

Middle Permian crinoids (Echinodermata, Crinoidea) from Cerros Los Monos, Caborca, Sonora, Mexico and paleogeographic considerations

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ABSTRACT

Crinoid columnals and pluricolumnals assigned to five species, *Pentaridica* (col.) *rothi* Moore and Jeffords, *Cyclocaudex* cf. *C.* (col.) *jucundus* Moore and Jeffords, *Cyclocaudex* cf. *C.* (col.) *costatus* Moore and Jeffords, *Preptopremnum* (col.) *rugosum* Moore and Jeffords, and *Heterostelechus* (col.) *texanus* Moore and Jeffords, were studied from the Permian beds of the Monos Formation which is exposed 50 kilometers west of Caborca, Sonora, in northwest Mexico. *Heterostelechus* (col.) *texanus* Moore and Jeffords is recorded for the first time in Mexico. Some crinoid samples preserve morphological features in the articular surface, allowing the species identification. The age of the fossiliferous strata was determined by the identification of fusulinids (*Parafusulina antimonioensis* Dunbar), ammonites (*Waagenoceras dieneri* Boese), and brachiopods (*Waagenoconcha montpelierensis* (Girty)) that are index fossils of Wordian (Middle Permian) age.

Key words: crinoids, paleogeography, Wordian, Caborca, Sonora, Mexico.

RESUMEN

Se identificaron placas columnares de crinoides de las especies *Pentaridica* (col.) *rothi* Moore y Jeffords, *Cyclocaudex* cf. *C.* (col.) *jucundus* Moore y Jeffords, *Cyclocaudex* cf. *C.* (col.) *costatus* Moore y Jeffords, *Preptopremnum* (col.) *rugosum* Moore y Jeffords y *Heterostelechus* (col.) *texanus* Moore y Jeffords; la presencia de *Heterostelechus* (col.) *texanus* se reporta por vez primera para México y los fósiles proceden de la Formación Monos que aflora a 50 km al poniente de la Ciudad de Caborca, Estado de Sonora, en el noroeste de México. Algunas de las muestras de fósiles de crinoides han conservado, en la superficie articular, caracteres morfológicos que han permitido la identificación de las especies. La previa determinación de la edad de los estratos con crinoides fue posible gracias a la presencia de fusulínidos de la especie *Parafusulina antimonioensis* Dunbar, de amonites (*Waagenoceras dieneri* Boese) y braquiópodos (*Waagenoconcha montpelierensis* (Girty)), todas especies índices del Wordiano, Pérmico Medio.

Palabras clave: crinoides, paleogeografía, Wordiano, Caborca, Sonora, México.

INTRODUCTION

The Monos Formation is a Middle Permian sedimentary unit that was deposited in a shallow marine environment. It crops out at Los Monos Hills, located about 50 km west of the City of Caborca, in northwestern Sonora, at 30°45' N and 112°36' W (Figure 1). The Monos Formation is a mostly carbonate fossiliferous sequence which includes algae, fusulinids and other foraminifers, sponges, corals, bryozoans, brachiopods, gastropods, ammonites, and crinoids. This contribution reports and illustrates several columnals and pluricolumnals. The species herein described belongs to *Pentaridica* (col.) *rothi* Moore and Jeffords, *Cyclocaudex* (col.) cf. *C. jucundus* Moore and Jeffords, *Cyclocaudex* (col.) cf. *C. costatus* Moore and Jeffords, *Preptopremnum* (col.) *rugosum* Moore and Jeffords, and *Heterostelechus texanus* Moore and Jeffords. These identifications, which were made following the methodology of Moore and Jeffords (1968), Jeffords

and Miller (1968), Moore *et al.*, (1968) and Wright (1983), provide significant paleogeographic information relative to faunal affinity with the North American Craton Province (Ross and Ross, 1979).

The Monos strata were first reported by Keller (1928) who described the rocks as Pennsylvanian in age. Later, Cooper and Arellano (1946) named this succession as Monos Formation. Subsequently, Cooper *et al.* (1953) reported that the stratigraphic section of the Monos Formation is more than 600 m thick and composed of reddish siltstone and sandstone alternating with fossiliferous limestone that contains a rich fauna of fusulinids, solitary corals, fenestellids-bryozoans, terebratulids, rhynchonellids like *Wellerella* sp, spiriferids and productids (including *Dictyoclostus*, *Liosotella*, *Muirwoodia*, *Chonetes* and *Marginifera*), pleurotomarids (*Pleurotomaria*, *Euphemites*, *Straparollus*), ammonites (*Waagenoceras*) and echinoderms. The species of crinoids here reported were collected from the middle part of the Monos Formation and correspond to columnals

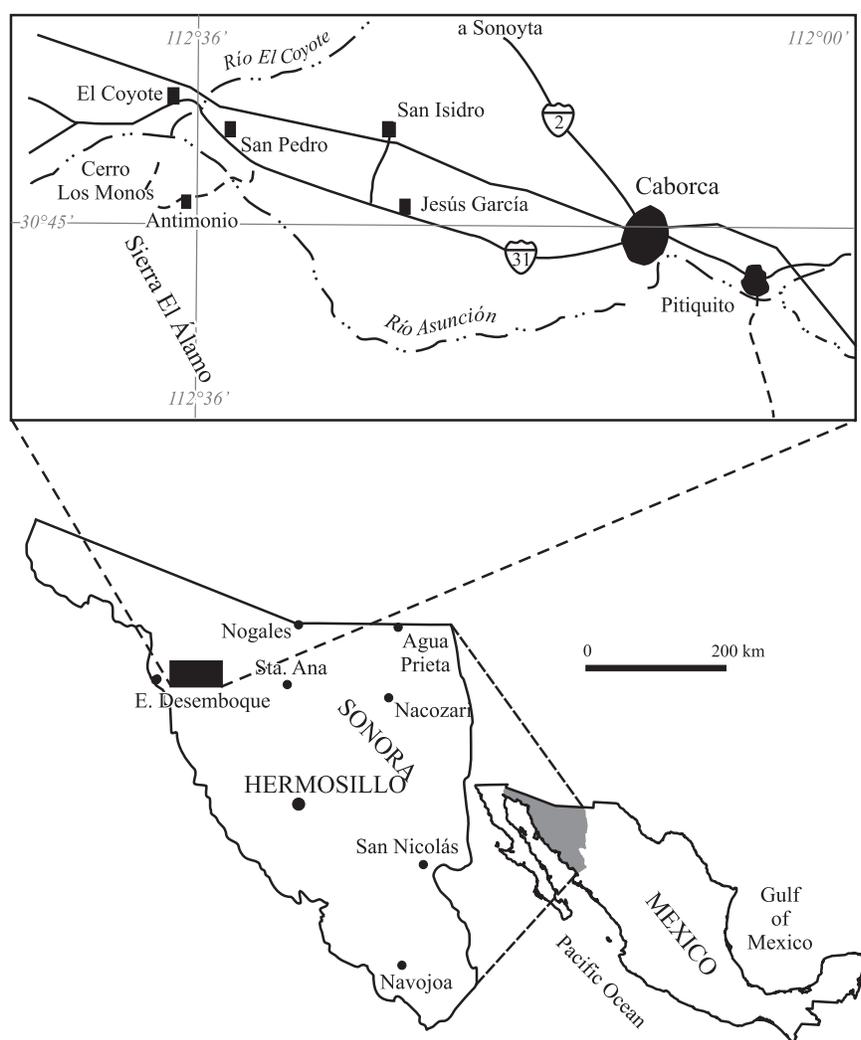


Figure 1. Location map of Cerro Los Monos hills, west of Caborca, Sonora, México.

first identified by Moore and Jeffords (1968) from Late Pennsylvanian and Permian strata of Texas. In association with the crinoids, the fusulinid *Parafusulina antimonioensis* Dunbar has been found and indicates a middle-late Wordian, (Middle Permian) age (Figure 2).

The aim of this paper is to report the systematic study of crinoidal articular plates from the northwest region of Mexico. For this purpose, we adopt the convention suggested by Donovan (1995) that uses the suffix (col.) for crinoid genera identifications that are based on elements of the columnal. The relatively good preservation of the specimens allowed to recognize paleontological diagnostic features that identify them to the species level, on the basis of the works of Moore and Jeffords (1968); Jeffords and Miller (1968); Moore, Jeffords, and Miller (1968); and Wright (1983).

AGE OF THE FAUNA

The crinoid species from the middle part of the Monos Formation correspond to paleontological forms that were previously identified by Moore and Jeffords (1968) from Late Pennsylvanian and Permian strata of Texas. Particularly, *Pentaridica* (col.) *rothi* was cited from the Blach Ranch Limestone (Virgilian); *Preptopremnum*

(col.) *rugosum* from the Thrifty and Graham Formations (Virgilian); *Heterostelechus* (col.) *texanus* from the Thrifty Formation of the Cisco Group (Virgilian) and from the Pueblo Formation of the Wichita Group (Wolfcampian). In the Monos Formation, these crinoids occur in association with fusulinids of the species *Parafusulina antimonioensis* index of a middle-late Wordian age (Dunbar in Cooper *et al.*, 1965, p. 18; Wilde, 1990; Vachard *et al.*, 1997).

The age of the fossiliferous layers was also supported by the ammonites *Waagenoceras dieneri* Boese (see Miller in Cooper *et al.*, 1965, p. 89) and the brachiopod *Waagenoconcha montpelierensis* (Girty) (see Cooper *et al.*, 1965, p. 49), both index fossils of the late Wordian (Wilde, 1990).

SYSTEMATIC PALEONTOLOGY

The material herein reported is deposited in the National Paleontological Collection of the Instituto de Geología, Universidad Nacional Autónoma de México, with the abbreviations IGM and catalogue numbers from IGM-8829 to IGM-8837.

Phylum Echinodermata

Class Crinoidea Miller, 1821

Group Pentameri Moore and Jeffords, 1968

Family Pentacauliscidae Moore and Jeffords, 1968

Genus *Pentaridica* Moore and Jeffords, 1968

Pentaridica (col.) *rothi* Moore and Jeffords, 1968

Figures 3a, 3b

Pentaridica rothi Moore and Jeffords, 1968, p. 55, pl. 9, figs. 12 and 13.

Pentaridica rothi Moore and Jeffords, 1968, Vachard, *et al.*, 1997, p. 361.

Description. Heteromorphic column with two preserved plates of slightly pentagonal sides, one of them corresponds to a large nodal plate with two cirrus scars, and the other one is an internodal plate smaller than the nodal. Articular facet has a pentagonal outline and is slightly angled. There is a thick culmina separated by thin crenellae. There is a pentagonal and smooth areola. Lumen and areola are half width of the plate. Lumen has a slightly pentagonal outline.

Dimensions in mm.

Type	Nodal plate	Internodal plate	Cirrus	Articular facet	Crenular surface	Areola	Lumen
IGM 8829	3.0	1.0	2.5	9.0	2.0	3.0	3.0
IGM 8830	3.0	1.0	6.6	10.2	2.5	3.2	2.0

Observations. Wright (1983, p. 595) proposed that the Pentameri Group is characterized by the pres-

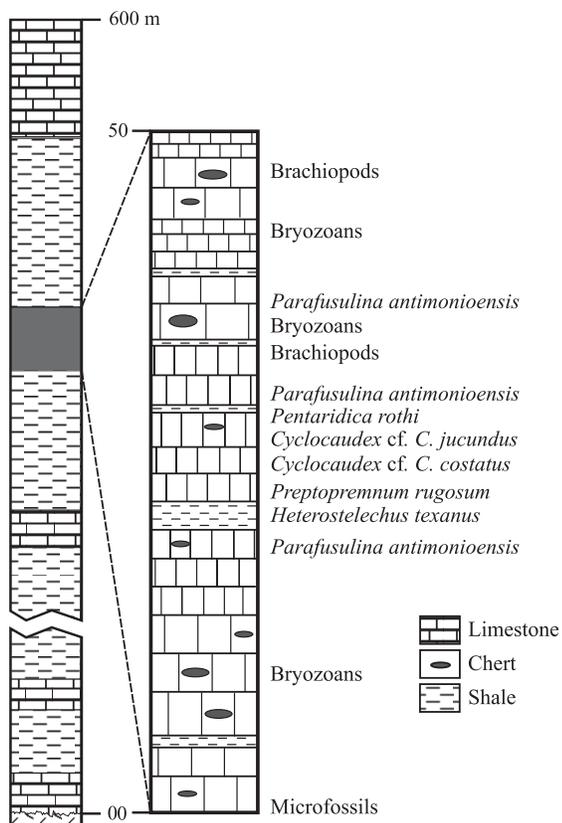


Figure 2. Stratigraphic column of the Monos Formation, modified after Cooper *et al.* (1965).

ence of pentagonal to quinquelobate columns, and the *Pentagonopentagonopa* morphogenus with a pentagonal lumen belongs to this group.

Pentaridica rothi Moore and Jeffords (1968) was described for the first time from the Virgilian Blach Ranch Limestone and Cisco Group of Texas, USA. The Mexican specimens have slightly more sunken areola than specimens from Texas, and are more closely related to *Pentaridica simplicis* Moore and Jeffords (1968, p. 55, pl. 9, figs. 11a, b), but differ from this last one by the subpentagonal shape of the plates and because the crenularium presents a more conspicuous culmina.

Specimens of *Pentaridica rothi* associated with *Cyclocaudex typicus*, *C. lineolata*, and *Pentagonopterix insculptus* were found associated with the middle-late Wordian fusulinids *Parafusulina deliciasensis* and *P. maleyi* in the La Cruz formation, Ihualtepec, Oaxaca (Vachard *et al.*, 1997).

Group Cyclici Moore and Jeffords, 1968
Family Cyclomischidae Moore and Jeffords, 1968
Genus *Cyclocaudex* Moore and Jeffords, 1968

***Cyclocaudex* cf. *C. (col.) jucundus* Moore and Jeffords, 1968**

Figures 3c, 3d

Description. Heteromorphic column with five plates of right side, the middle is an internodal plate, slightly thicker than the nodal plate, also with a cirrus scar. The articulation is a symplexy. The articular facet of the plate has a circular outline with a wide crenularium, and the culmina is separated by crenulae narrower than the culmina. The wide and depressed areola and the lumen cannot be observed and occupy a third of the surface of the articular facet.

Dimensions in mm.

Type	Nodal plate	Internodal plate	Articular facet	Crenular surface	Areola	Lumen
IGM 8831	2.0	1.0	1.3	9.7	3.0	3.7
IGM 8832	—	—	—	9.4	3.0	3.4

Observations. Wright (1983, p. 595) proposed that the Cyclici Group has circular columns, lumen of a circular outlines and that the *Cyclocycopa* morphogenus belongs to this group.

Moore and Jeffords (1968, p. 66, pl. 17, figs. 6, 7) described *Cyclocaudex jucundus* from the Chaffin and Belknap Limestone members of the Thrifty Formation, and from the Virgilian Cisco Group of Texas, USA. Buitrón *et al.* (1987, p. 132, fig. 5) recorded *Cyclocaudex jucundus* in the Del Monte Formation of Late Pennsylvanian (Virgilian) at Calnali, Hidalgo State, Mexico, and Velasco-de León and Buitrón (1992, p. 75, pl. 2, figs. 1-4) reported the same

species from the Late Pennsylvanian (Virgilian) rocks of the Patlanoaya Formation from Patlanoaya, Puebla, Mexico. Arellano-Gil *et al.* (1998) also reported this species along with the fusulinid *Skinnerella* from the Early Permian of the Guacamaya Formation in Pemuxco, Hidalgo.

The crinoid plates are abundant and poorly preserved in the rocks of the Monos Formation that are exposed in the Caborca region; this is insufficient for make a positive identification to species level.

***Cyclocaudex* cf. *C. (col.) costatus* Moore and Jeffords, 1968**

Figure 3e

Description. Straight-sided heteromorphic column with three plate. The middle is a nodal with the scar of the cirrus and its width is double of internodal plate. The articular facet of the plate has a circular outline with a wide crenularium which covers one fifth of the columnal width. It also has a wide culmina, separated by crenellae narrower than the culmina. There are no details of the areola and lumen, but their dimensions have been measured.

Dimensions in mm.

Type	Nodal plate	Internodal plate	Cirrus	Articular facet	Areola	Lumen
IGM 8833	2.0	1.0	1.3	10.1	2.0	6.1

Observations. *Cyclocaudex costatus* (Moore and Jeffords, 1968, p. 66, pl. 17, figs. 8a and 8b) was described from the South Bed Shale Member of the Graham Formation in the Virgilian Cisco Group of Texas, USA. Buitrón *et al.* (1987) published about the Late Pennsylvanian (Virgilian) species *Cyclocaudex* cf. *C. costatus*, *C. insaturatus*, *C. jucundus*, and *Heterostelechus keithi* from the Vicente Guerrero Formation in Calnali region, Hidalgo State in central Mexico; the species has been reported from the Upper Pennsylvanian of Olinalá (Olinalá Formation), Guerrero State (Flores de Dios and Buitrón, 1982). The difference between *C. jucundus* and *C. costatus* is that the first one has a wide areola and a crenularium formed by narrower culmina and crenellate.

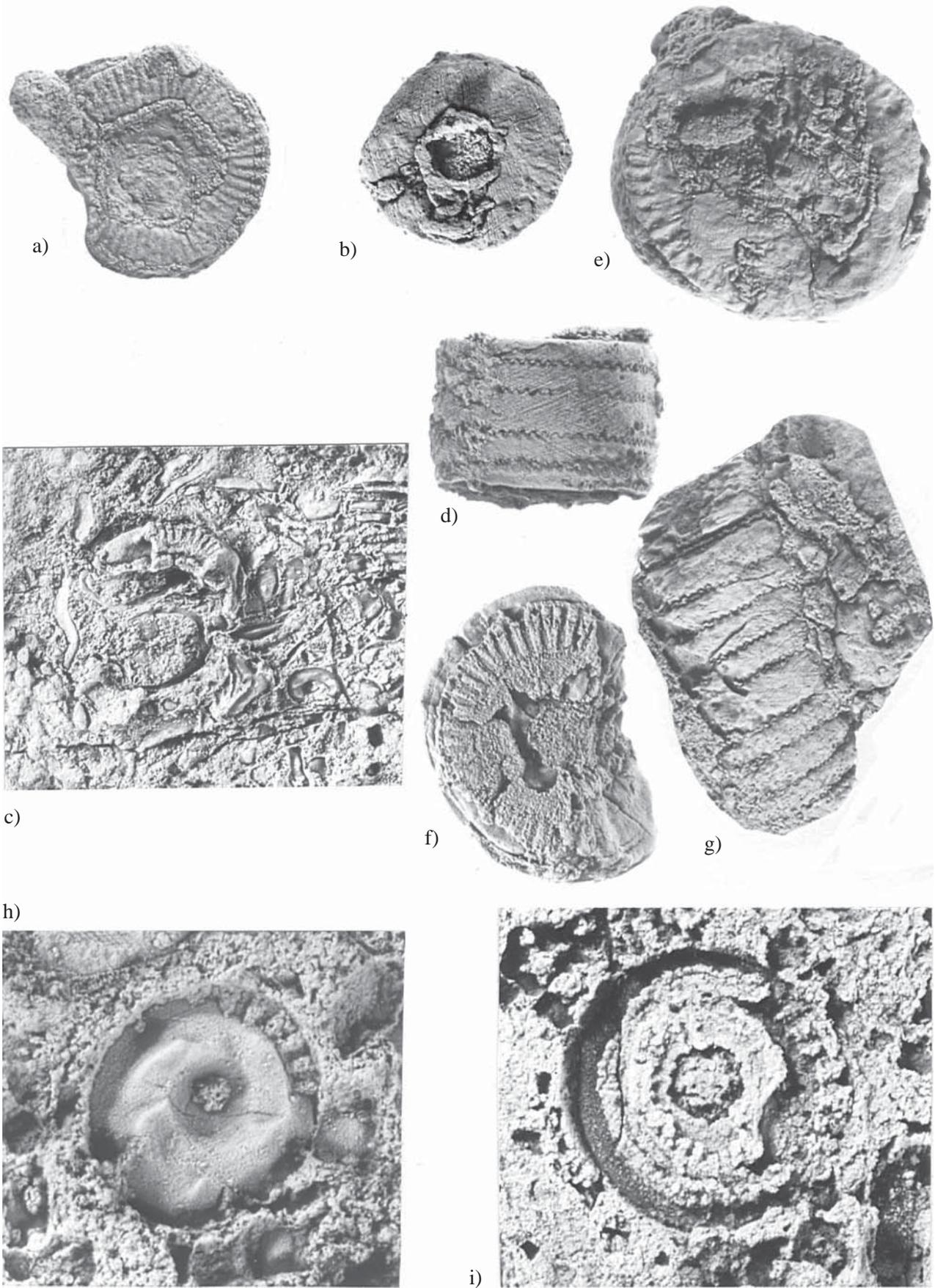
Family Leptocarphiidae Moore and Jeffords, 1968
Genus *Preptopremnum* Moore and Jeffords, 1968

***Preptopremnum* (col.) rugosum Moore and Jeffords, 1968**

Figure 3f, 3g

Preptopremnum rugosum Moore and Jeffords, 1968, p. 81, pl. 27, figs. 1-9; pl. 28, fig. 1.

Preptopremnum rugosum Moore and Jeffords, 1968; Arellano-Gil *et al.*, 1998, p. 11.



Preptopremnum rugosum Moore and Jeffords, 1968; Esquivel-Macías *et al.*, 2000, p. 1188. fusulinids of the genus *Skinnerella*.

Description. Heteromorphic column with sides finely granulose, with ten well rounded plates. The nodal plate is slightly wider than the internodal; with crenellate and indented suture. The articular facet, with short and wide culmina, in a series of two bifurcated between two simple culmina, in the contact with the areola; crenellae narrower than the culmen, which covers one third of the width of the articular facet. Areola has a circular outline and many small granulations, and the lumen is large and bordered by narrow perilumen, less wide than the articular facet.

Dimensions in mm.

Type	Nodal plate	Internodal plate	Cirrus	Articular facet	Crenular surface	Areola-Lumen
IGM 8834	2.0	1.0	1.3	9.5	3.0	3.5
IGM 8835	—	—	—	9.2	3.0	3.0

Observations. *Preptopremnum rugosum* was assigned to the Cyclici Group by Moore and Jeffords (1968) and Wright (1983). Wright (*op. cit.*) proposed the morphogenus *Cyclocyclopa* characterized by plates with granular sides, wide and short areola, with single and slender culmina. Nevertheless, this last author did not report specimens with bifurcated culmina. The authors of the present work consider the bifurcated culmina to be an evolutionarily derived feature in these Middle Permian crinoids from the Monos Formation.

Preptopremnum rugosum Moore and Jeffords (1968) was described for the first time in the Chaffin Limestone Member of the Thrifty Formation and the Gunsight Limestone and Wayland Shale Members of the Graham Formation, Cisco Group (Virgilian) of Texas, USA. There is a little variation in the morphology of this species, with mainly only the shape and size of the crenularium according to the conclusions of Jeffords and Miller (1968), who studied the ontogenic development of this species and confirmed the variability of these structures.

In Mexico, the species was studied by Buitrón (*in Arellano-Gil et al.*, 1998, p. 12) from Early Permian outcrops in the Guacamaya Formation of Pemuxco, Hidalgo. In this locality the species was associated with *Cyclocrista cheneyi*, *Cyclocaudex plenus*, *C. jucundus*, and *Mooreanteris perforatus* and associated also with a primitive species of

Genus *Heterostelechus* Moore and Jeffords, 1968

Heterostelechus (col.) *texanus* Moore and Jeffords, 1968 Figures 3h, 3i

Heterostelechus texanus Moore and Jeffords, 1968, p 81, pl. 28, fig. 7a, 7b.

Heterostelechus texanus Moore and Jeffords, 1968; Esquivel-Macías *et al.*, 2000, p. 1188.

Description. The plates have an articular facet of circular outline, and the crenularium covers one quarter of the column diameter. Short and wide culmina are separated by coarse and straight crenellae, narrower than the culminae. The areola is circular in outline with a smooth sunken and a small perilumen. The lumen is small and circular.

Dimensions in mm.

Type	Nodal plate	Internodal plate	Cirrus	Articular facet	Crenular surface	Areola-Lumen
IGM 8836	2.0	1.0	1.3	9.0	3.0	3.0
IGM 8837	—	—	—	9.2	3.0	3.2

Observations. Moore and Jeffords (1968) described *Heterostelechus* (col.) *texanus* from the Belknap Limestone of the Thrifty Formation of the Virgilian Cisco Group and also from the Waldrip Shale Member of the Pueblo Formation of the Wichita Group of Wolfcampian (Early Permian) age.

At Cerro Los Monos, Sonora, only two specimens of the species had been found and are associated with *Parafusulina antimonioensis* Dunbar (Cooper *et al.*, 1965; Wilde, 1990; Vachard *et al.*, 1997), consequently it is of late Wordian age. *Heterostelechus* (col.) *texanus* is reported for the first time for Mexico.

PALEOGEOGRAPHIC CONSIDERATIONS

Characteristic Permian benthic invertebrate faunas of warm marine environments are present in several formations in Sonora; among them is the Monos Formation that crops

Figure 3. Crinoid columnar plates of late Wordian age from Cerro Los Monos, Sonora. a: *Pentaridica rothi* Moore and Jeffords IGM-8829 (X 6) articular facet with culmina and crenellae. b: *Pentaridica rothi* Moore and Jeffords IGM8830 (X 4.8) incomplete articular facet with culmina and crenellate. c: *Cyclocaudex* cf. *C. jucundus* Moore and Jeffords, IGM 8831 (X 11.75) incomplete articular facet with culmina and crenellate. d: *Cyclocaudex* cf. *C. jucundus* Moore and Jeffords, IGM 8832 (X 6) column with four nodal and one internodal plates. e: *Cyclocaudex* cf. *C. costatus* Moore and Jeffords IGM 8833 (X 8) incomplete articular facet with culmina and crenellae. f: *Preptopremnum rugosum* Moore and Jeffords IGM 8834 (X 5.2) incomplete articular faceta with culmina, crenellae, granulose areola, and lumen. g: *Preptopremnum rugosum* Moore and Jeffords IGM 8835 (X 4.6) column with ten nodal plates and internodal plate. h: *Heterostelechus texanus* Moore and Jeffords IGM 8836 (X 6.0) incomplete articular facet with culmina and crenellae. i: *Heterostelechus texanus* Moore and Jeffords IGM 8837 (X 6.4) incomplete articular facet with culmina and crenellae.

out in the Monos hills of the Caborca region. The main fossil groups in this unit are foraminifera (Figure 4 a-d, h-l), corals, bryozoans (Figure 4g, m), brachiopods (Figure 4m, p), conodonts, and crinoids (Figure 3, Figure 4f). The Permian brachiopods include Productacea (*Avonia*, *Diaphragmus*, *Echinoconchus*, and *Dictyoclostus*), Rhynchonellacea (*Wellerella*), Spiriferacea (*Cyrtospirifer*, *Eumetria*, *Spirifer*, *Hustedia*, and *Crurithyris*) and Terebratulacea (*Dielasma*). Although these genus have a wide distribution around the world, the biota is stratigraphically and paleogeographically significant due to its relationship with the North American Craton and other global provinces (Ross and Ross, 1979; Buitrón et al., 2004; Molina-Garza and Iriondo, 2005).

Disarticulated skeletal elements of crinoids are abundant in Palozoic rocks (Moore and Jeffords, 1968; Gluchowski, 2002; Itano et al., 2003), but commonly the rocks are formed primarily only by fragmented columnal and columnal plates to form encrinites.

The Middle Permian fauna of the Monos Formation has a great affinity with faunas from other localities of Mexico. Specially the crinoid species here reported have a strong relationship with Olinalá, Guerrero (Olinala Formation); Ihualtepec, Oaxaca (La Cruz formation); Calnali (Del Monte Formation) and Pemuxco (Guacamaya Formation), Hidalgo; and Patlanoaya, Puebla (Patlanoaya Formation).

From the Pennsylvanian of Olinalá (Olinalá Formation), Guerrero, has been cited *Heterostelechus jeffordsi*, and *Pentaridica pentagonalis* (Flores de Dios and Buitrón, 1982; Esquivel-Macías, et al. 2004). Buitrón et al. (1987) had mentioned *Cyclocaudex* cf. *C. costatus*, *C. jucundus*, and *Heterosteleschus keithi* from the Pennsylvanian of Calnali, Hidalgo. Vázquez-Echeverría (1986) and Villaseñor et al. (1987) in their biostratigraphical studies from Patlanoaya, Puebla southern Mexico, had mentioned *Cyclocaudex* sp. and *Cyclocaudex typicus*. Velasco de León and Buitrón (1992) had described also another species of crinoids common with Sonora, closed to *Cyclocaudex jucundus* of Virgilian age (Late Pennsylvanian) from Patlanoaya. Buitrón and Solís-Marín (1993) made a catalogue of echinoderm species of Mexico and cited *Cyclocaudex* sp., *C. typicus*, *C. insaturatus*, and *C. jucundus*.

Vachard et al. (1997) conducted geologic and paleontologic studies in Ihualtepec (La Cruz formation) Oaxaca, southeastern Mexico, and mentioned the presence of fusulinids (*Parafusulina deliciasensis* = *P. maleyi*) and crinoids (*Cyclocaudex typicus* and *Pentaridica rothi*) both attributed to the early-middle Wordian.

Buitrón in Arellano et al. (1998) cited the species *Cyclocaudex plenus*, *C. jucundus*, and *Preptopremnum rugosum* associated to fusulinids *Skinerella* (Vachard in Arellano, et al., 1998) from Lower Permian rocks of Pemuxco, Hidalgo State. Esquivel-Macías et al. (2000) had published crinoids with a tetralobulate lumen from Patlanoaya region, Puebla State of Missourian-Virgilian age, and also their cited the species *Cyclocaudex jucundus*,

C. costatus, *Heterosteleschus texanus*, *Pentaridica rothi*, and *Preptopremnum rugosum* also present in Cerro Los Monos, Sonora.

The Pennsylvanian-Permian crinoids *Pentaridica*, *Cyclocaudex*, *Preptopremnum*, and *Heterostelechus* indicate similarities between Texas and Sonora. Some Permian fusulinids from Sonora are characteristic of the North American Craton (Midcontinent, Glass Mountains), specifically with exotic terranes of the North American Cordillera faunal region and also related with faunas of Eurasiatic-Arctic provinces. This fauna includes fusulinids of the genera *Pseudofusulina*, *Parafusulina*, *Triticites*, *Schwagerina*, and *Boultonia*.

During the Permian, the Sonora territories were also characterized by a diverse faunal association typical of the North American region that include brachiopods such as *Composita*, *Martinia*, *Wellerella*, *Liosotella*, *Hustedia*, *Rhynchopora*, *Spiriferellina* and *Dictyoclostus*, the tetracoral *Lophophyllidium*, the bryozoan *Fenestella*, ammonites (*Waagenoceras*) and the algae *Paraepimastopora* (Ross and Ross, 1979; Buitrón et al., 2004). Among the fusulinids of Sonora, *Parafusulina antimonioensis* Dunbar (Figure 4 a-e, i-j, l, n-o, q-t) is very close to *Parafusulina californica* (von Staff), and is a characteristic index fossil of late Wordian (Wilde, 1990) because it is transitional between the typical *Parafusulina* of the middle Wordian with a large central tunnel (Figure 4 A) and relatively irregular polar septal arches (Figure 4. L, T), and the typical *Polydixodina* of early-middle Capitanian with relative gigantism and the developed cuniculi (Figure 4o). *P. antimonioensis* appears at diverse localities and has a strong relationship with Sonora, California, New Mexico, Texas, and Canada paleoprovinces, whilst *Pseudoschwagerina* appears in Sonora, North America, and some Russian localities.

The Cerro Los Monos area could constitute a separate terrain due to the presence of the giant *Parafusulina antimonioensis* Dunbar, which is considered a guide fossil of North American Exotic Terrains (Ross and Ross, 1983; González-León and Stanley, 1993; Calmus et al., 1997; Stewart et al, 1990; Vachard et al., 2000) because it is found from the Klamath Mountains (North California) to the northeastern to the State of Washington. Nevertheless, this argument is not completely convincing because this taxon has also been reported in the Glass Mountains, Texas on the American craton (Ross, 1963; Kobayashi, 1957). Consequently, the so-called El Antimonio Terrain, where the Monos Formation is included, is considered here as a different terrain from that named Caborca or Seri Terrain and a piece of the North American Craton (Figure 5).

After this analysis of the Permian biota is concluded that the cosmopolitan distribution of the fauna studied is due to the connections between the seas of West North America and Eastern Asia. The benthic Late Permian Sonora fauna was widely dispersed in the Tethyan realm, which was extended from Western North America to Northern Africa and Asia.

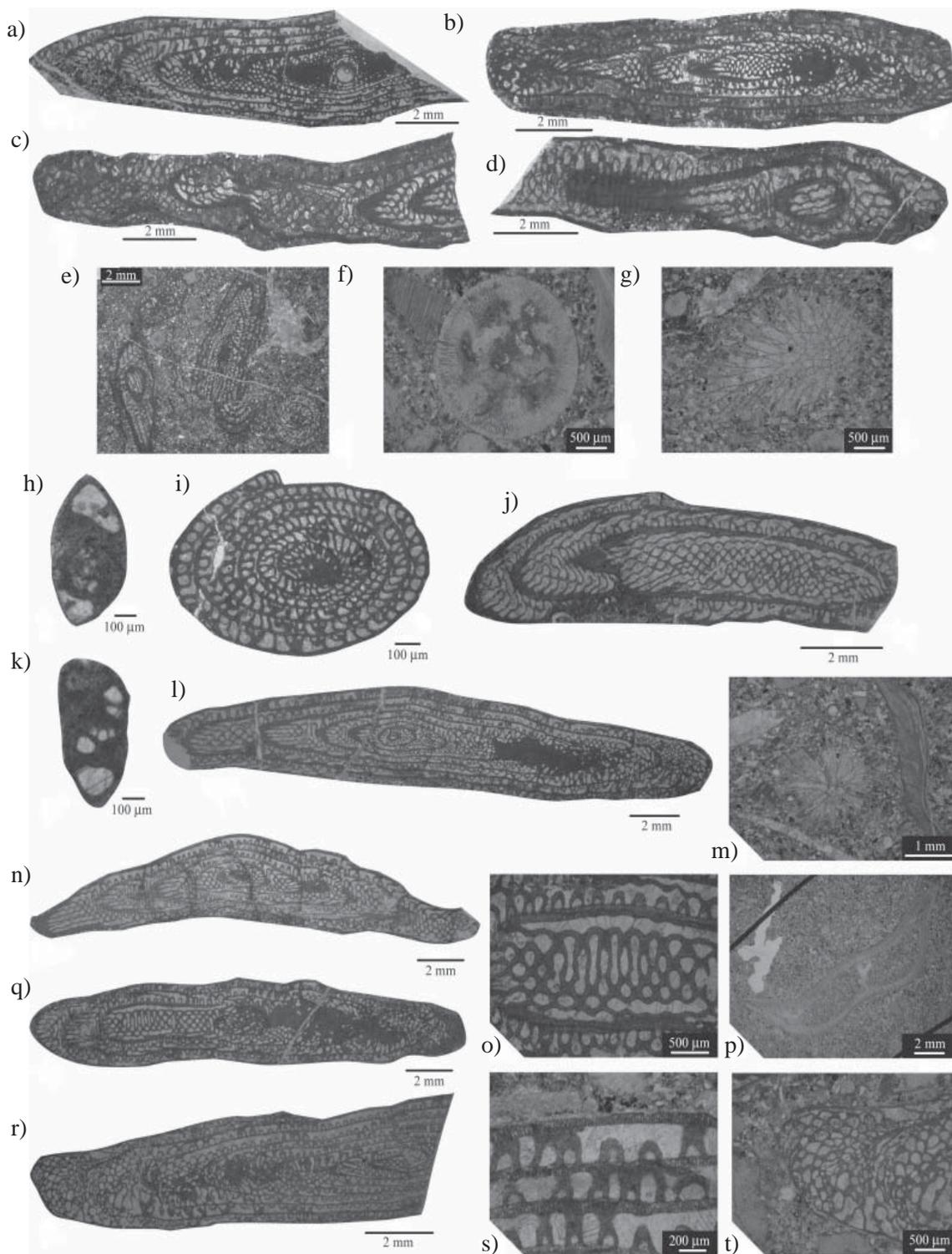


Figure 4. Microfossils and microfossils from the Monos Formation. a-e, i-j, l, n-o, q-y: *Parafusulina antimonioensis* Dunbar (in Cooper et al., 1953). a: Incomplete axial section of a megalospheric specimen, showing a complex proloculus, small axial filling, large tunnel and septal folding. b-d, j, l, n, q-r: Several aspects of diverse subaxial sections showing the axial filling (b, l, n, q-r), the cuniculi (b, d, l, q), the septal folding (d, j, n, r), diverse shapes of a septum from top to base (d, j, l) and a possible, more elongate microspheric individual (l). e: Several sections in a bioclastic floatstone with a matrix of sandy bioclastic wackestone (this lithology is the more favorable to the giant parafusulinids). i: Subtransverse section showing the numerous chambers. o: Detail of cuniculi at the base of a septum. s: Regular height of the whorls, relatively regular U-shaped central septal arches (an advanced character), and keriotheca (especially in the last whorl, right). t: Irregular polar septal arches (a primitive character). f: Unidentified crinoids with crenularium and lumen, partially bored by endobionts. g, m: Well preserved bryozoa colonies in a sandy wackestone matrix. h, k: *Neendothyra ex gr. parva* (Lange), a common foraminifer in the assemblage. h: Transverse section with the characteristic carina. k: Axial section with the characteristic carina and axial filling. m, p: Brachiopod bioclasts; p: Productoidea; m: longitudinal section.

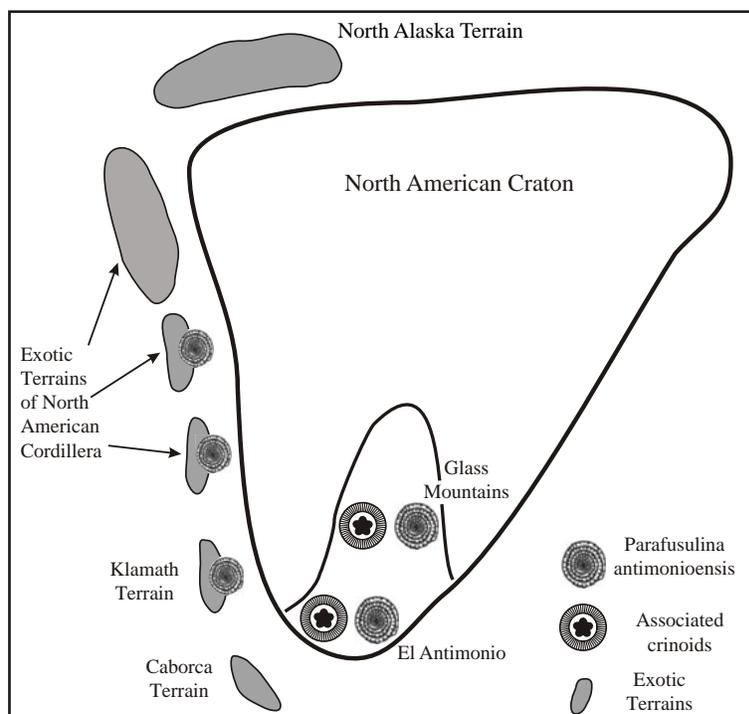


Figure 5. Fossil assemblages of the Monos Formation (crinoids and *Parafusulina antimonioensis*) indicating that this biota is not limited to the suspect terrains, but exist also on the North American Craton, consequently they are not evidence for the individuality of an Antimonio terrain.

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