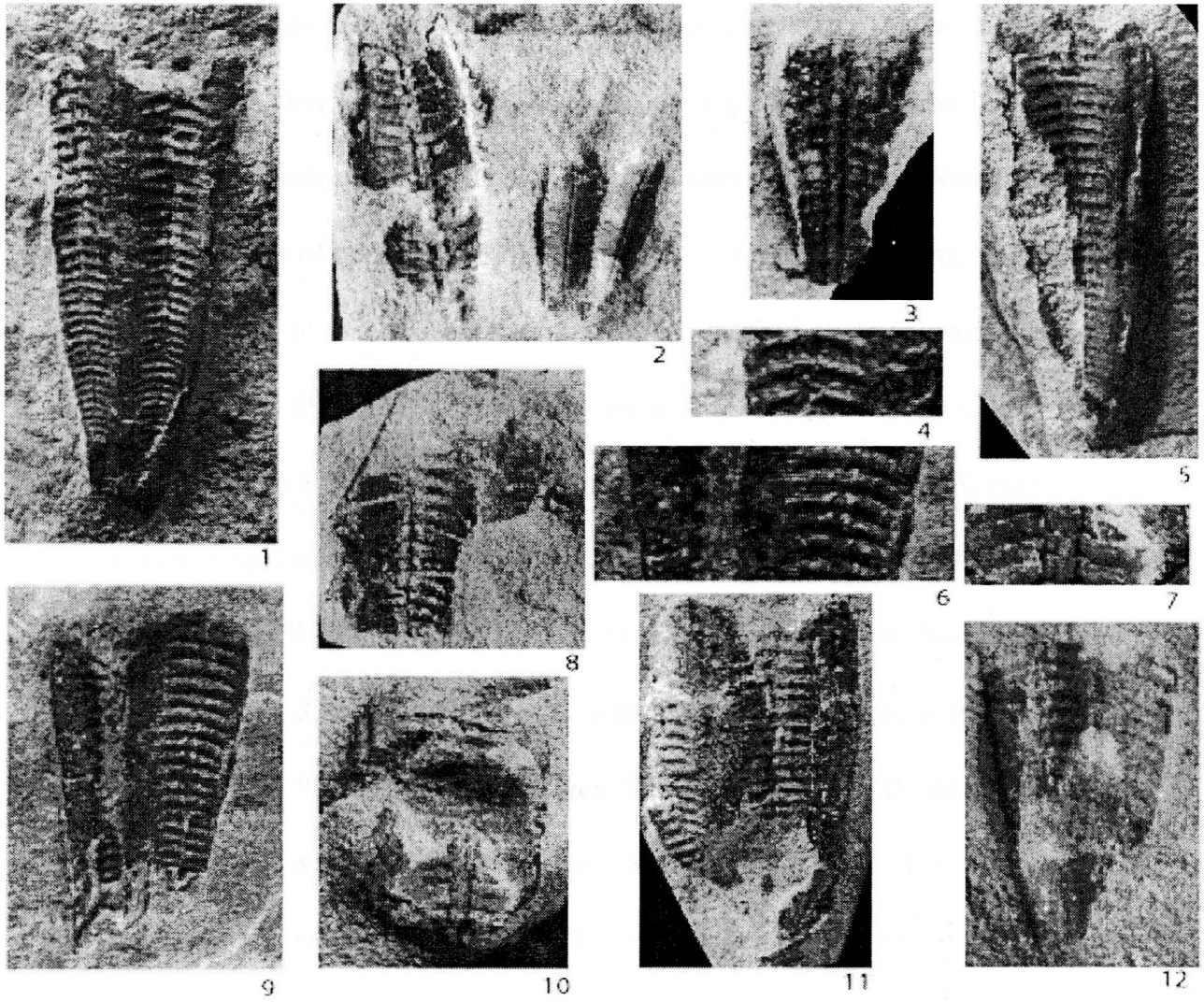


Figure 1

Figure 1 – *Climacoconus* n. sp., from the Yeongheung Formation (Ordovician), Yeongweol area, along Route 38, Samgeori area, Korea; all specimens repositied in the paleontology collections of Seoul National University (Seoul, Korea). 1, external view of specimen, SNU 890606; × 7. 2, two specimens, a) internal view of specimen, b) external view of specimen, which shows two corner grooves clearly, SNU 890620; ×8. 3, internal view of face, SNU 890626; ×12. 4, a close-up of figure 1.1 showing ridge articulation, SNU 890606; ×20. 5, external view of a broken specimen, SNU 890605; ×7. 6, a close-up of figure 1.9 showing ridge articulation, SNU 890603; ×20. 7, a close-up of figure 1.10 showing carinae, SNU 890617; ×20. 8, external view of two faces, showing details of the midline, SNU 890611; ×11. 9, external view of face, SNU 890603; ×9. 10, oblique view of specimen showing distinctive carinae, SNU 890617; ×10. 11, external view of large specimen, SNU 890612; ×9. 12, a specimen showing external and internal sides, SNU 890608; ×13.

Genus *Conularia* Miller in Sowerby, 1821

Remarks. – *Conularia* is characterized by generally having closely spaced ridges, relatively small apical angles, and spines and nodes on the ridges (Babcock and Feldmann, 1986a, Babcock, 1993).

Conularia quichua Ulrich in Steinmann and Döderlein, 1890 Figure 2

Conularia quichua – Ulrich in Steinmann and Döderlein, 1890, p. 343; Babcock et al., 1987, p. 205 (see for additional synonymy).

Material. – Seven samples provided by Hans Niemeyer Rubilar.

Occurrence. – Quartzite beds (metamorphosed fine sandstone layers) of the Zorritós Formation, Devonian, Cordón de Lila and Quebrada de las Zorras, (Atacama Desert), northern Chile.

Remarks. – New material from Chile is within the range of variation of *Conularia quichua*, a species that is widespread in the Devonian of South America and Africa (Babcock et al., 1987 and references therein). *Conularia quichua* is characterized by having closely spaced ridges (21 to 32/cm) that are arranged in a gothic arch pattern apically and in an angulated circular curve pattern elsewhere. The ridges are slightly undulose except in the apical region. Apical angles on the major face are in the range of 13 to 24 degrees, and those on the minor face are 11 to 23 degrees. The rods abut at the midline of each face. An apical wall has been observed in some specimens.

This is the first report of *Conularia* in Chile. These specimens of *C. quichua* show different rates of growth through ontogeny, a characteristic of *C. quichua* that has been illustrated, but not specifically described before. Slower growth rates are suggested by areas of closely spaced ridges.

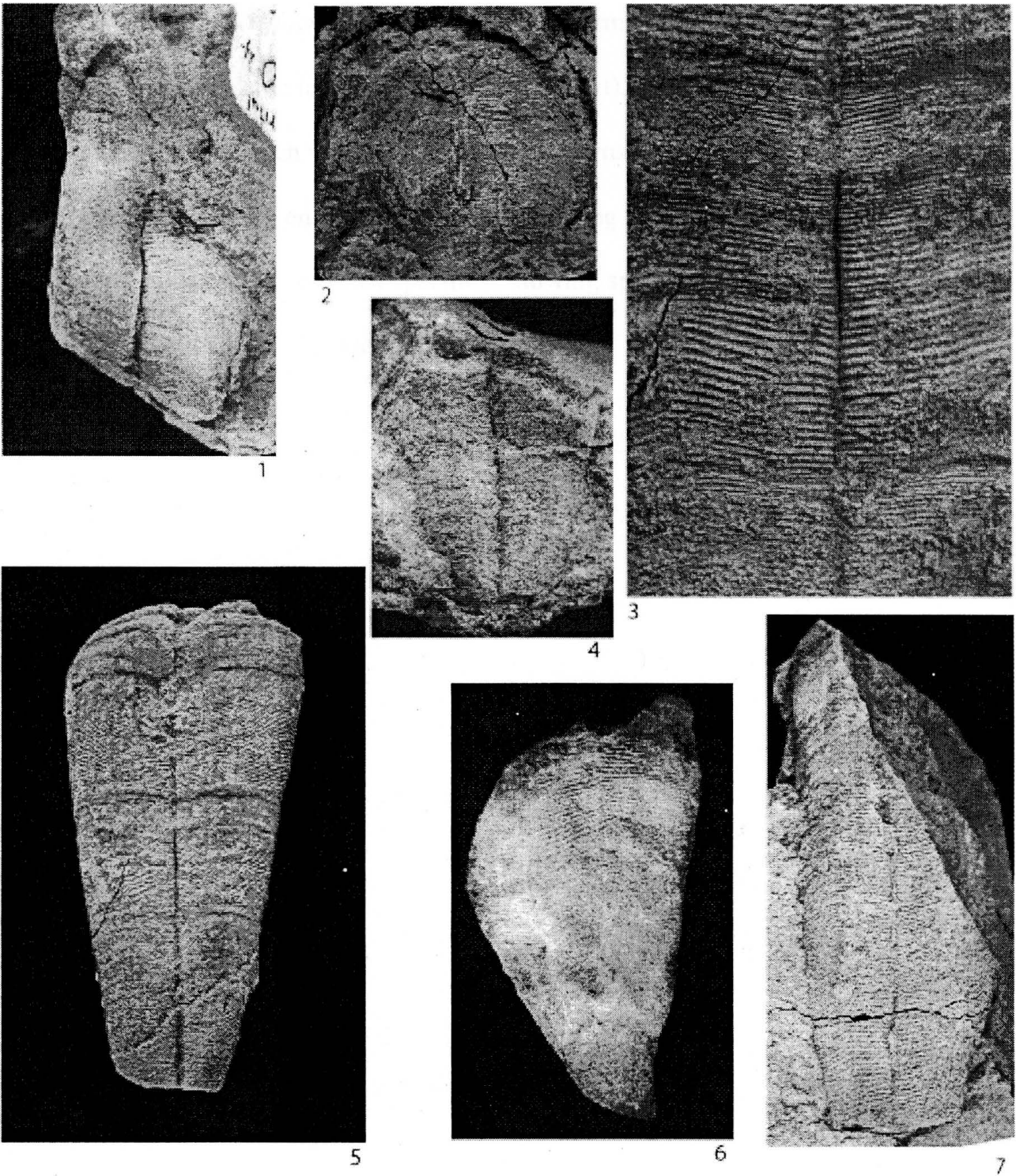


Figure 2

Figure 2 – *Conularia quichua*, from the Zorritós Formation (Devonian), Cordón de Lila and Quebrada de las Zorras, (Atacama Desert), northern Chile. 1, external view of crushed specimen within matrix; $\times 2$. 2, external view of face; $\times 2$. 3, external view of face; $\times 2.5$. 4, enlarged view of 2.1 showing spines, and slower growth rates of the ridges; $\times 7$. 5, crushed specimen showing apertural folds; $\times 1.5$. 6; external view of face; $\times 7$. 7, external view of face; $\times 2$.

Genus *Paraconularia* Sinclair, 1940

Remarks. – The genus *Paraconularia* is characterized by ridges that are generally widely spaced, 4-35 rods/cm. More than 60% of rods alternate at the midline; fewer than 40% abut. Apical angles are small, 9-28°. Nodes, adapertural spines, and adapical spines may be present; if present, they are usually widely spaced, 2-6/mm (Babcock and Feldman, 1986b).

Paraconularia new species

Figure 3

Material. – Seven specimens on five slabs collected by Royal H. Mapes.

Diagnosis. – A new species of *Paraconularia* having a high ridge angle, 25-27°, closely spaced ridges, 24-46/cm, and closely spaced nodes, 12-14/mm.

Description. – Exoskeleton up to 5.5 cm in length. Apical angle 28–30°. Ridge articulation gothic arch style in apical region giving way to inflected gothic arch style. Largest specimens have inflected circular curve ridge articulation near aperture. Ridges usually abut at midline, if they alternate, pattern is left superior. Ridge angle about 26°. Ridges number 24–26/cm near the aperture, increasing to 44–46/cm toward apex (extrapolated). 12-14 nodes/mm. Spines absent. Apical wall not observed.

Occurrence. Woodford Shale (Devonian) of the Ryan Quarry, Ada, Oklahoma. The illustrated specimens are compacted in dark gray shale.

Remarks. – *Paraconularia* n. sp. is unique within the genus because of the combination of closely spaced ridges, 24-46/cm, the number of nodes, 12-14/mm, and the high apical angle, 28-30 degrees.

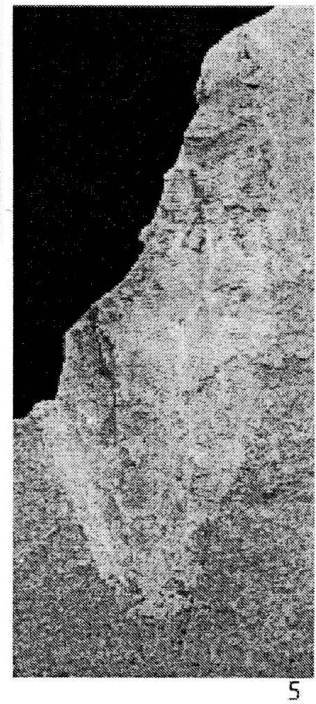
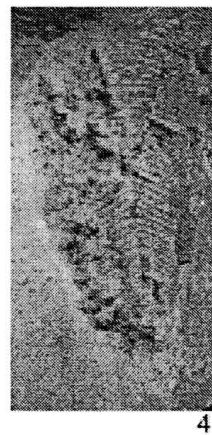
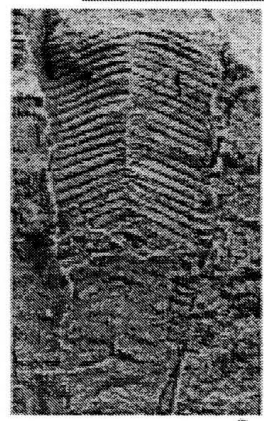
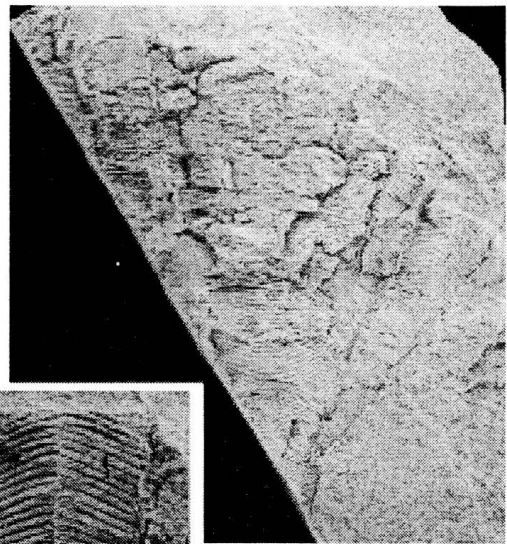


Figure 3

Figure 3 – *Paraconularia* n. sp. from the Woodford Shale (Devonian), Ryan Quarry, Ada, Oklahoma; all specimens repositied in the Orton Geological Museum of The Ohio State University. 1, compacted specimen showing closely spaced rods towards the apex; $\times 3$. 2, cluster of three specimens; $\times 2$. 3, close-up of right-most specimen in figure 3.2 showing closely spaced nodes; $\times 5$. 4, external view of face; $\times 2.5$, external view of face; $\times 2$,

Paraconularia new species

Figure 4

Material. – One specimen from the Coffeeville Shale, (Carboniferous: Pennsylvanian), Caney, Kansas, collected by Tom Servais. Six specimens from the Coffeeville Shale (Carboniferous: Pennsylvanian), Copan, Oklahoma, collected by L. E. Babcock and Tom Servais.

Diagnosis. – A new species of *Paraconularia* having a relatively low apical angle and closely spaced ridges in the apical region. Ridges usually abut and lack nodes and spines.

Description. – Exoskeleton up to 6.5 cm in length and nearly square in cross section. Apical angle 10–17°. All available specimens show inflected circular curve style ridge articulation. Ridges usually abut at midline. Ridge angle about 17°. 10–12 ridges/cm near aperture, increasing to 22–26/cm toward apex (extrapolated). Nodes and spines absent. Apical wall not observed.

Occurrence. – Coffeeville Shale along Highway 75 near Caney, Kansas, and Wann Shale, east and west sides of Highway 75, north of Copan, Oklahoma. Both formations are thought to be the same formation that outcrop in different states. The illustrated specimens, preserved in three dimensions with siderite infilling, were collected loose at the surface following weathering from gray shale.

Remarks. – *Paraconularia* n. sp. is similar to *P. byblis* (White, 1862). Both have ridge angles varying from 12 to 18 degrees and both have similar ranges of ridges/cm

(10 to 26). *P. n. sp.* is distinguished from *P. byblis* by lacking nodes on its ridges as well as having a smaller apical angle. The maximum measured apical on *P. n. sp.* is 17 degrees whereas the minimum apical angle of the major face of a *P. byblis* is 18 degrees.

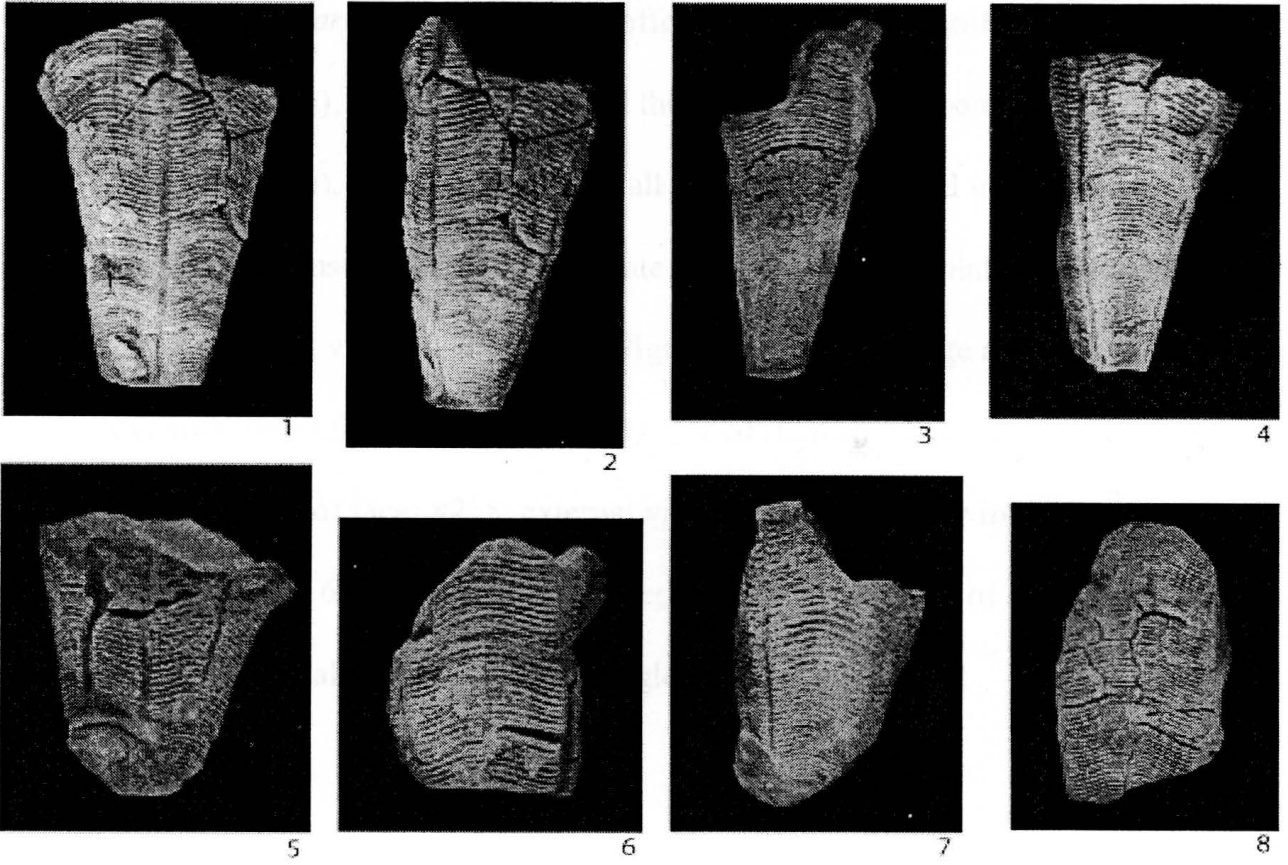


Figure 4

Figure 4 – *Paraconularia* n. sp. from the Coffeeville Shale (Carboniferous: Pennsylvanian), Caney, Kansas, and the Wann Shale (Carboniferous: Pennsylvanian), Copan, Oklahoma; all specimens repositied in the Orton Geological Museum of The Ohio State University. 1, external view of two faces; ×1. 2, external view of specimen in figure 4.1 showing ridge articulation; ×1. 3, external view of face showing closely spaced ridges in apical region; ×1.5. 4, external view of face; ×2. 5, external view of specimen showing collapsed apical region; ×1.33. 6, external view of face; ×2. 7, external view of specimen showing collapsed apical region; ×1.33. 8, single fragmented face; ×1.

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