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ECHINODERMS FROM THE LOWER DEVONIAN (EMSIAN) OF BOLIVIA (MALVINOKAFFRIC REALM)

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ABSTRACT—Crinoid faunas from the Lower Devonian of South America are poorly known. Two new taxa are described from the Emsian Icla Formation at Cerro Kochis in the Cochabamba Department: the rhodocrinitid, *Lutocrinus boliviaensis* n. gen. n. sp. and *Griphocrinus pirovanoi* n. sp. Two additional camerates are reported from the Emsian Belèn Formation of the Altiplano region in the La Paz Department, including *Ctenocrinus branisai* n. sp. and *Boliviacrinus isaacsoni* McIntosh, 1988. In addition, a specimen of the blastoid, *Pachyblastus dicki* Bremier and Macurda, 1972, was recovered from the Altiplano region. These crinoids and material previously collected by Leonardo Branisa, including specimens of *C. branisai* n. sp., *Apurocrinus sucrei* McIntosh, 1981, *B. isaacsoni* McIntosh, 1988, and *L. boliviaensis* n. sp., are described and revised. The specimens give new insights into the Lower Devonian Malvinokaffric Realm of Bolivia, a relatively new frontier in crinoid paleontology.

INTRODUCTION

CRINOIDS AND other pelmatozoans are poorly known from the Devonian Southern Hemisphere Malvinokaffric Realm. Kirk (1913) described the cladid crinoid *Botryocrinus doubleti* Kirk, 1913 from a single, poorly preserved specimen from the Falkland Islands. Bradshaw and McCartan (1991) figured a crinoid holdfast from the Horlick Formation of the Ohio Range of Antarctica that they attributed to *Ancyrocrinus*? sp., and *Cyathocrinites elongatus* Knod, 1908 was described from the Cuyo Basin of Argentina. In addition, pelmatozoans are known from the Malvinokaffric and post-Malvinokaffric Realms of Bolivia. Branisa (1965) figured numerous columnals, named ?*Botyrocrinus* sp., and illustrated three unidentifiable calices, one of which, USNM PAL 3400009, is described herein. Macurda (1979) described two blastoid genera from the Lower Devonian Belén Formation, one of which is also reported here. McIntosh described two genera from Bolivia: *Apurocrinus* McIntosh, 1981 from the Emsian Belén Formation and *Boliviacrinus* McIntosh, 1988 from the Eifelian Sica Sica Formation. The fauna described here includes one new genus and four new species in addition to new specimens that add to our understanding of previously described taxa. This fauna is important because it nearly doubles the known pelmatozoan taxa from the high latitude, cold water, and primarily siliclastic Malvinokaffric Realm (e.g., Isaacson, 1974, 1977; Melo, 1988; Lieberman, 1993) and gives new insights into the pelmatozoan taxa from the Emsian of Bolivia.

STRATIGRAPHY AND GEOLOGIC SETTING

The crinoids and blastoid discussed herein are from three localities in Bolivia. MHNC 13503 and 13504, USNM PAL 340009 and 305767, and USNM S47064 are from Belén in the Altiplano of the La Paz Department, approximately 140 km southeast of La Paz (Fig. 1). MHNC 13501 and 13502 are from Cerro Kochis, a poorly known locality approximately 3 km north of the Rio Grande in the Cochababma Department. USNM 305764a-b and USNM 305766 are from Candelaria, approximately 30 km southeast of Tarabuco. The specimens from Belén are from the lower member of the Belén Formation, and those from Cerro Kochis and Candelaria are from the Icla Formation. These two formations are lateral equivalents; however, the Belén crops out in the Altiplano, whereas the Icla occurs in Cochabamba (Babcock et al., 1987). The Belén and Icla were dated as Siegenian to Emsian based on biostratigraphic evidence from trilobites (Wolfart and Voges, 1968), brachiopods (Isaacson, 1977), and palynomorphs (McGregor, 1984). Due to the lack of carbonate beds in these strata, Isaacson (1977) deduced that the paleoenvironment recorded in the Icla and Belén formations was a shallow cool sea. Also, Isaacson (1975) suggested that most of the siliciclastics deposited in the Devonian were derived from the erosion of a large source region to the west, because of the presence of thicker and coarser Devonian sediment in the northwestern part of the country. Isaacson (1975) and Isaacson et al. (2003) made the case for a gradual rise in sea level through the Emsian. The Belén and Icla formations were deposited at the beginning of this deepening and represent part of a transgressive event (Isaacson et al., 2003).

The rocks from which the MHNC 13503 and MHNC 13504 were recovered are silty shales and contain abundant fine-grained muscovite. According to Isaacson (1975), this muscovite may have come from the Precambrian metamorphic basement rocks that now crop out in northwestern Argentina. The *Francovichia* Zone occurs within the lower member of the Belén Formation at Belén and equivalent units at Cerro Kochis. Strata from this zone are described as silty in the lower two fifths, followed by a silty shale, a shale of greenish black color, and the upper fifth becoming more sandy (Branisa, 1965; Macurda, 1979). USNM 305767 and USNM PAL 340009 are from the *Platyceras* Zone in the lower Belén Member and are preserved in similar brown, micaceous siltstones. USNM S47064 is also from the lower member of the Belén Formation. MHNC 13501 and MHNC 13502 are preserved in carbonate nodules and are from the *Francovichia* Zone of the Icla Formation at Cerro Kochis. These carbonate nodules are composed of grey micrite and appear to encase the specimens. USNM 305764a-b and 305766 are preserved as internal molds in siltstone from the Icla Formation.

SYSTEMATIC PALEONTOLOGY

Terminology follows Ubaghs (1978a), with modifications from Ausich et al. (1999). Brachial shape follows Webster and Maples (2008), and the scheme for defining relative proportions of the calyx follows Ubaghs (1978a, fig. 72). Repository is Museo historia natural Alcides d'Orbigny in Cochabamba

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FIGURE *1*—Map of Bolivia detailing locations of localities and major cities. Cities are indicated by dots, localities by an x; department names indicated in bold.

(MHNC) and the Smithsonian Institution National Museum of Natural History (USNM) in Washington D.C.

Class CRINOIDEA Miller, 1821
Subclass CAMERATA Wachsmuth and Springer, 1885
Order DIPLOBATHRIDA Moore and Laudon, 1943
Superfamily RHODOCRINITACEA Roemer, 1855
Family RHODOCRINITIDAE Roemer, 1855
Genus LUTOCRINUS new genus

Type species.—*Lutocrinus boliviaensis* n. gen. n. sp. by monotypy.

Diagnosis.—As for species.

Etymology.—From the Latin *lutus* (m.) meaning mud and referring to the carbonate mud in which the holotype was preserved.

Occurrence.—This new genus is only known from the Lower Devonian (Emsian) of Bolivia.

Remarks.—Three specimens are known of this new genus. The radial plates are not in contact around the entire calyx, placing the specimen in the Rhodocrinitacea. The morphology of *Lutocrinus* is included within the morphological disparity known for the Rhodocrinitidae. It is differentiated from similar genera as noted below. The bowl shape and height of the calyx are similar to that of *Rhipidocrinus* Beyrich, 1879. However, this crinoid has a distinct CD interray (Fig. 2.1, 2.7, 3.1), and its arms are more regular than those of *Rhipidocrinus*. The free arms of *Lutocrinus* (Fig. 2.3) are similar to those of *Cadiscocrinus* Kirk, 1945, but *Cadiscocrinus* has only 10 free arms. There are also many differences between their calices, most notably, the large number of plates in *Lutocrinus* and the large basal plates present in *Cadiscocrinus*. The branching of the fixed brachials in *Lutocrinus* is very similar to that in *Thylacocrinus* Oehlert, 1878, but the calyx size and shape are very different.

LUTOCRINUS BOLIVIAENSIS new species
Figures 2.1–2.3, 2.7, 2.8, 3.1

Diagnosis.—Rhodocrinitid with flat, bowl-shaped calyx; infrabasals, basals, and radials in basal invagination; 1–2 plating in proximal part of regular interrays; P-3 plating in proximal part of CD interray; median ray ridges absent; anitaxial ridge absent; primanal heptagonal; fixed pinnules absent; 20 free arms, brachials biserial.

Description.—Calyx, medium in size; flat-bowl shaped (Fig. 2.2); very wide basal concavity; arms not grouped; calyx plate sculpturing smooth with low convexity; fine-scale crenulation to calyx plates. Infrabasal plates mostly covered by column thus shape and width unknown. Basal plates five, hexagonal, approximately twice as high as wide (Table 1), in sutural contact with all interrays. Infrabasals and basals located within the basal concavity. Radials, five, pentagonal, approximately as high as wide and immediately inside basal concavity (Fig. 2.8). Radial circlet interrupted in all interrays (Fig. 2.7). Interrays in contact with tegmen; first interradial heptagonal, wider than high, larger than radials and first primibrachials. Second range typically with two plates; plating 1-2-3-2-2-?. Primanal heptagonal; larger than radial plates and first interradials; plating on CD interray P-3-5-5-5-4-?; CD interray in contact with tegmen; anitaxis with plates more convex than other calyx plates.

First primibrachial fixed, hexagonal, wider than high, slightly smaller than radial plate; second secundibrachial fixed, axillary, pentagonal to heptagonal. Second tertibrachial distal-most fixed brachial; tegmen unknown; free arms, 20, atomous; brachials flat-chisel biserial (Fig. 2.3), wider than high, pinnulate. Proximal column holomeric, circular, heteromorphic with very convex nodals; other aspects of column unknown.

Etymology.—Species name *boliviaensis* refers to Bolivia, the country from where the holotype was recovered.

Types.—MHNC 13501 is the holotype; USNM 305764a and 305764b are paratypes.

Occurrence.—This species is from the *Francovichia* Zone in the Icla Formation; it is Emsian in age. The holotype was recovered from Cerro Kochis.

Remarks.—The arms of the holotype (MHNC 13501) are fairly well preserved, but only approximately 65% of the calyx above the first primibrachials is preserved, and details within the basal concavity are totally obscured. The tegmen is entirely enclosed by the arms in the holotype. The two other specimens are only partially preserved molds that include the plating in the basal concavities and the proximal calices; thus, they have more complete infrabasal, basal, and radial circlets than the holotype (Fig. 2.7, 2.8). The size, shape, and depth of the basal concavity of the two partial calices match those of the holotype. Also, the unusual crenulated plate sutures exist in all three specimens assigned to this new species.

Superfamily DIMEROCRINITACEA Zittel, 1879
Family DIMEROCRINITIDAE Zittel, 1879
Genus APUROCRINUS McIntosh, 1981

Type species.—*Auprocrinus sucrei* Mcintosh, 1981.

APUROCRINUS SUCREI McIntosh, 1981
Figures 3.3, 4.1, 4.2, 4.4, 4.5, 5.6

1981 *Apurocrinus sucrei* MCINTOSH, p. 949, fig. 1A, 1B, 1C.

Material.—USNM 305766 and USNM 305767a.

Remarks.—USNM 30577a is an external mold of the calyx, and thus, a latex cast was made for study (Fig. 4.1). USNM 305766 is an internal cast of a complete calyx. McIntosh's (1981) description is accurate; and the following details only enhance his work. However, it should be noted that the holotype specimen is in all likelihood a juvenile. The most obvious support for this is

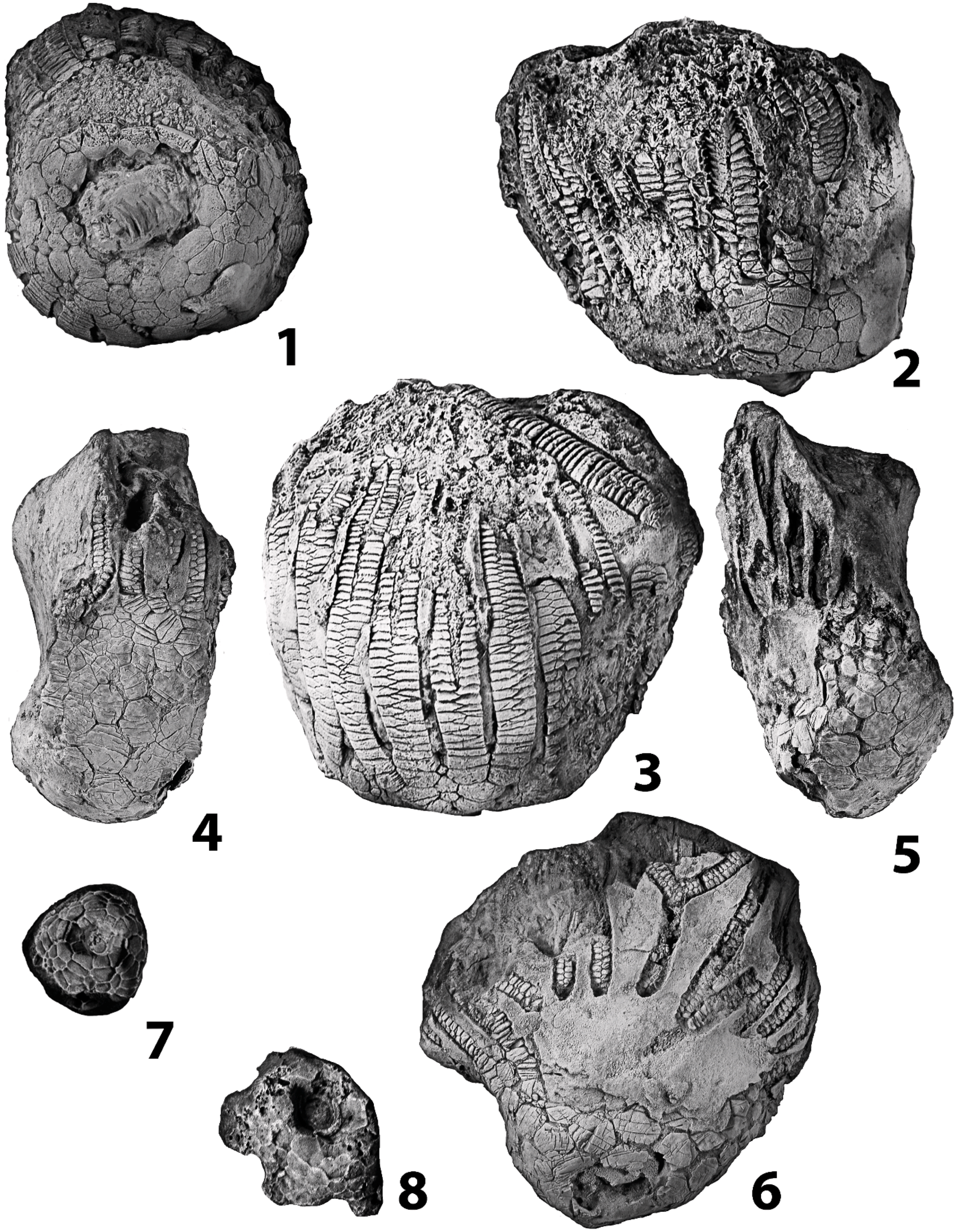

FIGURE *2—1–3, Lutocrinus boliviaensis* n. sp., MHNC 13501, holotype: *1*, basal view of calyx, column present within basal invagination, radial plates down missing, ×1.5, compare with *Fig. 3.1*; *2*, lateral view of calyx, ×1.5; *3*, lateral view of arms, ×1.5; *4–6*, *Griphocrinus pirovanoi* n. sp., MHNC 13502, holotype: *4*, posterior view of calyx, C-D interray, ×1.0; *5*, lateral view of calyx, nodose ray plates, ×1.0; *6*, lateral view of calyx, possible isotomous branching, ×1.0; *7, 8, Lutocrinus boliviaensis* n. sp.: *7*, USNM 305764a, paratype, internal mold of base of calyx, radial plates and below present, ×2; *8*, USNM 305764b, paratype, internal mold of base of calyx, ×2.0.

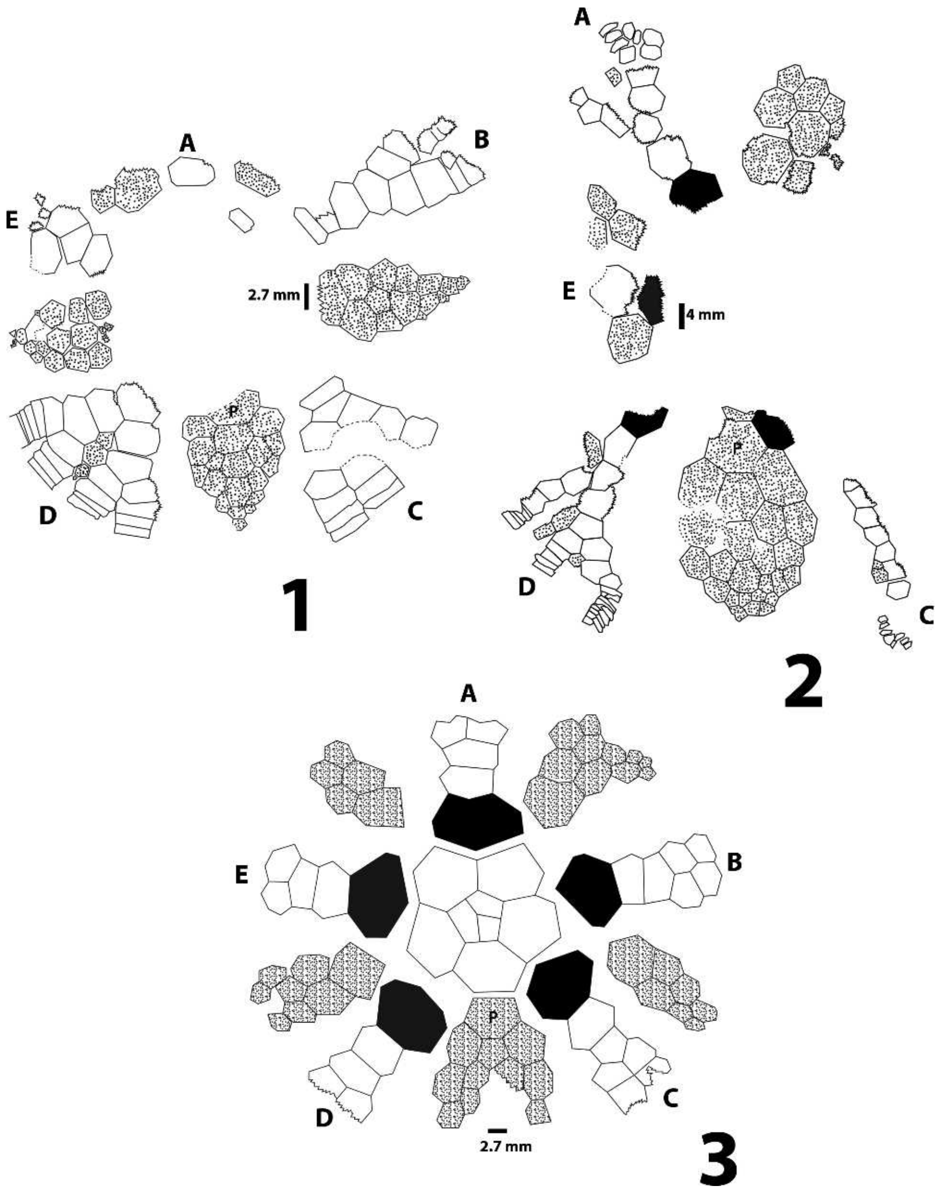

FIGURE 3—Plate diagrams of *Lutocrinus boliviaensis* n. sp., *Griphocrinus pirovanoi* n. sp., and *Apurocrinus sucrei* McIntosh, 1981. *1*, *Lutocrinus boliviaensis,* MHNC 13501, holotype, compare to *Fig. 2.1*, specimen's calyx above the radial plates present; *2, Griphocrinus pirovanoi*, MHNC 13502, holotype; *3, Apurocrinus sucrei,* USNM 305766; plate diagrams, scale as indicated, A-E, designation of rays; black=radial plates; stippled=interradial plates.

the difference in size between USNM 305766 and USNM 305767a and the holotype. The holotype calyx is 7.0 mm high whereas USNM 305766 and USNM 30577a have calyx heights of 34.0 mm and 24.32 mm high, respectively (Table 1). Also, there are two arm plates between axillary brachials in the holotype; whereas there are four to five arm plates between axillary brachials on USNM 305767a (Fig. 4.1). Information regarding the infrabasal plates was absent from McIntosh's description due to the lack of preservation of fine sutural details. USNM 305767a has preserved details of the infrabasal plates; and thus, it is noted that there are three infrabasals that are tetragonal and approximately 1.35 times higher than wide (Figs. 3.3, 4.2). Unknown on the holotype, the tegmen is poorly preserved on USNM 305766. All interrays are in contact with the tegmen (Fig. 4.4), which is a flat cone, much lower than the calyx (Fig. 4.5). A short conical anal tube protrudes from the distal margin of the CD interray. The tegmen top is composed of many relatively small plates, and the ray regions are raised. Finally, the arms of USNM 30577a have small circular pitted holes that are *Oichnus paraboloides* Bromley, 1981. These holes (Fig. 5.6) resulted in plate interruption and are surrounded by a bulge. *Oichnus* is known to occur on crinoids (e.g., Brett, 1985; Donovan et al., 2006; Donovan and Lewis, 2010; Wilson et al., 2010), so its presence on this crinoid is not surprising.

Genus GRIPHOCRINUS Kirk, 1945

Type species.—*Rhodocrinus (Acanthocrinus) nodulosus* Hall, 1862.

Occurrence.—The genus *Griphocrinus* occurs in the Devonian (Givetian) of the United States, the Middle Devonian (Couvinian) of Spain, the Middle Devonian (late Emsian–Eifelian) of Algeria, and now the Lower Devonian (Emsian) of Bolivia.

Remarks.—This specimen appears to belong to the genus *Griphocrinus* upon initial inspection, however, with much of the base of the calyx missing, it is difficult to discern whether or not the specimen is a monobathrid or diplobathrid. Because the radial

TABLE 1.—Measurements of Bolivian monobathrid and diplobathrid camerates. All measurements in mm, asterisk indicates crushed or incomplete specimen, N/A indicates characters not present in monobathrids.

Order	Diplobathrida				
Species	*Lutocrinus boliviaensis*			*Apurocrinus sucrei*	
Museum Number	MHNC 13501	USNM 305764a	USNM 305764b	USNM 3056766	USNM 305767a
Aboral cup height	-	6.75	-	20	16.21
Aboral cup width	-	9.32	-	36	27.02
Basal plate height	-	4.59	4.32	7.43	6.89
Basal plate width	-	2.7	4.05	8.37	7.16
Calyx height	15*	-	-	32.7	24.32*
Calyx width	37*	14.18	-	40	27.02*
Crown height	43.5*	-	-	-	75.648*
Primanal plate height	5.41	2.16	2.97	8.24	8.1
Primanal plate width	5.81	3.24	4.05	7.02	6.89
Radial plate height	-	2.43	3.91	7.16	7.83
Radial plate width	-	3.24	4.72	11.08	7.02
1st primibrachial height	3.38	1.48	2.7	5.54	6.21
2nd primibrachial height	3.51	1.75	-	4.05	4.86
1st interradial Plate height	4.05	2.16	3.1	7.56	4.429
Infrabasal plate height	-	0.54	-	-	3.1
Infrabasal plate width	-	-	-	-	2.29
Infrabasal circlet height	-	0.54	-	-	3.1

circlet is only interrupted in the CD interray and because of the calyx shape, the specimen is judged to belong to either the diplobathrid superfamily Dimerocrinitacea or the monobathrid superfamily Periechocrinacea. Periechocrinids have a basal circlet comprised of three plates with sutures typically below the B ray, E ray, and CD interray (Ubaghs, 1978b). A suture does not exist below the CD interray in this specimen; the primanal sits directly above a single posterior basal plate (Fig. 3.2). In addition, in periechocrinids, the primanal must be either heptagonal with three plates in the next highest row, or hexagonal with two plates in the next highest row (Ubaghs, 1978b). In this specimen, the primanal is hexagonal with three plates in the next highest row. Therefore, it is presumed to be a dimerocrinitid, supporting the original hypothesis that it belongs to *Griphocrinus*.

GRIPHOCRINUS PIROVANOI new species
Figures 2.4–2.6, 3.2, 5.4

Diagnosis.—*Griphocrinus* with low bowl-shaped calyx, proximal plating in posterior interrays 1-2-3; plate sculpturing nodose but lacking radiating ridges; radials largest plate in calyx, hexagonal; first or third tertibrachial distal-most fixed brachial; fixed axillary tertibrachials present or absent; free arms 20 or more, biserial flat-chisel brachials.

Description.—Calyx large in size, low bowl shape (Fig. 2.4); arms not grouped; calyx plate sculpturing slightly nodose with ray plates more convex than interradial plates (Fig. 2.5). Infrabasal and basal plates unknown except CD basal in contact with primanal. Radial circlet approximately 22% of calyx height (Table 1), only interrupted in posterior (Fig. 3.2). Radial plates presumably five, hexagonal, approximately as wide as high. Primanal hexagonal, approximately equal in width and height, approximately same size as radial plates, interrupts radial circlet; plating in CD interray P-3-5-5-7-4-0; in contact with tegmen; anitaxis composed of slightly more convex plates than remainder of interradials, anitaxis does not continue onto tegmen (Fig. 2.4).

First primibrachial fixed, hexagonal, slightly higher than wide, approximately same size as smaller radial plate. Second secundibrachial axillary, fixed. Second or third tertibrachial last fixed brachial. Tegmen unknown. Free arms, presumably 20, may have isotomous branching (Fig. 2.6). Brachials wedge biserial proximally and flat-chisel biserial within 10 mm above the calyx; long, slender pinnules. Column unknown.

Etymology.—Named for Giuseppe Piróvano, Bolivian fossil collector who has been instrumental in the collection of fossils in Bolivia.

Types.—Holotype is MHNC 13502.

Occurrence.—The holotype is from the *Francovichia* Zone in Icla Formation of Cerro Kochis, Cochabamba Department, Bolivia, which is Emsian in age.

Remarks.—The tegmen is not known, and approximately 50% of the calyx is missing. Only a small piece of a basal plate is present, but it is important in the identification of the primanal. The remainder of the basal and infrabasals are not preserved. Many of the plates, excluding those in the posterior, are slightly disarticulated and worn. The distal-fixed plates in the A ray are nodose (Fig. 2.5), which is typical for this genus. Although the base of the calyx is not preserved, the proximal portion of a well-preserved convolute organ (perigastric coelomic organ of Haugh, 1975) (Fig. 5.4) is preserved inside the calyx. This convolute organ is comprised of a spicular sheath that was presumably an open meshwork. The sheath is spiraled onto itself at least once.

Order MONOBATHRIDA Moore and Laudon, 1943
Suborder GLYPTOCRININA Moore, 1952
Superfamily MELOCRINITACEA d'Orbigny, 1852
Family MELOCRINITIDAE d'Orbigny, 1852
Genus CTENOCRINUS Bronn, 1840

Type species.—*Ctenocrinus typus* Bronn, 1840.

Occurrence.—The genus *Ctenocrinus* is known from the middle Silurian (Wenlockian) to the Late Devonian (Frasnian) of Europe; from the middle Silurian (Niagaran) to the Early Devonian (Helderbergian) of the United States; from the Devonian (late Lochkovian) of Australia; and now from the Lower Devonian (Emsian) of Bolivia.

CTENOCRINUS BRANISAI new species
Figures 5.1–5.3, 6

1965 Crinoid indet. 2 BRANISA, pl. 23, fig. 2; WEBSTER, 2003.

Diagnosis.—*Ctenocrinus* with medium bowl-shaped calyx (Fig. 5.1, 5.2); basal plate sizes equal; first primibrachial hexagonal, two fixed secundibrachials, tegmen unknown; proximal CD interray plating P-2-?; 4 arms per ray with two adaxial arms grouped to form one trunk with biserial, pinnulate ramules (Fig. 5.1); two very small abaxial arms; arms erect.

Description.—Calyx medium size; medium bowl shape; arms grouped; calyx plates slightly convex. Basal circlet about 16% of calyx height (Table 1); basal plates four, nearly equal in size (Fig. 6.1). Radial circlet averages approximately 18% of calyx height, uninterrupted in posterior, radial plates five, hexagonal, approx-

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TABLE 1.—Extended.

Diplobathrida	Monobathrida				
Griphocrinus branisai	*Ctenocrinus pirovanoi*			*Boliviacrinus Isaacsoni*	
MHNC 13502	MHNC 13503a	USNM PAL 340009	USNM B49 (9611)	MHNC 13504	USNM 305767b
10.81*	5.67*	5.94	-	9.45	8.64
37.00*	12.43*	8.24	-	14.72	14.72
-	2.3	2.16	-	3.37	4.59
-	3.65	2.97	-	4.86	-
31.00*	17.00*	8.51*	4.45*	9.45*	20.00*
51.00*	25.00*	16.21*	6.62*	14.72*	14.72
66.00*	46.00*	29.85*	15.67*	-	33.51*
10	-	-	-	-	-
10.27	-	-	-	-	-
10.14	2.7	2.43	-	4.59	5.81
9.19	4.19	3.37	-	6.62	7.02
6.76	2.84	2.56	1.48	4.72	3.64
5.95	2.84	1.89	1.21	1.89	2.97
-	N/A	N/A	N/A	N/A	N/A
-	N/A	N/A	N/A	N/A	N/A
-	N/A	N/A	N/A	N/A	N/A
-	N/A	N/A	N/A	N/A	N/A

imately 1.6 times wider than high. Normal interrays in contact with tegmen, plate sculpturing as described above. Second range typically with two plates; plating 1-2-2-3-? (Fig. 6.3). Primanal dimensions unknown; plating in CD interray P-2-?; CD interray in contact with tegmen.

First interprimibrachial hexagonal approximately as high as wide, on average same size or larger than radials and basals; second primibrachial axillary, pentagonal, fixed; distal-most fixed brachial third secundibrachial. No intrabrachial plates. Tegmen unknown. Free arms 20, two large, adaxial arms in each ray grouped into arm trunks flanked by small inconspicuous abaxial arms in each ray. Arm trunks, uniserial, with pinnulate, biserial arms (Fig. 6.2, 6.3). Column circular, holomeric, heteromorphic with a pattern of N11, nodals thicker than internodals (Fig. 5.1).

Etymology.—Named for Leonardo Branisa, Bolivian geologist and paleontologist.

Types.—Holotype is MHNC 13503a, paratypes are USNM S47064 and USNM PAL 340009.

Occurrence.—*Ctenocrinus branisai* is only described from the *Francovichia* Zone in the lower Bélen Member of the Belén Formation at Belén, La Paz Department, Bolivia, which is Emsian in age.

Remarks.—This crinoid is similar to species of *Melocrinites* Goldfuss, 1831 but is placed within *Ctenocrinus* because it has very small arms on the abaxial sides of the arm trunks. The holotype is a slightly compressed internal mold of the calyx and the column. The column is preserved unattached and to the side of the calyx, giving a false impression of the calyx height. In the holotype (Fig. 5.1) the column cicatrix projects straight out of the slab; thus the basal circlet is exposed and much information regarding calyx plating is preserved. Based on its size in comparison with the other two specimens, USNM PAL 340009 is interpreted to be a juvenile (Fig. 5.3).

Superfamily PATELLIOCRINACEA Angelin, 1878
Family PATELLIOCRINIDEA Angelin, 1878
Genus BOLIVIACRINUS McIntosh, 1988

Type species.—*Boliviacrinus isaacsoni*, McIntosh, 1988.

Occurrence.—Eifelian and Emsian of Bolivia.

Remarks.—McIntosh's (1988) description is accurate, and little new morphological information can be added. However, this is the first occurrence of this species and genus outside of the Sica Sica Formation and also the first in the Emsian, which extends the stratigraphic range of the both the genus and species.

BOLIVIACRINUS ISAACSONI McIntosh, 1988
Figure 4.3, 4.6–4.8

1988 *Boliviacrinus isaacsoni* MCINTOSH, p. 623, figs. 1, 2.

Material.—MHNC 13504 and USNM 305767b. MHNC 13505 is questionably assigned to this species.

Occurrence.—Eifelian, Sica Sica Formation, peninsula de Copacabana, La Paz Department and now Emsian, Belén Formation, lower Belén Member, near Belén, La Paz Department, Bolivia.

Remarks.—MHNC 13504 is an internal and external mold of the calyx (Fig. 4.6, 4.7), and USNM 305767b is an excellent external mold of the calyx (Fig. 4.3; Table 1). Much of the basal calyx details from MHNC 13505 are obscured, and this initially made identification and description difficult. The calyx of MHNC 13504 is flattened. All specimens mentioned exhibit limonite staining. MHNC 13505 has excellent detail of the pinnulate arms (Fig. 4.8).

Class BLASTOIDEA Say, 1825
Order FISSICULATA Jaekel, 1918
Family NYMPHAEOBLASTIDAE Wanner, 1940
Genus PACHYBLASTUS Breimer and Macurda, 1972
PACHYBLASTUS DICKI Bremier and Macurda, 1972
Figure 5.5

1972 *Pachyblastus dicki* BREIMER AND MACURDA, pl. 1, figs. 1–8.
1979 *Pachyblastus dicki* MACURDA, p. 1361, 1365, pl. 1, figs. 1–8.
1983 *Pachyblastus dicki* MACURDA, p. 104.

Remarks.—MHNC 13503b was preserved on the same slab as the holotype of *Ctenocrinus branisai* n. sp. This blastoid is preserved as a mold, and only about 75% of the theca and some brachioles are preserved (Fig. 5.5). Macurda (1979) previously described *Pachyblastus dicki* (Breimer and Macurda, 1972) from the lower Belén Formation of Bolivia. The presence of this blastoid is important paleoecologically because it indicates that blastoids and crinoids from this fauna were living together in stalked echinoderm communities.

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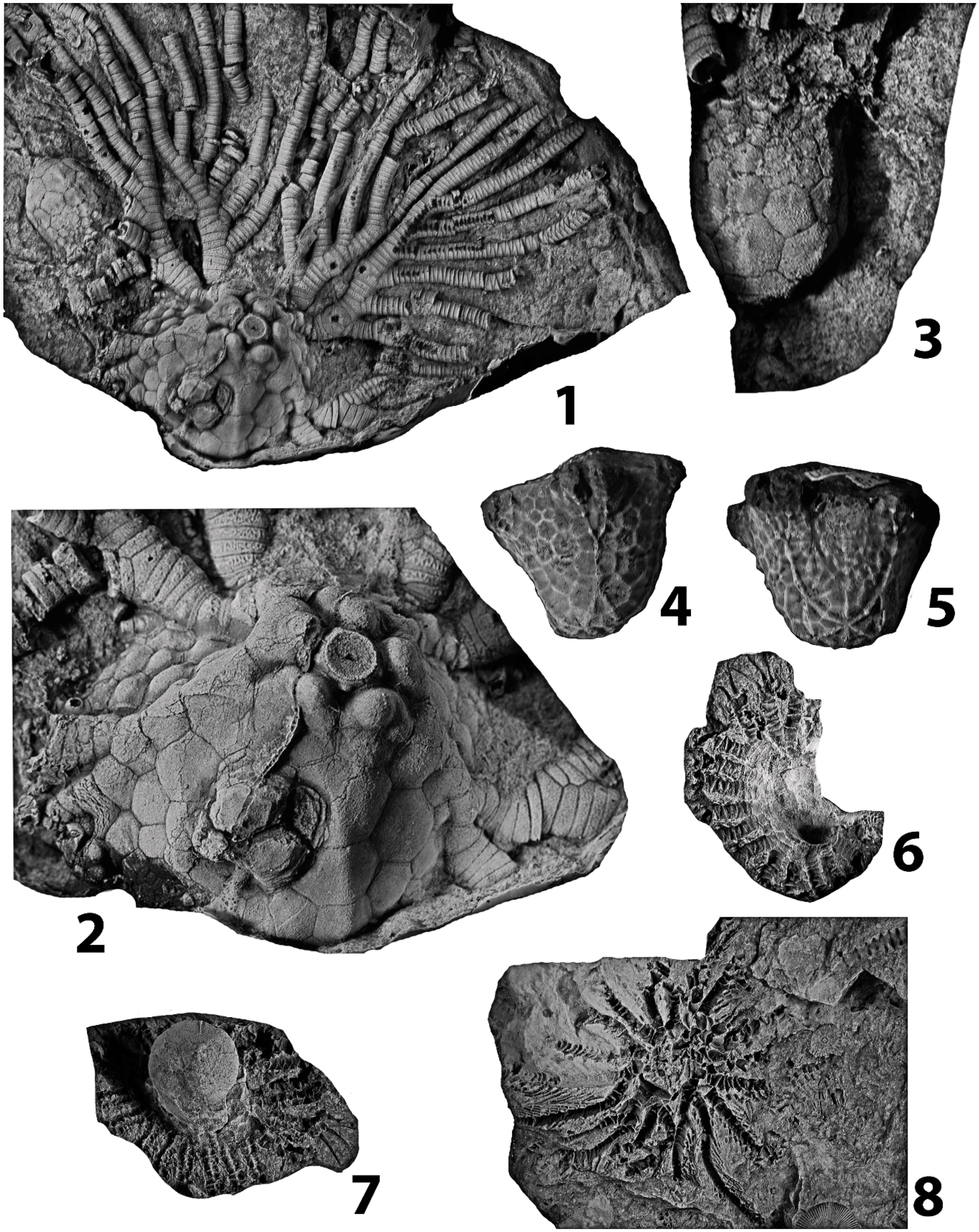

FIGURE 4—*1, 2, Apurocrinus sucrei* McIntosh, 1981, USNM 305767a: *1,* basal view of calyx and arms, external mold ×1.0; *2*, close-up view of base of calyx and C-D interray, ×2.0; *3*, *Boliviacrinus isaacsoni* McIntosh, 1988, USNM 305767b, lateral view of calyx, ×2.0; *4*, *5, Apurocrinus sucrei,* USNM 305766: *4,* lateral view of calyx internal mold, ray ridges present ×1.0; *5,* lateral view of posterior internal mold, C-D interray, ×1.0; *6–8, Boliviacrinus isaacsoni* McIntosh, 1988: *6*, MHNC 13504 (part), internal mold of calyx, ×1.0; *7*, MHNC 13504 (counterpart), external mold of calyx, ×1.0; *8*, MHNC 13505, calyx and pinnulate arms, ×1.0.

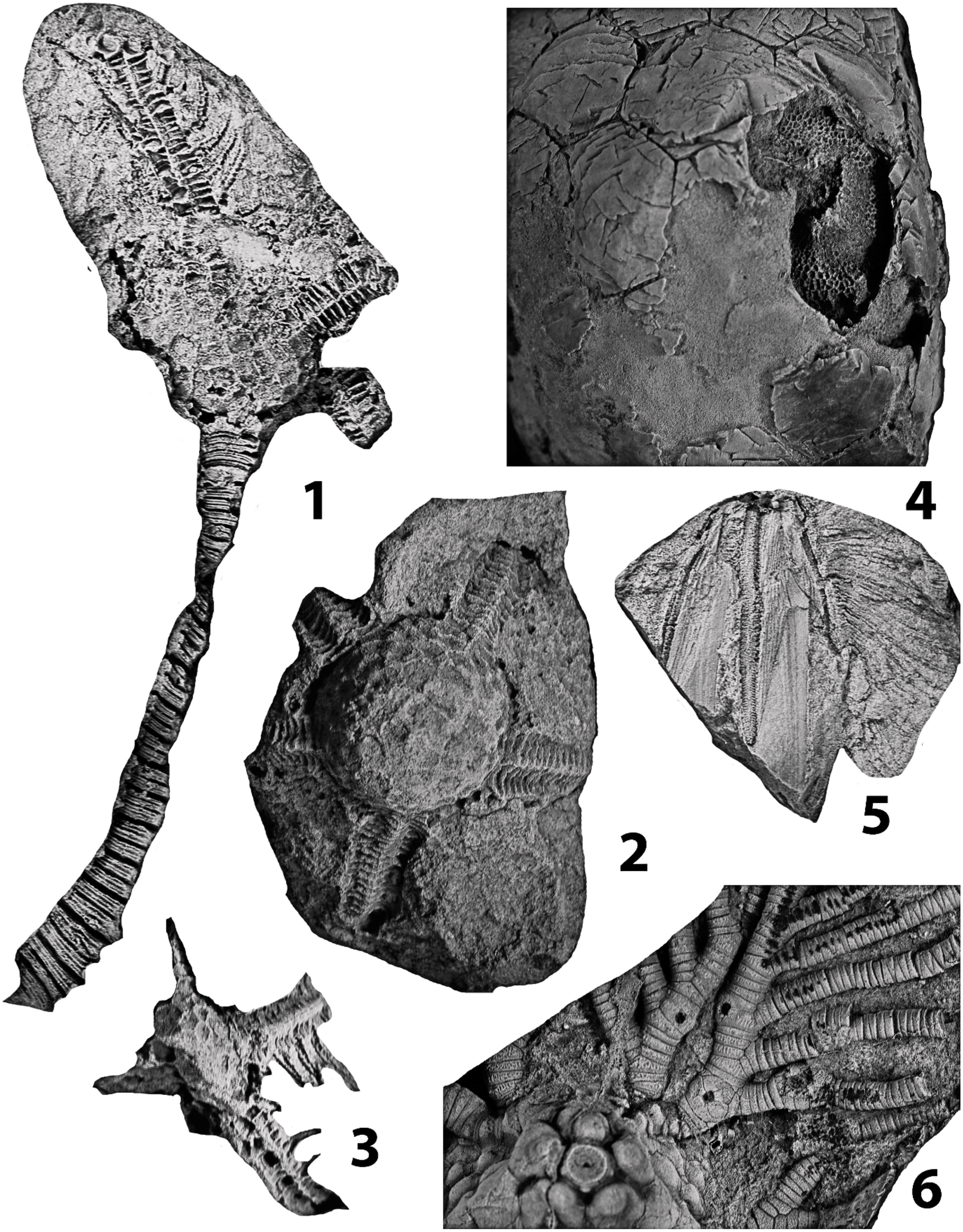

FIGURE 5—*1–3*, *Ctenocrinus branisai* n. sp.: *1*, MHNC 13503a, holotype, lateral view of theca and stem, ×1.5; *2*, USNM PAL 340009, paratype, basal view of calyx and arms, ×2.0; *3*, USNM S47064, paratype, juvenile, basal view of calyx and arms, ×3.0; *4, Griphocrinus pirovanoi* convolute organ (Haugh, 1975), MHNC 13502, ×3.0; *5, Pachyblastus dicki* Breimer and Macurda, 1972, MHNC 13503b, lateral view of theca and brachioles, ×1.5; *6, Oichnus paraboloides* trace fossils present on arms of USNM 305767a, ×1.5.

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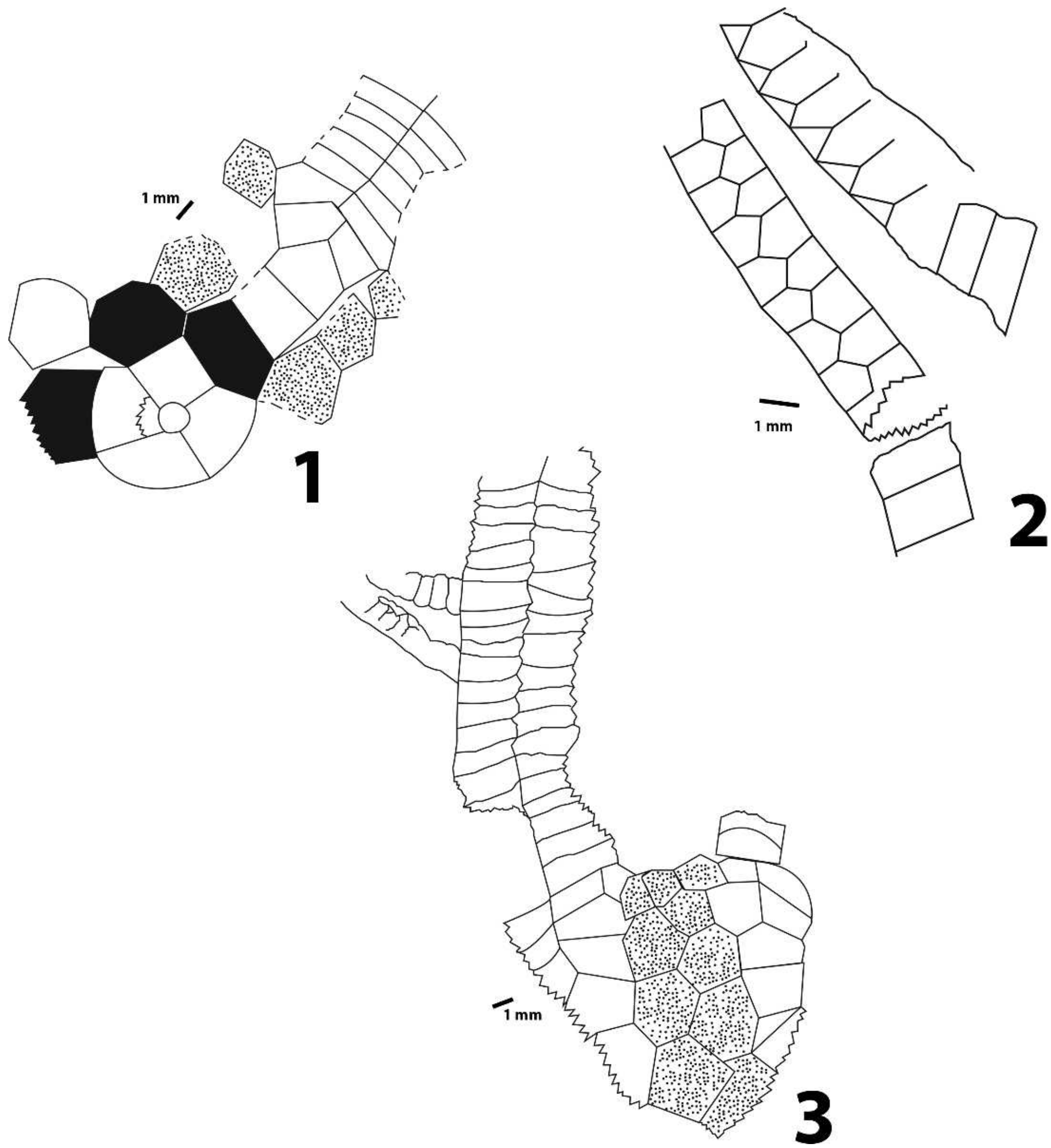

FIGURE *6*—Plate diagrams of *Ctenocrinus branisai* n. sp. *1*, plate diagram of basal and radial circlets; *2*, arm pinnules; *3*, MHNC 13503a, plate diagram of arm rays and interray. Black=radial plates; stippled=interradial plates.

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