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### Caryocrinitidae (Echinodermata: Rhombifera) of the Laurel Limestone of Southeastern Indiana

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#### INTRODUCTION

In a series of papers Miller (1892, 1894), Miller and Gurley (1895), and Springer (1926) described a large echinoderm fauna from the Laurel Limestone (Middle Silurian: Wenlock) in southeastern Indiana. Nearly all of their specimens are recorded as coming from near St. Paul, Decatur County.

While the fauna is dominated by crinoids, Bassler and Moodey (1943, p. 44) list three caryocrinitid cystoids, all of which were originally placed by Miller in his family *Stribalocystitidae* and in the genus *Stribalocystites*. The occurrence of a fourth caryocrinitid at St. Paul is mentioned by Miller and Gurley (1894, p. 11) in their description of the Osgood species *Caryocrinites ellipticus*.

None of Miller's or Springer's material was personally collected: the bulk of it was donated by the Doctors Howard, C. C. Washburn, A. C. Benedict, W. F. E. Gurley, and H. E. Wilson (Springer, 1926, pp 6-7). Most of the types of Miller and Miller and Gurley, as well as the collections of the Howards, Washburn, Benedict, and Wilson are now housed in Field Museum of Natural History. Springer's specimens are housed in the U. S. National Museum.

Miller's occasionally ambiguous descriptions and the lack of new material have rendered the systematic position of *Stribalocystites* somewhat uncertain. The genus was recognized by Bassler (1938), but not by Bassler and Moodey (1943), and only provisionally by

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Springer (1926) and Kesling (1967). Examination of the old collections and of new material I have collected has considerably expanded the size of the Laurel cystoid fauna and has clarified the status of Miller's species.

At least six species of *Caryocrinites* have been collected from the Laurel. The Laurel forms appear to be highly endemic: only one, *C. stellatus* n. sp., is known to occur outside of the formation (Joliet Dolomite of Illinois). None of the Laurel species appears to be closely related to those found in the underlying Osgood or in the Waldron Shale, which succeeds the Laurel in most of its outcrop area. The lack of definite antecedents or descendents of the Laurel forms indicates that a number of species of this already extraordinarily large cystoid genus remain to be discovered.

I would like to thank Dr. Eugene S. Richardson Jr., Field Museum, and Mr. Carl Armstrong, Indiana State Museum, for access to and loan of specimens under their care; and Dr. C. R. C. Paul, Liverpool University, and Dr. R. Kesling, University of Michigan, for critically reviewing the manuscript. All specimens unless otherwise noted are deposited in Field Museum (FMNH).

### STRATIGRAPHY

The Laurel Limestone (Laurel Member, Salamonie Dolomite, of Pinsak and Shaver (1964)) is extensively exposed in southeastern Indiana. Most outcrops are totally unfossiliferous and dolomitic. In a few places, however, notably near St. Paul and Sandusky, Decatur County, Indiana (Frest and Paul, 1971, p. 425), the Laurel is richly fossiliferous. The fauna is mostly echinoderms (cystoids, crinoids, blastoids, and cyclocystoids), but other invertebrates (notably corals, trilobites, and brachiopods) are frequently found.

Caryocrinitid cystoids were collected from loose material and in place by the author from two localities in the vicinity of St. Paul. The majority of specimens were found in the abandoned Adams Quarry, 0.2 miles SE of St. Paul (SW $\frac{1}{4}$  SW $\frac{1}{4}$  SW $\frac{1}{4}$  sec. 3, T 11 N, R 8 E, Waldron 7 $\frac{1}{2}$ ' quadrangle), but well-preserved cystoids were also collected from an active quarry owned by the St. Paul Stone Co., Inc., located in the center of the NE $\frac{1}{4}$  of sec. 9, T 11 N, R 8 E, Waldron 7 $\frac{1}{2}$ ' quadrangle, 0.6 miles SW of St. Paul. The former locality is believed to have been the source of Miller's and Springer's material (Springer, 1926, p. 6). There are several other small disused quarries in the vicinity, but these proved practically barren. At both localities identifiable fossils were found only in the upper 20 ft. of the Laurel. A section of the rocks exposed in the



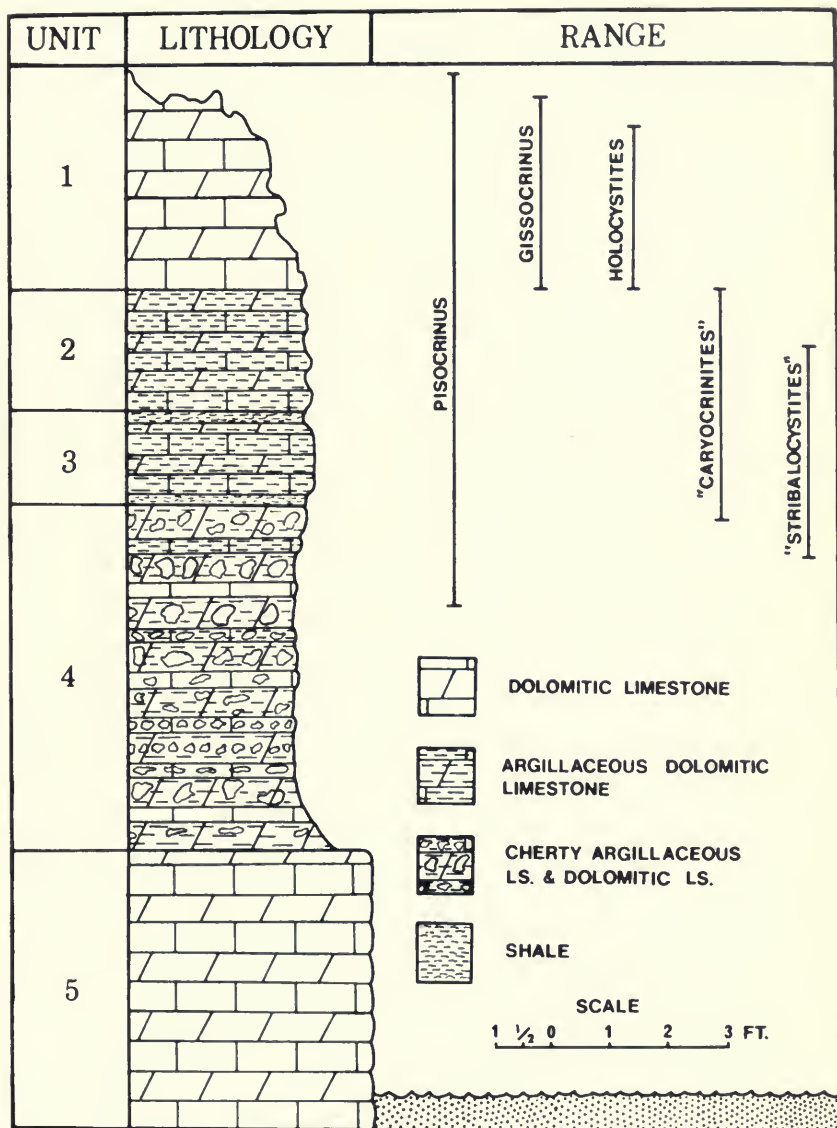


FIG. 1. Stratigraphic section of the Laurel Limestone exposed at the Adams Quarry, SE of St. Paul, Indiana. The term "Stribalocystites" includes the small thick-plated species *C. sphaeroidalis* (Miller) and *C. stellatus* n. sp. "Caryocrinites" refers to the larger forms *C. laurelensis* n. sp. and *C. tribrachiatus* n. sp. Ranges compiled from occurrences at both the Adams Quarry and the St. Paul Stone Co. quarry localities.

Adams Quarry is given as Figure 1; the upper part of the section in the active quarry is virtually identical. As the Adams Quarry was expanded considerably in the period 1921-1926 before closing down permanently, the section is considerably different from that recorded from the same locality by Foerste (1897, pp. 230-231).

This section differs considerably not only from that of the typical Laurel but also from the section at Sandusky described by Frest and Paul (1971, fig. 1). It is suggested on the basis of combined lithologic and paleontologic data that unit 1 of the Adams section is equivalent to the *Pisocrinus*-bearing strata at the top of the east face of the Sandusky quarry. Thus the strata containing *Caryocrinites* occur at a level approximately 10 ft. below the bottom of the unit in which *Callocystites brevis* was found.

### PALEOECOLOGY

The Laurel caryocrinitids may be encountered at any level in units 2 and 3 and in the upper 18 in. of unit 4. The small, thick-plated types are especially common near the middle of unit 3 and in the highly argillaceous beds near the top of 4. This is also the source of most of the crinoids described by Springer and Miller. The larger form, *C. laurelensis* n. sp., occurs throughout but is especially common near the top of unit 2.

The dominant lithologic type is a shaly dolomitic bioclastic limestone composed largely of micritized echinoderm plates and ossicles and occasional whole specimens. Contacts between units are sharp but within each there are highly local variations in grain size and amount of clastics and in the size of fossil particles. Whole thecae generally occur in small patches of coarser debris accumulated in slight depressions on bedding surfaces. Frequently in-place root systems and still articulated lengths of crinoid stem are associated with these patches. While complete crowns are exceedingly rare, the distance of transport, if any, was small.

In a study of the petrography of the Silurian rocks of southeastern Indiana and southwestern Ohio, Priddy (1939) concluded that the typical Laurel was deposited in about 500 ft. of water and the more clastic formations, such as the Osgood, at a depth of around 150 ft. An intermediate figure is likely for the fossiliferous Laurel localities. Although the number of Laurel localities with abundant fossils is too small for the evidence to be conclusive, fossil distribution in the Laurel appears to be influenced by the "Ripley Island" positive area of Foerste (1904, p. 325). Similar control of fossil distribution has been noted by Kindle and Barnett (1909) for

the Waldron Shale and is described in detail by Paul (1971, pp. 33-37, fig. 11) for the *Holocystites* fauna of the Osgood. My field work in 1970-1971 suggests that the proportion of terrigenous material in the Laurel is considerably higher in the area adjacent to and including the "island."

Indicators of strong current activity, such as crossbedding, are absent, as are biogenic sedimentary structures. Both sedimentological and paleontological evidence suggest a quiet and relatively barren soft sea floor with small but dense patches of echinoderms scattered over the bottom in favorable locations. Currents were weak but persistent and the sedimentation rate was slow. Individual stands probably did not persist for long, but *in toto* were the primary organic contributors to the accumulating deposit. The rarity of other marine invertebrate groups which are abundant in most fossiliferous Paleozoic rocks (e.g., brachiopods and corals), in addition to the evidence cited above, suggests a moderately deep-water environment.

## SYSTEMATIC DESCRIPTIONS

Class Rhombifera Zittel 1880 nom. trans. Paul 1972

Order Dichoporida Jaekel 1899 emend. Paul 1972

Superfamily Hemicosmitida Jaekel 1918

Family Caryocrinitidae Bernard 1895 emend.

*Definition*—Rhombiferan cystoids comprising the family Caryocrinitidae have a theca composed of three circlets of plates (fig. 2) which are probably homologous with the basals (B, plural BB), infra-laterals (IL,ILL), and laterals (L,LL) of the Glyptocystitida, plus a variable number of tegminals (T,TT) covering the adoral portion of the theca. The family is distinguished from the Heterocystitidae by the possession of only six ILL, and from the Hemicosmitidae by the lack of a radial circlet, the position of the periproct, and the possession of a tegmen and three hypothecal food grooves. It also differs considerably from the monotypic family Thomacystidae which has three basals, an "adoral" circlet, no tegmen, and four epithecal food grooves (Paul, 1969). Well-known genera have a constant plate formula in the first three circlets: four BB, six ILL, and eight LL. The brachiole facets, variable in number, are distributed around the lateral edge of the tegmen, which covers both the peristome and ambulacral tracts. The periproct is high on the adoral portion of the theca either completely surrounded by

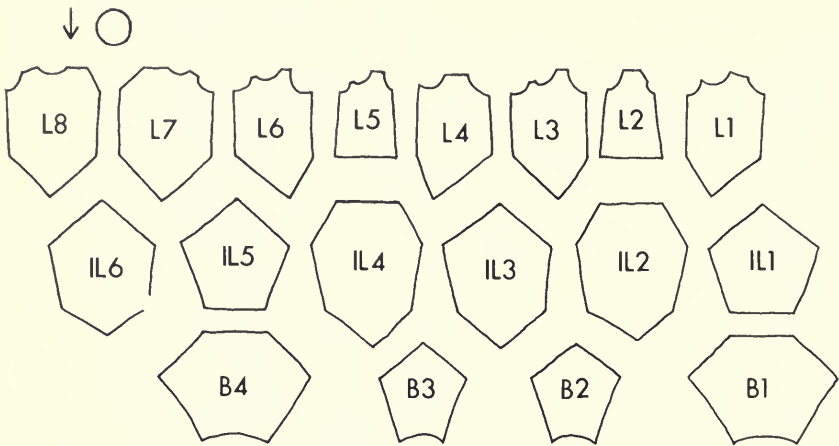


FIG. 2. Thecal plate arrangement of the first three circlets in *Caryocrinites*. B1-B4 = basals; IL1-IL6 = infralaterals; L1-L8 = laterals. Curved lateral sutures indicate positions of ambulacral facets in *C. ornatus* Say. The position of the periproct is indicated by a circle; that of the gonopore by an arrow.

the tegminals or between them and the LL. Cryptorhombs are developed on the first three circlets. Each dichopore (canal) terminates on the surface of the theca in two external pores, one of which is a simple opening while the other is expressed as a sieve-like group of tiny pores.

### *Caryocrinites* Say 1825

- Caryocrinites* Say, 1825, Jour. Acad. Nat. Sci. Phil., 4, p. 289.  
*Cariocrinites* (sic) Say, Bronn, 1834, Lethaea Geognostica, p. 64.  
*Caryocrinus* (sic) Say, Agassiz, 1836, Mem. Soc. Neuchatel, 1, p. 198.  
*Cariocrinus* (sic) Say, Austin and Austin, 1845, Mon. Rec. Foss. Crin., p. 53.  
*Caryocrinus* Say, Hall, 1852, Nat. Hist. N.Y., pt. 6, 2, pp. 216, 248.  
*Caryocrinus* Say, Zittel, 1880, Hanb. Paleontol., 1, p. 418.  
*Stribalocystites* Miller, 1892, 17th Ann. Rept., Geol. Surv. Ind., p. 630.  
*Ennaecystis* Haekel, 1896, Amphor. Cyst., p. 143.  
*Stribalocystites* Miller, Jaekel, 1899, Stammes. Pelmat., 1, p. 313.  
*Caryocrinites* Say, Jaekel, 1899, Stammes. Pelmat., 1, p. 312.  
*Caryocrinus* Say, Bather, in Lankaster, 1900, Treatise Zool., 3, p. 28.  
*Caryocrinus* Say, Grabau, 1901, N.Y. State Mus., Bull. 45, p. 149.  
*Caryocrinus* Say, Bather, in Reed, 1906, Paleontol. Indica., n.s., Mem. 2(3), p. 28.  
*Caryocrinus* Say, Springer, in Zittel-Eastman, 1913, Textb. Paleontol., 1, p. 163.  
*Caryocrinus* Say, Foerste, 1916, Ottawa Natur., 30, p. 110.  
*Stribalocystites* Miller, Springer, 1926, Smithsonian Inst., Misc. Pub. 2871, p. 142.  
*Stribalocystites* Miller, Bassler, 1938, Foss. Cat., Animalia, pars 83, p. 176.

*Caryocrinites* Say, Bassler and Moodey, 1943, Geol. Soc. Amer., Spec. Paper 45, p. 137.

*Caryocrinites* Say, Kesling, in Moore, ed., 1967, Treatise Inver. Paleontol., pt. S, 1, p. S223.

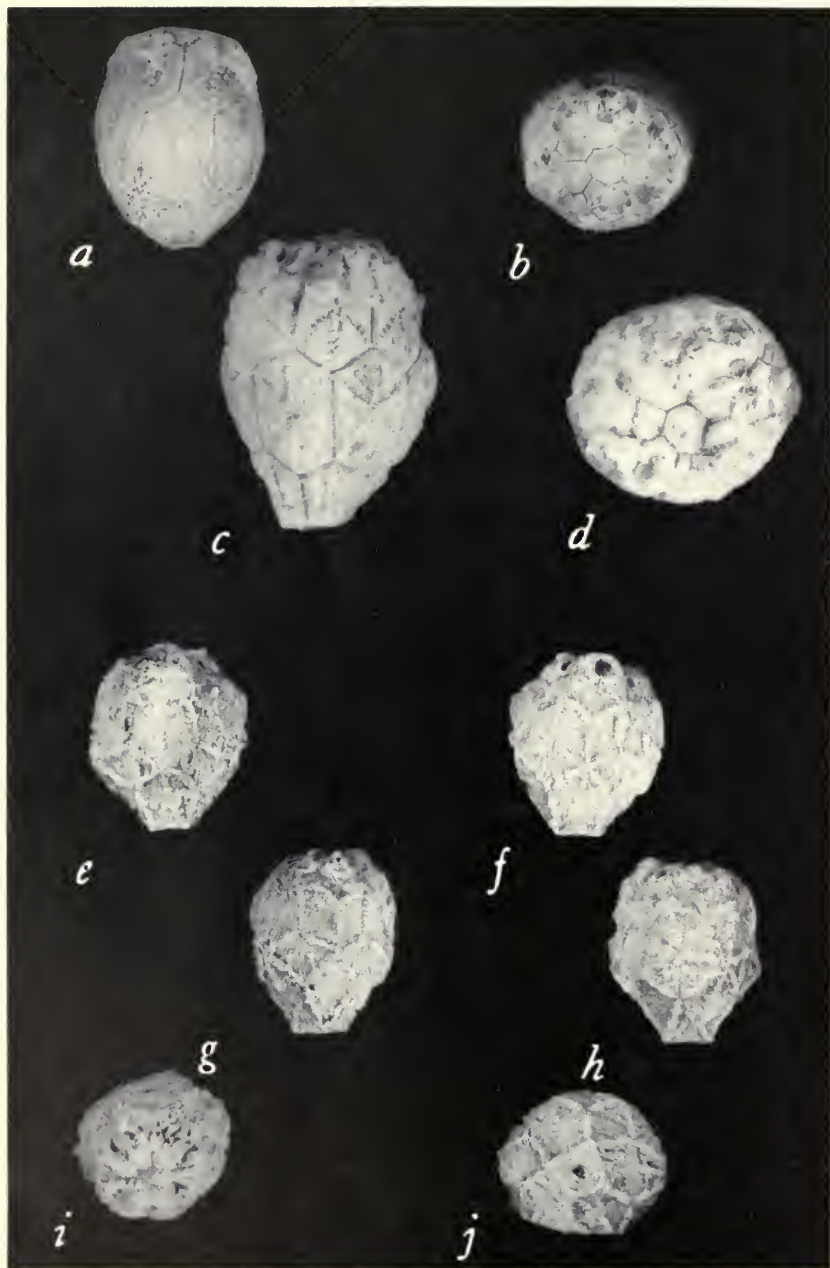
*Type species.*—*Caryocrinites ornatus* Say 1825.

*Diagnosis.*—A genus of Caryocrinitidae with an ovoid to elongate theca, four BB, six ILL, eight LL, and a variable number of tegminals (figs. 3, 4). Brachiole facets vary in number but are always arranged in three distinct groups. The oral surface is flat to gently convex and the three ambulacral grooves and the mouth are roofed over by a well-developed tegmen.

*Remarks.*—The single most important feature distinguishing the Caryocrinitidae from the Hemicosmitidae is the presence in the former of a well-developed tegmen. The caryocrinitid tegmen is a functional analogue to that of crinoids, although the plates of which it is composed probably are analogous to some of the ambulacral covering plates of other cystoids, notably to the palatals of the Sphaeronitidae and the Holocystitidae (Paul, 1971, pp. 6-7). In recognition of the considerable differences between this structure and that present in the other diploporite cystoids mentioned above and the often-noted crinoid-like features of *Caryocrinites*, the term "tegmen" is retained for this family. The individual plates collectively comprising the tegmen are herein termed "tegminals" (T, plural TT).

The system of numbering plates used here is the same as that used by Paul (1969, p. 194) for the genus *Thomacystis*: the plates of each circllet are numbered consecutively starting from the left of the gonopore and proceeding clockwise around the theca. The presence of the gonopore on the tegminal adjacent to the periproct on its left side has been noted in three species (*C. ornatus*, *C. persculptus*, and *C. laurelensis* n. sp.). The hydropore is a small, round opening developed on the tegmen immediately above the anal opening in *C. ornatus* (figs. 3b, 4). Neither of these two thecal orifices is evident in the other species described herein.

The unique nature of the caryocrinitid tegmen necessitates the use of different nomenclature than that employed for the "orals" of the Glyptocystitida or other hemicosmitid cystoids. While the composition of the tegmen is known to change during ontogeny in at least one species (*C. ornatus*), the number and disposition of the tegminals in the adult are fairly constant and differ in only minor respects from specimen to specimen in the three species which are



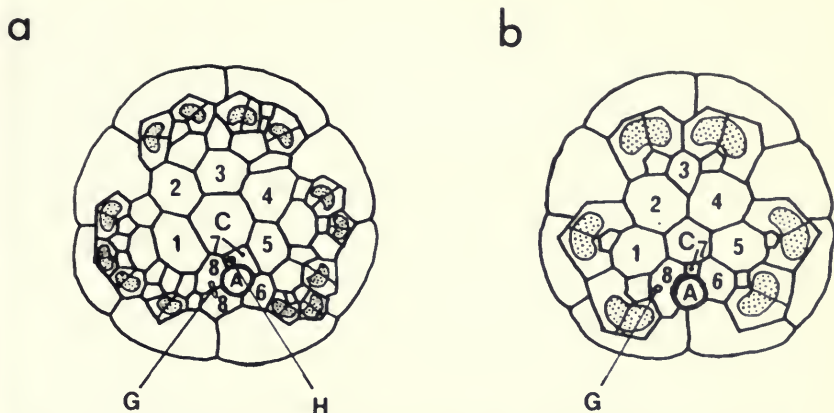


FIG. 4. Diagrammatic representation of the plate arrangement of the tegmen of a, *Caryocrinites ornatus* Say, and b, *C. persculptus* Springer. C-central: pericentrals numbered consecutively 1-8; A-anus; G-gonopore; H-hydropore. Ambulacral facets dotted.

represented in museum collections by large numbers of individuals (*C. ornatus*, *C. kentuckyensis*, and *C. sphaeroidalis*). The theoretical number of possible arrangements is quite large and a wide range is encountered among the score or so of species ascribed to the genus. Because of the high specificity and taxonomic utility of the tegmen, more emphasis is placed upon its characters herein than formerly was the case. The terminology defined below is illustrated diagrammatically in Figure 5.

A single plate, the central (C) covers the mouth. It is surrounded by a circlet of eight plates, termed pericentrals (Pc, plural Pcc), which are numbered consecutively in the same manner as those of the other circlets. Thus Pc 8 bears the gonopore and Pc 7 the hydropore. The ambulacral grooves pass beneath pericentrals 1, 3, and 5; 2, 4, and 6-8 occupy interambulacral positions. The periproct is surrounded by Pcc 6-8 and occasional accessories. In some

#### Opposite.

FIG. 3. a,b, *Caryocrinites ornatus* Say, FMNH PE 27881. a, lateral view; b, oral view to show tegmen, gonopore, and hydropore. c,d, *Caryocrinites persculptus* Springer, FMNH PE 27882. c, lateral view; d, oral view. e,j, *Caryocrinites laurelensis* n. sp., holotype (FMNH PE 19172). e, anterior lateral view to show plate arrangement; f, posterior lateral view to show periproct; g, left lateral view to show cryptorhombs and ambulacral facets; h, right lateral view; i, oral view to show tegmen; j, basal view to show column facet. All X 1.5, whitened with ammonium chloride sublimate.

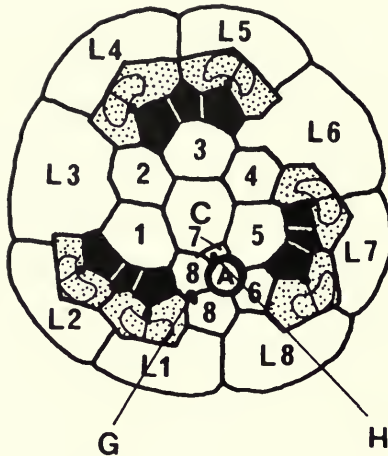


FIG. 5. Diagrammatic representation of the tegminal plate arrangement in the genus *Caryocrinites* Say. L1-8 = laterals; Pcc numbered consecutively 1-8. A-anus; G-gonopore; H-hydropore; C-central. Facetals dotted, accessories black. Heavy line indicates periproct border.

species LL 7 and 8 also form part of the periproct border. Other accessories are often disposed symmetrically between pericentrals 1, 3, and 5 and the brachiole facets. The branches of the main ambulacral grooves undoubtedly pass beneath some of these. Unlike the C and Pcc, accessories vary somewhat in position and number.

Bordering the pericentrals are the facetals (F, FF). In all species examined each brachiole facet is developed on a pair of plates, with separate openings for the ambulacral tract and the radial nerve positioned on the suture between the pair. In a few species an additional pore is developed on the facetal to the right or left of the brachiole facet. These pores are believed to have borne small brachioles or pinnules performing a sensory function. Unlike the pericentrals, which often form a closed circlet, the facetal circlet is usually disrupted. Pcc 2 and 4 are commonly in contact with LL 2 and 5. All eight Pcc seldom abut the central. Pcc 1, 3, 5, and 6 are most frequently out of contact with the central plate.

*Caryocrinites laurelensis* new species. Figures 3e-j, 6, 7e.

*Diagnosis.*—A species of *Caryocrinites* of medium-to-large size with six brachiole facets and facetal circlet closed except where periproct intrudes.

*Type.*—FMNH PE 19172 (holotype).



*Material.*—Eight complete thecae and many isolated plates. FMNH.

*Horizon and locality.*—The holotype is from the top of unit 2 at the Adams Quarry. Other specimens came from beds 2 and 4 at the same locality and also from unit 3 at the St. Paul Stone Co. quarry.

*Description.*—

**THECA:** Subspheroidal with large basals and wide stem facet. Dimensions of holotype: height 18.6 mm., diameter 17.4 mm. Isolated plates suggest a maximum height of over 30 mm. Height/diameter ratio 1.07.

**PRIMARIES:** BB 1 and 4 large, equal, hexagonal, H/W ratio 0.77. Ornamentation consists of two thin, sharp ridges and sporadically developed secondary ridges parallel or normal to edges of the plate, rest of plate surface smooth or finely granular. BB 2 and 3 narrow, equal, pentagonal, H/W ratio 1.18, ornamented with one central lengthwise ridge and rare secondaries. Ridges on BB coalesce at base to form a raised, square platform into which the column facet is indented. Column facet round, diameter 4.23 mm.

**ILL** 1, 5 equal, nearly regularly pentagonal, H/W ratio 1.22. **ILL** 2 and 4 equal, heptagonal, H/W ratio 1.38. All **ILL** with sharp, radiating ridges to each corner, meeting in center of plate. Secondary ridges and nodes infrequent, most of plate covered with fine granules and parallel growth lines. **LL** variable in size and shape, large (average height 6.2 mm.). Ornamenting ridges developed



FIG. 6. Diagrammatic representation of the tegmen of *Caryocrinites laurelensis* n. sp., based on the holotype. A-anus; G-gonopore; C-central; Pcc numbered 1-8; ambulacral facets dotted.

mainly on bottom half of LL, radiating aborally from the center to corners.

Cryptorhombs regularly diamond-shaped, developed most extensively along L-IL sutures, 13-19 dichopores per rhomb. B-IL cryptorhombs with seven dichopores. Simple pores found only on ILL. No intra-circlet rhombs detected.

TEGMEN: Central heptagonal, in contact with Pcc 2, 4, 5-8, and one accessory. One accessory each associated with Pcc 1, 3, and 5. Brachiole facets six, large, centered on paired facetals, pore for sensory brachiole developed on outer member of each pair. Facetals in contact except those adjoining periproct. Plates smooth or slightly granular. Gonopore round, 0.33 mm. in diameter, on Pc 8 near suture with adjacent facetal. Tegmen about three-fourths of thecal diameter.

Hydropore not observed.

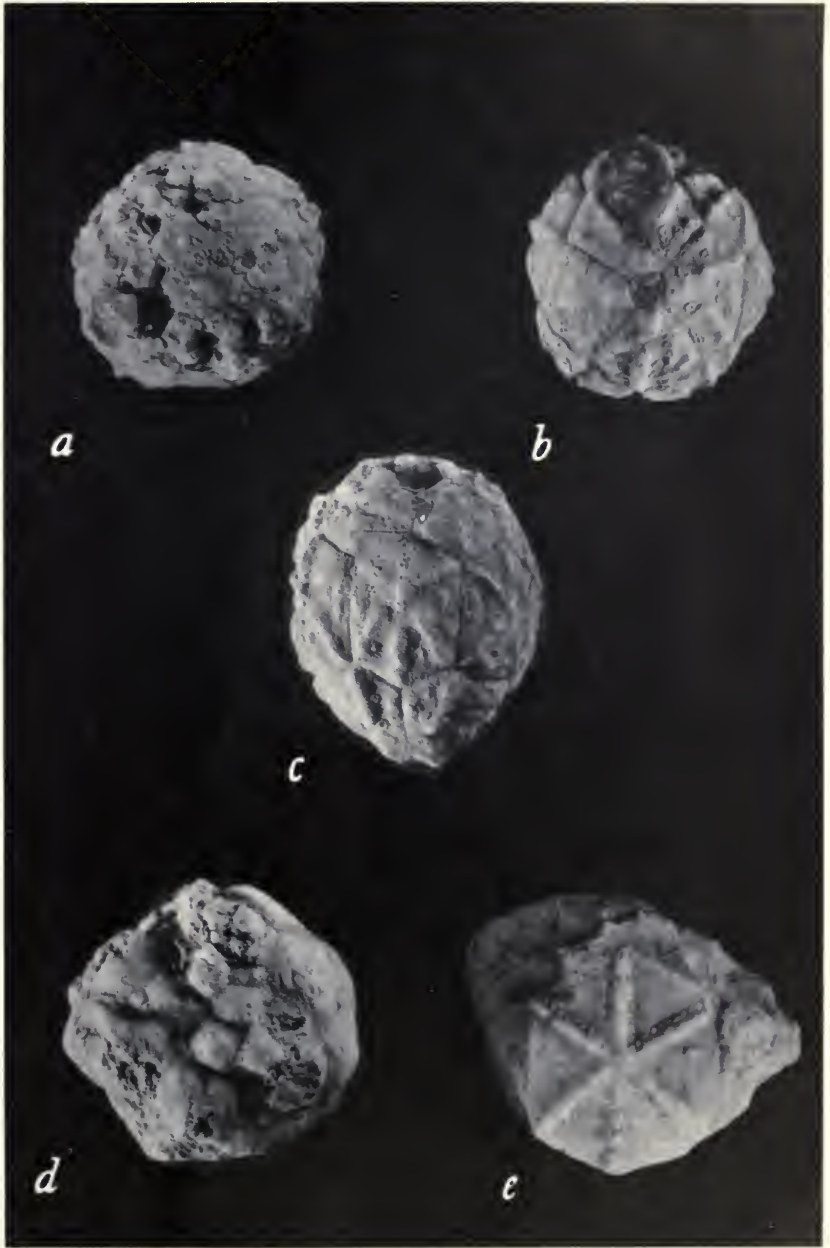
PERIPROCT: Small, circular (2 mm. diameter), distinctly protrusive from theca, bordered by Pcc 6-8 and LL 7, 8.

*Remarks.*—This is the most abundant and wide-ranging caryocrinid in the Laurel. Whole thecae are especially common near the top of unit 2. Isolated plates decrease in abundance from unit 2 to the top of 4, where they are rare. Miller (1894, p. 10), in his description of the Osgood species *C. ellipticus*, mentions four specimens of *Caryocrinites* collected by Gurley at St. Paul, commenting that "they seem to differ only in bearing higher and sharper radiating lines." Six specimens of this species, all fragmentary or buried in matrix, are registered in Field Museum (UC 15518) under the name *C. ellipticus* and are labelled as being from Gurley's collection. The incomplete nature of the specimens is probably responsible for the misidentification. The type of *C. ellipticus* could not be located, but a specimen from Gurley's collection (UC 53122) which bears a label in Gurley's handwriting is illustrated for comparison (figs. 7a-c, 8).

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*Opposite.*

FIG. 7. a-c, *Caryocrinites ellipticus* Miller and Gurley (FMNH UC 53122). a, oral view to show tegmen; b, basal view to show column facet; c, posterior lateral view to show plate proportions and ornament. d, oral view of holotype of "*Stribalocystites*" (*Caryocrinites*) *sphaeroidalis* Miller (FMNH UC 6128), showing tegmental plate arrangement. e, infralateral plate of *C. laurelensis* n. sp. to show simple pores and plate arrangement. FMNH PE 27825. a-c, X 2.5; d, X 3.4 approximately; e, X 4.0. All figures whitened with ammonium chloride sublimate.



**Caryocrinites sphaeroidalis** (Miller and Gurley). Figures 7d, 9, 10a-f.

*Stribalocystites tumidus* Miller, 1892, 17th Ann. Rept., Geol. Surv. Ind., p. 630, pl. 6, figs. 33-34.

*Stribalocystites gorbyi* Miller, 1894, 18th Ann. Rept., Geol. Surv. Ind., p. 265, pl. 2, figs. 3-8.

*Stribalocystites sphaeroidalis* Miller and Gurley, 1895, Ill. State Mus., Bull. 6, p. 58, pl. 5, figs. 19-21.

*Caryocrinus gorbyi* (Miller) Bather, in Reed, 1906, Paleontol. Indica, n.s., Mem. 2(3), p. 28.

*Caryocrinus sphaeroidalis* (Miller and Gurley) Bather, in Reed, 1906, Paleontol. Indica., n. s. Mem. 2(3), p. 28.

*Stribalocystites gorbyi* Miller, Springer, 1926, Smithsonian Inst., Pub. 2871, p. 142, pl. 33, figs. 15-18.

*Caryocrinites gorbyi* (Miller), Bassler and Moodey, 1943, Geol. Soc. Amer., Spec. Paper 45, p. 138.

*Caryocrinites sphaeroidalis* (Miller and Gurley), Bassler and Moodey, 1943, Geol. Soc. Amer., Spec. Paper 45, p. 140.

*Caryocrinites tumidus* (Miller), Bassler and Moodey, 1943, Geol. Soc. Amer., Spec. Paper 45, p. 140.

**Diagnosis.**—A caryocrinitid of small size (height: 4.14 mm.) and variable shape with three brachiole facets, a very small tegmen with only six plates in contact with the palatals, and unusually thick tegminal plates.

**Type.**—“*S. sphaeroidalis*” FMNH UC 6128; FMNH PE 1917a, b (two paratypes).

**Material.**—At least 150 complete thecae and numerous fragments. FMNH and USNM.

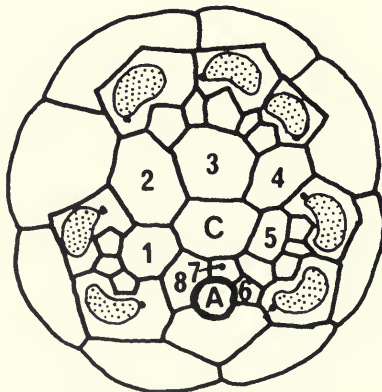


FIG. 8. Diagrammatic representation of the tegmen of *Caryocrinites ellipticus* Miller and Gurley, based on FMNH UC 53122. Pcc numbered; C-central; A-anus.

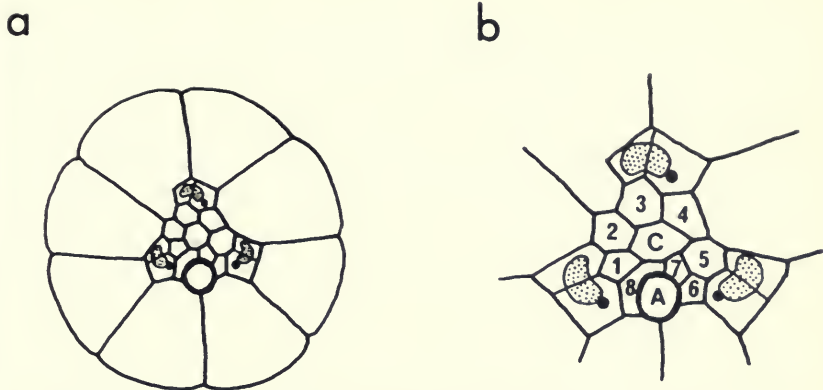


FIG. 9. Diagrammatic representation of the tegmen of *Caryocrinites sphaeroidalis* (Miller and Gurley). a, oral view to show relative diameters of tegmen and theca; b, enlargement of a, to show tegminals. A-anus; C-central; Pcc numbered; ambulacral facets dotted. Based mainly on paratype FMNH PE 19175b.

**Horizon and locality.**—Lower half of unit 2, the entirety of unit 3, and upper 18 in. of unit 4, Laurel Limestone, Adams Quarry and St. Paul Stone Co. quarry.

**Description.**—

**THECA:** Ovoid to subturberate, with narrow, round stem facet 1.31 mm. in diameter. Holotype distorted: dimensions of paratype FMNH PE 1917a, height 11.9 mm., diameter 9.07 mm., H/D ratio 1.20.

**PRIMARIES:** All plates thick, tumid, broadly convex with impressed sutures. Ornamentation on well preserved specimens consists of low, narrow ridges from corners of plates, merging in center. Small, shallow, broadly rounded ridges often developed between major ridges. Entire plate surface including ridges ornamented with very small granules.

Basals small, forming broad shallow cone, BB 2 and 3 unusually elongated. Dimensions of BB 1 and 4: height 3.73 mm., width 4.15 mm., H/W ratio 0.90; dimensions of BB 2 and 3: height 3.75 mm., width 3.02 mm., H/W ratio 1.24. Stem facet deeply excavated into BB, small.

ILL 1 and 5 equal, subpentagonal, shorter sutures facing adjacent heptagonal ILL, H/W ratio 1.16.

ILL 2 and 4 equal, heptagonal, H/W ratio 1.12. ILL 3 and 6 narrow hexagons, H/W ratio 1.28. LL smaller and less prominent than in most species, widely variable in size.

Pores of cryptorhombs often evident only on ILL and seldom seen

on basals. No intra-circlet dichopores. Eleven dichopores usual in adult L-IL rhombs. L-IL rhombs regular in shape: B-IL cryptorhombs appear to be developed irregularly and are sometimes absent.

**TEGMEN:** Flat or gently curved, size somewhat variable: generally about one-sixth greatest diameter of theca. Central small to moderate in size, hexagonal, bordered by Pcc 2-8. Pcc 1 and 3 widely separated from central, small. No accessories present. Pcc 2 and 4 in contact with laterals (LL 3, 4, and 6). Facetals paired, together occupy about 60 per cent of tegminal surface. All plates smooth or slightly granular, tumid. Gonopore and hydropore not seen.

**PERIPROCT:** Circular, protrusive, bordered by Pcc 6-8 and LL 7 and 8, diameter 0.68 mm.

*Remarks.*—Miller (1892, pp. 630-631) originally erected the family Stribalocystitidae and the genus *Stribalocystites* to receive one species, *S. tumidus*, described from a single specimen. The distinguishing characteristics of the family are stated to be the tumid plates and the fact that it has "no arms." I have been unable to locate the holotype of this species, but from the description and illustration it appears to be a juvenile. A number of small, immature forms have subsequently been collected but juveniles of at least both the preceding and following species would be indistinguishable from "*S. tumidus*" since all St. Paul cystoids in this range are poorly preserved. At any rate, very young examples of any caryocritid species cannot be readily discriminated from juveniles of other species under the best of circumstances.

In 1894 Miller added a second species, *S. gorbyi*, to the genus, described from two better-preserved specimens. This form may well be conspecific with *S. sphaeroidalis*, judging from the figures and written description, but the types, formerly in the Indiana State Museum, appear to have been lost. The holotype of *S. sphaeroidalis* (Miller and Gurley, 1895), while crushed and apparently etched by treatment with acid, shows a tegminal plate arrangement identical to that seen in numerous examples of "*S. gorbyi*" collected and subsequently labelled by Miller, Gurley and others.

*Stribalocystites tumidus*, even if the type is later located, is, in my opinion, a juvenile of an undeterminable species; accordingly the name should be restricted to the type. The specific name *sphaeroidalis* thus applies to the only available recognizable entity, despite the imperfection of the holotype specimen, until and unless the types of *gorbyi* are relocated. The characters of "*Stribalocys-*

*tites*'' *sphaeroidalis*, as outlined above, do not seem to be sufficiently distinctive from *Caryocrinites* to warrant the recognition of a separate genus. The genus is, therefore, placed in synonymy with *Caryocrinites*, following Bassler and Moodey (1943, p. 137).

This species is by far the most abundant cystoid in the Laurel. Judging by lithology, most of the old specimens were collected from the shaly beds at the top of unit 4. Most of the specimens I collected were from the middle of unit 3. Those from the more calcareous sediments are consistently better preserved.

*Caryocrinites shemai* new species. Figures 10g-l, 11.

*Diagnosis.*—A small caryocrinitid with six brachiolar facets and thin, highly convex plates. The tegmen is moderate in size, Pcc 6 and 7 are fused, and only Pc 1 is not in contact with the palatal.

*Type.*—FMNH PE 19173 (holotype).

*Material.*—One damaged theca, FMNH.

*Horizon and locality.*—The holotype was collected in unit 2 of the Laurel, 4 in. above the base in the Adams Quarry, south of St. Paul, Indiana.

*Description.*—

**THECA:** The holotype is a small, inverted pyriform theca with a gently convex oral surface, height 12.6 mm. and diameter 9.56 mm.

**PRIMARYES:** BB average in size, BB 1 and 4 considerably larger than 2 and 3 (height 3.83 mm., width 5.01 mm., H/W ratio 0.77), hexagonal. BB 2 and 3 small, broad, pentagonal with a H/W ratio 0.97 (height 3.81 mm., width 3.94 mm.). All BB convex, ornamented with one or two major ridges and several minor ridges coalescing at base of each B.

Shapes of ILL and LL typical for genus (fig. 2). ILL 1 and 6 and LL 1 and 8 damaged on specimen. Dimensions of IL 5: height 5.20 mm., width 4.02 mm., H/W ratio 1.26. Corresponding dimensions of IL 2 and 3: 5.41 mm., 5.21 mm., 1.04 and 5.48 mm., 4.84, 1.13, respectively. Height and width of visible portions of LL about equal to that of BB.

All plates thin, highly convex, ornamented with low, crooked ridges radiating from the center to the corners of the plate, as well as many irregular short ridges and knobs. Cryptorhombs on L-IL sutures with nine or 11 dichopores; those on B-IL with five dichopores. Intra-circler cryptorhombs consist of single dichopore across IL sutures. Pores on ILL simple, those on BB and LL complex.

**TEGMEN:** Central large, heptagonal, adjoined by Pcc 2-8 and one accessory. Pcc 6 and 7 fused into single plate, Pc 1 separated from

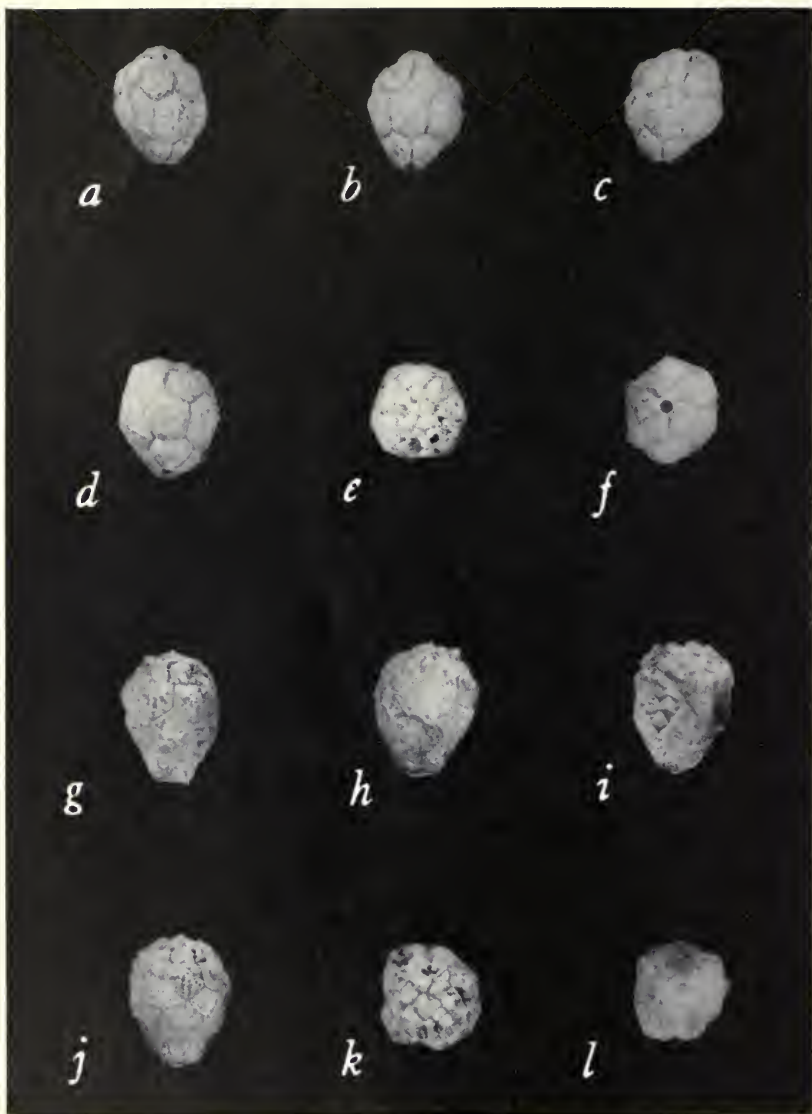


FIG. 10. *Caryocrinites sphaeroidalis* (Miller and Gurley); a-d, f, paratype FMNH PE 19175a; e, paratype FMNH PE 19175b. a, anterior lateral view; b, posterior lateral view to show protrusive periproct; c, left lateral view; d, right lateral view to show tumid plates; e, oral view to show ambulacral facets and tegmen; f, basal view. g-l. *Caryocrinites shemai* n. sp. (holotype FMNH PE 19173). g, anterior lateral view to show compound pores on LL; h, posterior lateral view to show periproct; i, left lateral view; j, right lateral view to show ambulacral facets and plate ornament; k, oral view to show tegmen; l, basal view. All X 1.5, whitened with ammonium chloride sublimate.



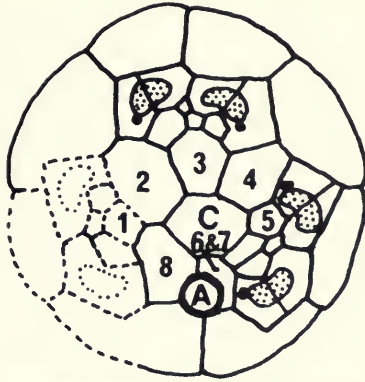


FIG. 11. Diagrammatic representation of tegminal plate arrangement in *Caryocrinites shemai* n. sp. A-anus; C-central; Pcc numbered; ambulacral facets dotted. Dotted lines indicate plates damaged in holotype.

central by 2 and 8. Accessories include paired large plates associated with each ambulacrum and considerably smaller plates occupying positions between ambulacral branches. Peripheral region of ambulacrum I damaged. Tegmen diameter five-sixths that of theca at widest point. Brachiole facets 6, in groups of two separated by Pcc 2 and 4 and plates surrounding periproct, developed on pairs of facetals. Openings for sensory brachioles present, disposed as in *C. laurelensis*. All tegminals highly convex, with strongly elevated central node. Gonopore and hydropore unknown.

**PERIPROCT:** Bordered by Pcc 6-8 and LL 7 and 8, elliptical in shape, 0.90 mm. by 1.38 mm. in diameter. Surrounding plates flush with rest of theca.

*Remarks.*—Even though the single known specimen is incomplete, the holotype presents a combination of distinct features which warrant its recognition as a separate species. Because of the rarity and restricted occurrence of *C. shemai*, it seems unlikely that any other specimens will be found in the near future. The specific name honors the finder, Mr. Joseph P. Shema.

**Caryocrinites stellatus** new species. Figures 12, 13.

*Diagnosis.*—A small spheroidal species having a tegmen no more than one-third the maximum diameter of the theca and strong stellate ornament. The central is bordered by seven plates (Pcc 1.5, 7, and 8).

*Material.*—At least 14 complete thecae. FMNH.

*Horizon and locality.*—Specimens I collected came from the lower 6 in. of unit 2 and the upper half of unit 3, Adams Quarry. Most

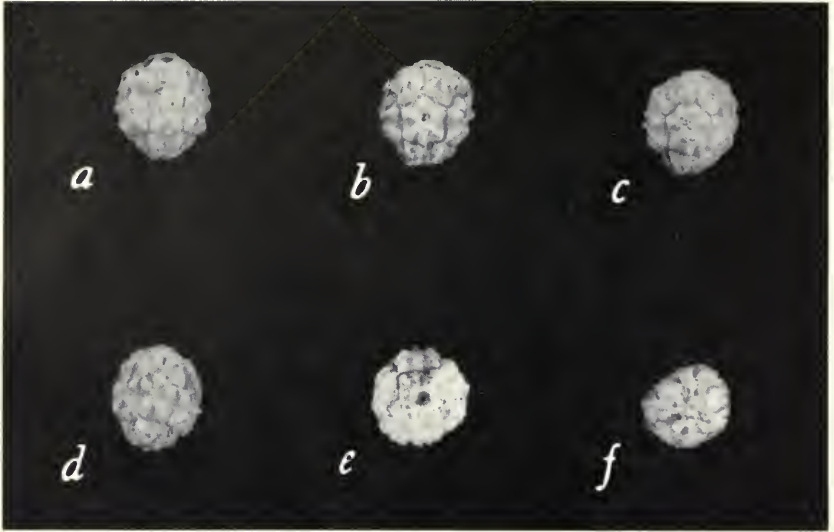


FIG. 12. *Caryocrinites stellatus* n. sp. a-e, holotype (FMNH PE 19174a); f, paratype (FMNH PE 19174b). a, posterior lateral view to show periproct; b, anterior lateral view; c, left lateral view to show irregularly developed dichopores; d, right lateral view; e, basal view; f, oral view to show tegmen. All figures whitened with ammonium chloride sublimate, X 1.5.

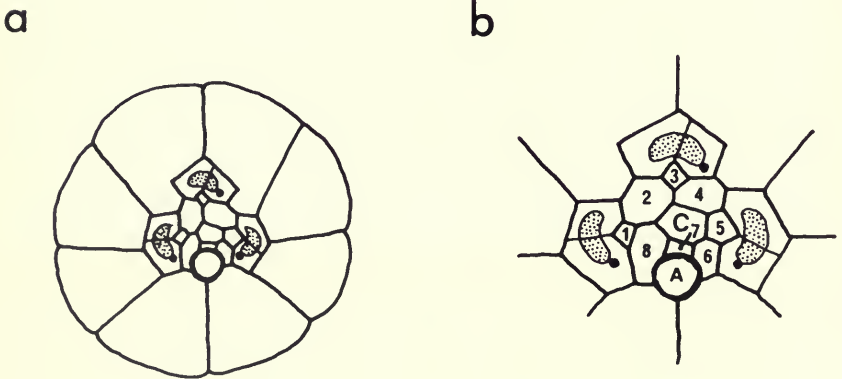


FIG. 13. Diagrammatic representation of the tegmen of *Caryocrinites stellatus* n. sp., based on paratype FMNH PE 19174b. a, oral view to show relative diameter of tegmen and theca; b, enlarged representation of tegmen. A-anus; C-central; Pcc numbered; ambulacral facets dotted.

museum specimens probably were from the uppermost 1.5 ft of unit 4 at the same locality.

*Description.* —

**THECA:** Subspheroidal, small (height 10.00 mm., H/W ratio 1.05). Primaries thick, tumid, with impressed sutures, surface broken by short, broad ridges arranged in stellate pattern originating from corners toward center of plate, not meeting. Small sub-central tubercle often present, rest of plate including ridges smooth.

**PRIMARYES:** BB broad, forming low saucer-like cup, deeply excavated for insertion of small (diameter 1.29 mm. in holotype), rounded column. BB equal in height, but BB 2 and 3 narrow, pentagonal (H/W ratio 1.24), while BB 1 and 4 broad, hexagonal (H/W ratio 0.90).

**ILL** 1 and 5 narrow, pentagonal, H/W ratio 1.16. **ILL** 2 and 4 larger than other **ILL**, broadly heptagonal. **ILL** 3 and 6 hexagonal, more than usually narrow, H/W ratio 1.28. **LL** medium-sized, nearly equal in area. All plated broadly curved along long axis, strongly convex.

Cryptorhombs not clearly defined, apparently irregularly sub-rhombic with 5-11 dichopores in L-LL rhombs, 3-5 in B-IL rhombs.

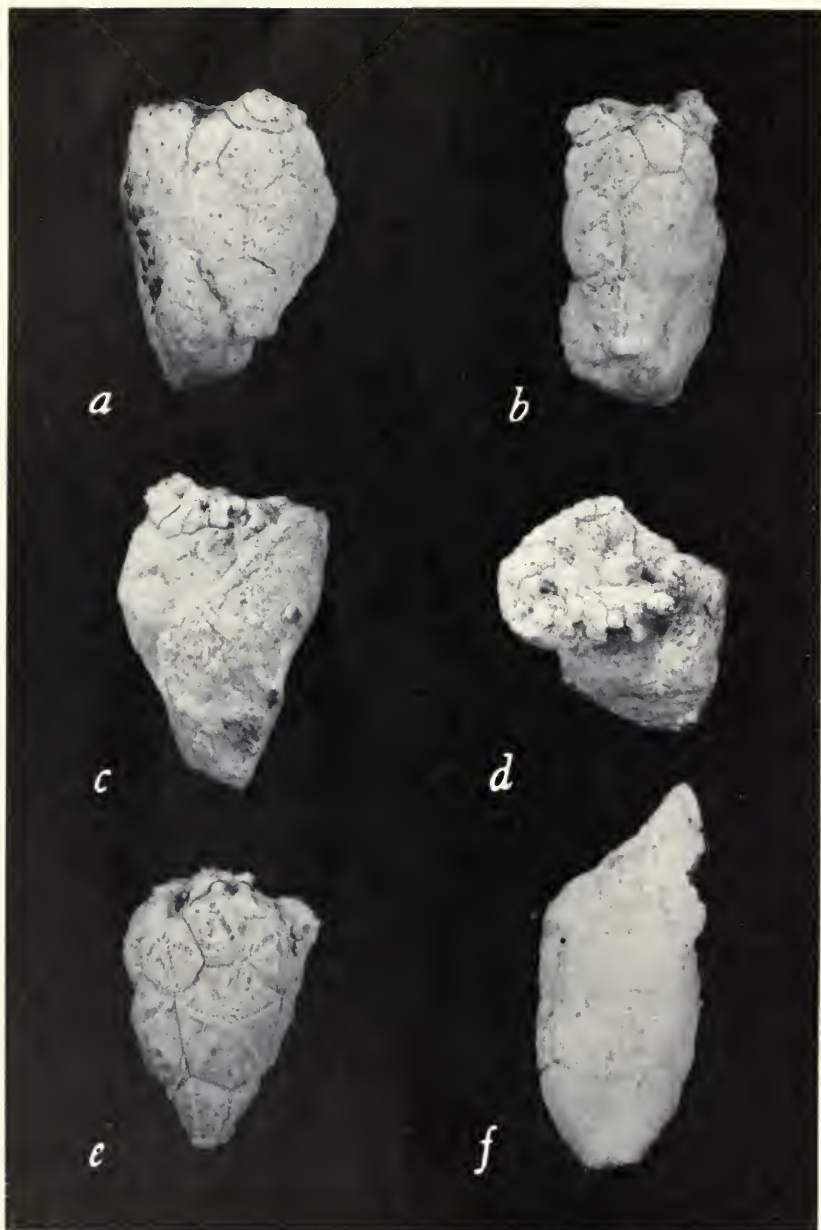
**TEGMEN:** Entire oral surface weakly convex, tegmen occupying a relatively small area (diameter about 3 mm.), distinctly triangular in shape. Brachiole facets three, large. Opening for sensory brachiole developed on right side (proceeding in a clockwise direction from periproct) of each pair of facetals. Central surrounded by seven Pcc, no accessories present. Pcc 6 and 7 small, 6 not in contact with central. Remaining pericentrals about equal in size, thin, not tumid, smooth.

**PERIPROCT:** Small, circular, protrusive, set high on theca. Periproct bordered by Pcc 6-8 and LL 7 and 8, diameter 0.96 mm.

*Remarks.* — Though uncommon, this species is the third most abundant at St. Paul. Specimens I personally collected were from the more argillaceous portions of the formation, particularly the upper 12 in. of unit 3. A dolomitized partial theca referable to this species is registered in Field Museum (PE 24282). According to the label, the specimen is from the Joliet Dolomite, Chicago Drainage Canal, Lemont, Ill.

**Caryocrinites tribrachiatus** new species. Figures 14a-e, 15.

*Diagnosis.* — A medium-sized caryocrinitid characterized by its



elongate theca and wide tegmen with three exceptionally large brachiole facets.

*Type.*—FMNH UC 33678 (two specimens: holotype UC 33678a, paratype UC 33678b).

*Material.*—Two complete thecae, two partial. FMNH.

*Horizon and locality.*—Fragmentary specimens collected by the author came from the upper third of unit 2 at the Adams Quarry.

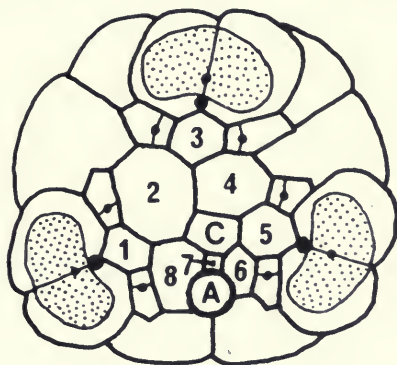


FIG. 15. Diagrammatic representation of tegminal plate arrangement in the holotype of *Caryocrinites tribrachiatum* n. sp. Pcc numbered; A-anus; C-central.

*Description.*—

**THECA:** Elongate, subturbinate, stem facet small. Dimensions of holotype: height 36.5 mm., diameter 14.1 mm., H/D ratio 2.59.

**PRIMARIES:** Ornamentation consists of radial ridges to corners of plates and extensively developed secondary ridges and chevron-shaped nodes. Cryptorhombs with 15-17 dichopores in IL-L rhombs, nine dichopores in IL-B rhombs, and three in IL-IL rhombs.

All BB higher than wide (BB 1 and 4 H/W ratio 1.03, BB 2 and 3 H/W ratio 1.31), facet for column attachment slightly indented into BB, round, diameter 3.80 mm. ILL with shapes typical for genus, elongate (IL 1: H/W ratio 1.26, IL 2: H/W ratio 1.19, IL 3: H/W ratio 1.31), approximately equal in area.

*Opposite.*

FIG. 14. a-e, *Caryocrinites tribrachiatum* n. sp. a-d, holotype FMNH UC 33678a; e, paratype FMNH UC 33678b. f, *Caryocrinites* sp. (FMNH PE 27826). a, anterior lateral view; b, left lateral view; c, posterior lateral view to show periproct and ambulacral facets; d, oral view to show tegmen and ambulacral facets; e, lateral view of paratype to show plate ornament and cryptorhombs; f, lateral view of preserved plates of *Caryocrinites* sp.

All primaries gently convex, thin, sutures not deeply impressed.

**TEGMEN:** Trigonally symmetrical, large, elevated somewhat above the level of the LL. Brachiole facets three, exceptionally large, developed on paired facetals, broadly smooth. Central small, in contact with Pcc 2, 4-8, Pcc 1 and 3 small, widely separated from central. Sensory brachiole pores developed on sutures between pairs of accessory plates, upper of which is quadrangular and about one-third maximum length of lower pentagonal member of each pair. Two such pores are associated with each brachiole facet. Gonopore and hydropore not observed.

**PERIPROCT:** Small, rounded, about 2 mm. in diameter, oriented parallel to main axis of theca, nearly at a right angle to rest of tegmen. Periproct bordered by Pcc 6-8, LL 7 and 8.

*Remarks.*—Although this species somewhat resembles the Waldron Shale species, *C. persculptus*, in size and shape of theca and plate proportions, the features of the tegmen are completely distinctive. It is unusual in possessing only three brachioles despite having a sizeable tegmen. The arrangement of the TT in *C. tribrachiatus* closely resembles that in *C. sphaeroidalis*, from which it differs in the size and shape of the theca, the area of the tegmen, and in the relative sizes of each plate circlet. *C. tribrachiatus* also lacks the thick tumid plates of the latter species.

#### **Caryocrinites sp. Figure 14f.**

A small weathered fragment of a large caryocrinitid was discovered loose in weathered material at the Adams Quarry locality. Associated fossils suggest that this material was derived mainly from unit 2. The incomplete nature of the specimen precludes accurate determination at the specific level, but the proportions of those plates preserved are considerably different from those of *C. laurelensis*, the only other Laurel species which attains a comparable size. The inferred shape and size of the original fossil are similar to those of only one other described species, the common Brownsport (Ludlow) form *C. romeri* Jaeke.

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