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THE CRINOID *SYNBATHOCRINUS* IN THE MIDDLE
DEVONIAN TRAVERSE GROUP OF MICHIGAN

BY

ROBERT V. KESLING and RAYMOND N. SMITH

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THE UNIVERSITY OF MICHIGAN
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VOLUME XVIII

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6. Key for Classification of Cystoids, by Robert V. Kesling. Pages 101-116.
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10. The Crinoid *Opsiocrinus mariae* Kier in the Bell Shale of Michigan, by Robert V. Kesling and David L. Meyer. Pages 177-184, with 1 plate.
11. The Crinoid *Synbathocrinus* in the Middle Devonian Traverse Group of Michigan, by Robert V. Kesling and Raymond N. Smith. Pages 185-196, with 1 plate.

THE CRINOID *SYNBATHOCRINUS* IN THE MIDDLE
DEVONIAN TRAVERSE GROUP OF MICHIGAN

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CONTENTS

Introduction	185
Localities	187
Species of <i>Synbathocrinus</i>	187
Systematic descriptions	188
<i>Synbathocrinus michiganensis</i> , sp. nov.	189
<i>S. sp. cf. S. michiganensis</i> , sp. nov.	192
<i>S. matutinus</i> Hall	192
Literature cited	194
Plate	(after) 195

INTRODUCTION

SEVERAL SPECIMENS of the crinoid *Synbathocrinus* have been collected from Middle Devonian rocks of the Traverse Group exposed in Alpena County, northeastern Michigan. They have been found in the Four Mile Dam Formation and its Dock Street Clay member and in the Thunder Bay Limestone. Some are well preserved. Three specimens from the Dock Street Clay retain several arm brachials and part of the anal series. The crinoids from the Four Mile Dam Formation constitute a new species, closely related to or conspecific with the specimen which we have seen from the Thunder Bay Limestone. Because specimens from the Traverse Group were previously classified as *Synbathocrinus matutinus* Hall, a plastoholotype of that species was carefully examined and used for the revised description presented herein.

Only one specimen of *Synbathocrinus* from Michigan is in the collection of the Museum of Paleontology, The University of Michigan. It is catalogued as UMMP 23870. It was found by Mr. Leon O. Pettyes many years ago, probably in 1926, and later purchased by The University of Michigan along with other fossils collected by Mr. Pettyes from the Dock Street Clay exposures in the quarry of the Thunder Bay Quarries Company in Alpena, Michigan, near his home.

This was not the first discovery of *Synbathocrinus* in Alpena County, however. In the Museum of Paleontology are two ledgers containing notes,

observations, and fossil lists prepared by Dr. Carl L. Rominger. In one of the ledgers, on page 213, under the heading "Crinoids deposited in the University Museum" is the entry "Synbathocrinus matutinus / Broadwells Mills Alpena 1 Stk." The writing is in Dr. Rominger's distinctive script, and the "1 Stk." undoubtedly was his reversion to the German "Stück" for specimen. Through the years, Broadwell's Mill was also known as Broadwell's Saw Mill, Three Mile Dam, Fletcher Dam, and Four Mile Dam. Under the last name, it became the type locality of the Four Mile Dam formation. There is a possibility that Dr. Rominger had access to rocks that are no longer exposed, inasmuch as the present dam is located downstream from the previous dams on the Thunder Bay River. We can only presume that the specimen he recorded was from strata of the upper part of the Four Mile Dam Formation, because no outcrops of Dock Street Clay have ever been reported at Four Mile Dam or nearby. The specimen is lost.

In the same ledger, on page 265, Dr. Rominger listed "Fossils collected at Partridge Point, Alpena, Aug 1898 besides enumeration of fossils found there on previous visits." One of the entries was originally "Synbathocrinus sp. nov." but later the "sp. nov." was lined through and "matutinus Hall" was added. The rocks exposed at Partridge Point belong to the Thunder Bay Limestone. In the second ledger, on an unnumbered page, Dr. Rominger wrote, under the heading "February 1903. Register of Crinoids sent to the Smithsonian Institute," the following: "Synbathocrinus matutinus Hall/Hamilton Group Partridge Point Alpena."

We wrote to Dr. Porter M. Kier, of the United States National Museum, to inquire about specimens of *Synbathocrinus* from Michigan. He made a thorough inspection of the collections there and reported that the only specimen from Michigan is identified by label as "93201 *Synbathocrinus matutinus* Hall/Devonian (Hamilton)/Partridge Point, Alpena, Michigan/Rominger Coll." Through the courtesy of Dr. Kier, we studied this specimen and illustrate it in this paper in Plate I, Figures 17-19.

Seven specimens of *Synbathocrinus* are catalogued in the Buffalo Museum of Science under catalogue number E16581. Data with the specimens shows that they were collected by Mr. Irving G. Reimann while he was employed by that museum. All are from the Dock Street Clay in the quarry of the Thunder Bay Quarries Company, the same exposures where Mr. Pettyes found a specimen (UMMP 23870) previously. Through the courtesy of Dr. Fred Hall we were permitted to study and photograph these crinoids.

To decide whether the Michigan specimens were actually *Synbathocrinus matutinus* Hall, we borrowed the plastoholotype and one other speci-

men from the Walker Museum of The University of Chicago. The whereabouts of the holotype cannot be determined; information with the plastroholotype (UCWM 15853) indicates that the original specimen is in the "James Hall collection." The second specimen (UCWM 11370) is in the Gurley collection. Both are from the Hamilton strata at New Buffalo, Iowa.

We wish to thank Dr. Porter M. Kier and Dr. G. Arthur Cooper of the United States National Museum, Mr. Matthew H. Nitecki of the Walker Museum of The University of Chicago, and Dr. Fred Hall of the Buffalo Museum of Science for the loan of specimens. We also appreciate the helpful comments on the manuscript of this paper by Professor Lewis B. Kellum and Professor Chester A. Arnold.

LOCALITIES

1. Quarry of Thunder Bay Quarries Company (now abandoned), eastern edge of city of Alpena, Alpena County, SE $\frac{1}{4}$ sec. 14, T. 31 N., R. 8 E. Type locality of Dock Street Clay member of the Four Mile Dam Formation.
2. Exposures on banks and in bed of Thunder Bay River near Four Mile Dam. One specimen, subsequently lost, found by Dr. Carl L. Rominger when dam was at Broadwell's Mill, reportedly upstream from present dam. Specimen presumably from Four Mile Dam Formation near its type locality in Alpena County, $\frac{1}{4}$ mile south of center of sec. 7, T. 31 N., R. 8 E.
3. Bluffs on northeast shore of Partridge Point, 4 miles south of Alpena, Alpena County, extending from center into SE $\frac{1}{4}$ sec. 11, T. 30 N., R. 8 E. Type locality of Thunder Bay Limestone.

SPECIES OF *Synbathocrinus*

To properly classify the Michigan specimens of *Synbathocrinus* it was necessary for us to review the characteristics of all species currently assigned to the genus. Our results are offered in Table I. They are helpful in assessing the knowledge of *Synbathocrinus* and in emphasizing the bases for separation of species.

Several species listed by Bassler and Moodey (1943, pp. 694-97) have since been removed from *Synbathocrinus*. Moore (1941, pp. 102-5) tentatively transferred some crinoids from *Synbathocrinus* to *Taidocrinus* Tolmatchoff because their initial anal plate (*X*) is entirely excluded from the dorsal cup and lies at the same level as the primibrachials (*PBrBr*), the first plates of the arms. The species and subspecies or varieties tentatively transferred by Moore were *S. campanulatus* (Wanner), *S. campanulatus elongatus* (Wanner), *S. campanulatus inflatus* (Wanner), *S. constrictus* (Wanner), *S. constrictus sinuosus* (Wanner), *S. melbus* Strimple, *S. ogivalis* de Koninck, and *S. poljenowi* (Tolmatchoff). The last species was originally placed in *Taidocrinus*. We endorse this transfer. With the elimination of

these species from *Synbathocrinus*, the range of the genus is restricted to Devonian and Mississippian.

Remeš (1929, p. 242, Pl. 1, Figs. 3a, b) described and figured a new crinoid from the Devonian of Czechoslovakia as "*Synbathocrinus* [sic] *celechovicensis*" and compared it with "*Synbathocrinus* [sic] *fritillus* Müller." Insofar as we can discover, there never was a "*Synbathocrinus fritillus* Müller." The species referred to is undoubtedly *Platycrinus fritillus* Müller, which Bassler and Moodey (1943, p. 630) placed in the genus *Storthingocrinus*. We find no record of Müller's species ever being assigned to *Synbathocrinus*. Because the article by Remeš contained no bibliography, it is impossible to determine why he made this peculiar reference; perhaps, he referred to a mislabeled museum specimen. At any rate, his figures show clearly that the Czechoslovakian species does not belong in *Synbathocrinus*. The arm articulation facets are deeply indented into the central part of the distal margins of the radials, leaving a relatively small surface for articulation with the arms. These characters are found in the genus *Storthingocrinus* Schultze, according to the analysis by Wachsmuth and Springer (1886, pt. 3, pp. 171-72). We believe, therefore, that Remeš intended to make his crinoid congeneric with *Storthingocrinus fritillus* (Müller), and to this we would agree.

Hall (1861, p. 18) described *Synbathocrinus papillatus* from the Mississippian Burlington Limestone. No figures accompanied his description and the species was never reported again. Wachsmuth and Springer (1886, p. 169) believed that *S. papillatus* was merely a variety of *S. dentatus*, also from the Burlington Limestone. The description of *S. papillatus* fits specimens of *S. dentatus* equally well. Hence, we regard *S. papillatus* as a junior synonym of *S. dentatus*.

Including the new species described here, we recognize twenty-three species of *Synbathocrinus* (Table I).

SYSTEMATIC DESCRIPTIONS

Class CRINOIDEA

Subclass Inadunata Wachsmuth and Springer, 1885

Order DISPARATA Moore and Laudon, 1943

Diagnosis.—Monocyclic; dorsal cup composed only of basals (*BB*), radials (*RR*), generally an *X* plate, and either (1) a radianal (*RA*), or (2) an inferradianal (*iRA*) and superradianal (*sRA*); arms free above *RR*.

Family Synbathocrinidae S. A. Miller, 1889

Diagnosis.—Cup subconical, small; crown tall, slender; *BB* 3 to 5;

RR 4, subequal, facets broad; *RA* in circllet of *RR* in right posterior position, supporting *X* and an arm; arms unbranched, nonpinnulate.

Genus *Synbathocrinus* Phillips, 1836

Type species.—By original designation of Phillips, 1836, p. 206, *Synbathocrinus conicus* Phillips.

Diagnosis.—*BB* 3, forming a low, subcircular disk; *RR* subtrapezoidal, rapidly increasing in width to broad, nearly straight facets; *X* set into notch in cup; arms very long, tapering gradually; proximal plates (*PBrBr*) larger and in some with different cross sections than succeeding plates (*BrBr*).

Synbathocrinus michiganensis, sp. nov.

(Pl. I, Figs. 1-21)

Dorsal cup.—Truncate conical height about $\frac{1}{3}$ greatest width (height measured vertically from base of *BB* to axial canal on distal facet of *RR*; greatest width measured horizontally at level of axial canals on distal facets of *RR*). Body cavity small, circular, its diameter equal to half the greatest cup width, its depth equal to about half the cup height. Cup smooth except for ridges on *RR*. *BB* circllet low, about $\frac{1}{6}$ height of *RR* as viewed laterally (Pl. I, Figs. 3, 9), about $\frac{1}{2}$ greatest diameter of cup as viewed basally (Pl. I, Fig. 10), not expanded, containing two large subequal plates and one small plate. Dorsal surface of circllet flat or nearly flat, except for shallow columnar facet bearing radial grooves in its margin (Pl. I, Figs. 6, 8); sides of circllet subvertical (Pl. I, Figs. 11, 13). Large *BB* having the shape of circular sectors, but with a slight angulation on the periphery, contiguous in right posterior radius (Pl. I, Fig. 16). Small *B* triangular, located in left anterior interradius (Pl. I, Fig. 12). Height of *BB* less in anterior, left anterior, and left posterior radii than elsewhere.

RR subtrapezoidal (Pl. I, Fig. 2), except left posterior *R* which has its right border slightly modified by the adjacent *X* (Pl. I, Fig. 4). Height of anterior and left anterior *RR* normally less than that of left posterior and right anterior *RR*. Left ventral corner of *RA* truncated to accommodate full basal width of *X*. *RR* and *RA* slope at 40 to 60 degrees from vertical. Distal (ventral) width of each plate about twice the proximal (dorsal) width (Pl. I, Fig. 10). Median ridge on *RR* and *RA* varying from specimen to specimen and from plate to plate within the same specimen, well developed (Pl. I, Figs. 4, 5, 21) or poorly developed (Pl. I, Figs. 9, 12); sutures with spoonlike depressions wherever contiguous plates have strong median ridges (Pl. I, Figs. 2, 5). Strong median ridges and beveled outer facets forming T-shaped, raised areas on some *RR* (Pl. I, Figs. 4, 21).

KESLING AND SMITH

TABLE I

COMPARISON OF SPECIES OF *Synbathocrinus*

Species	<i>anglicus</i> Phillips	<i>angularis</i> Miller and Gurley	<i>antiquus</i> Strimple	<i>blari</i> Miller		
Basals (<i>BB</i>)	Low	2 small and 1 large	High and erect	Slightly concave sides		
Radials (<i>RR</i>)	Evenly convex	Beveled laterally from center, subpyramidal	Equal, very elongate	Arcuate base; sutures depressed		
Primi-brachials (<i>PBrBr</i>)	Rounded dorsally	Subangular dorsally	Slightly wider than high	Sharply angular dorsally		
Succeeding Brachials (<i>BrBr</i>)	Broadly rounded	Angular dorsally	Unknown	Sharply angular dorsally; longer proximally		
Ratios	Distal Width/Basal	<i>RR</i>	2.0	2.0	2.0	1.2
		<i>PBrBr</i>	.67	.50	?	.88
	Height/Width	Dorsal Cup*	.50	...	1.50	.50
		<i>BrBr</i>	.33	‡50-1.00
Height <i>BB/RR</i>	.33	.50	.75	.33		
Calyx	Tapers rapidly; no ridges	Compressed laterally; ant.-post. 2 times lateral diameter	Elongate, narrow; strong distal flare	Depressed sutures		
Anal† (<i>X</i> , <i>X</i> ₁ , <i>X</i> ₂ ...)	<i>X</i> to top of <i>PBr</i> ; <i>X</i> ₁ short; triangular	<i>X</i> followed by 2 short plates	Not described	<i>X</i> with L/W = 2½; <i>X</i> ₁ short, triangular		
Remarks	<i>BB</i> shorter than in <i>conicus</i>	Calyx laterally compressed; angular plates	Calyx high, narrow, flared	Brachials shorten distally		

* Height measured from base of *BB* to top of *RR*; width measured at top of *RR*.

† Except as noted, *X* approximately twice as long as wide.

‡ Slightly higher or longer than wide.

§ Slightly wider than high or long.

? Not described or observed.

COMPARISON OF SPECIES OF *Synbathocrinus*

<i>brevis</i> Meek and Worthen	<i>conicus</i> Phillips	<i>dentatus</i> Owen and Shumard	<i>expansus</i> Goldring
Sides nearly straight	Buttonlike base	High, conical	Extending well beyond stem
Evenly convex	Suture areas often ridged; convex to concave	Center slightly depressed	Flaring widely from base, curving outward slightly
Rounded dorsally	Somewhat rounded dorsally	Gently convex dorsally	Unknown
Angular dorsally; sutures depressed	Rounded; distal <i>BrBr</i> wider than long	Proximal convex, subangular above <i>Br₃-Br₄</i>	Unknown
1.3	1.8	1.7	2.5
1.00	?	.67	...
.60	.67	.67	?
§	1.00-1.50	.67-1.00	...
.33	.50-.67	.33-.50	.25-.50
Nearly straight sides from base to top of <i>RR</i>	Conical or bell-shaped	Conical plates thick	Low, broadly conical; low median ridge on <i>RR</i>
<i>X₁</i> half as long as <i>X</i>	<i>X₁</i> short, triangular	<i>X₁</i> shorter, narrower than <i>X</i>	Unknown
Calyx spreading less, arms shorter than in <i>wortheni</i> or <i>dentatus</i>	<i>BB</i> longer than <i>anglicus</i>	Large specimens with prox. <i>BrBr</i> wider than long	<i>RR</i> flaring more rapidly, with lower ridges than <i>sulcatus</i>

KESLING AND SMITH

TABLE I—Continued

Species		<i>granulatus</i> (Troost)	<i>granuliferus</i> Wetherby	<i>hamiltonensis</i> Springer	<i>illinoisensis</i> Miller and Gurley	
Basals (BB)		Slightly rounded	Wider than high	Missing	3 times as wide as high	
Radials (RR)		Strongly convex center, distal bevel extending to center of plates	Slightly convex	Anal notch nearly ½ height of RA; RR and RA convex	Evenly convex	
Primi-brachials (PBrBr)		Unknown	Convex dorsally	Apparently constricted at top	Unknown	
Succeeding Brachials (BrBr)		Unknown	Convex dorsally; distal BrBr slightly wider than high	Proximal angular, distal more rounded	Unknown	
Ratios	Distal Width/Basal	RR	1.8	2.0	?	1.5
		PBrBr80	?	...
	Height/Width	Dorsal Cup*	.50	.3350
		BrBr	...	§-‡	1.50-2.00	...
	Height BB/RR		.40	.25-.3367
Calyx		Tuberculate surface	Small, rounded; small granules or tubercles on cup and arms	Turbinate; surface faintly granular	Evenly constricted and rounded to base of RR; sutures slightly beveled	
Anals† (X, X ₁ , X ₂ ...)		Unknown	X twice as long as X ₁	X with L/W = 4/3; 2 or 3 more plates	Unknown	
Remarks		Resembles <i>angularis</i> except not laterally compressed	Granules more numerous distally on arms	X deeply inserted into RR-RA circlet	Surface granular	

* Height measured from base of BB to top of RR; width measured at top of RR.

† Except as noted, X approximately twice as long as wide.

‡ Slightly higher or longer than wide.

§ Slightly wider than high or long.

? Not described or observed.

COMPARISON OF SPECIES OF *Synbathocrinus*

<i>matutinus</i> Hall	<i>michiganensis</i> , sp. nov.	<i>onondaga</i> Springer	<i>oweni</i> Hall
High, inflated	Low, not inflated	Not inflated	Base short, rotund
Prominent median ridge	Median ridge varies in prominence	Evenly convex	Wider than high
Dorsally angular	Dorsally angular	?	?
Angular dorsally; height = width	Angular dorsally; higher than wide	Angular dorsally	?
1.5	2.0	?	?
.80	.50	?	?
.33	.33	.50	?
1.00	1.33	2.00	?
.67	.17	.25	?
Low, expanding evenly from <i>BB-RR</i> suture	Low, expanding rapidly to top of <i>RR</i> , some from <i>RR</i> center	Small, conical; no ridges	Round below, gradually enlarging to summit of <i>RR</i> ; surface granular
Unknown except distal end of tube	<i>X</i> angular dorsally, $L/W = 2$	Not described	?
<i>BB</i> ring prominent, projecting; <i>BB</i> 2/3 height <i>RR</i>	Cup low, broad; <i>BB</i> low, 1/6 height of <i>RR</i>	<i>BrBr</i> twice as long as wide	Meager description and no figure

KESLING AND SMITH

TABLE I—Continued

Species		<i>robustus</i> Shumard	<i>sulcatus</i> Goldring	<i>swallovi</i> Hall	<i>texanensis</i> Moore and Ewers	
Basals (BB)		Short	Low, extending well beyond stem	?	Lateral wall subvertical	
Radials (RR)		Gently convex; depressed sutures	Sutures, deeply depressed, gradually widening distally	Regularly expanding upward	Sloping upward at 55°; prominent keel on midline	
Primi-brachials (PBrBr)		Angular dorsally	Angular dorsally	Unknown	Unknown	
Succeeding Brachials (BrBr)		Subangular dorsally; sutures slightly depressed	Angular dorsally; laterally opposed faces sharply squared off	Unknown	Unknown	
Ratios	Distal Width/Basal	RR	1.5	2.5	?	2.0
		PBrBr	.83	1.00
	Height/Width	Dorsal Cup*	.50	.50	?	.50
		BrBr	.33-.50	1.50
Height BB/RR		.33-.50	.12-.17	?	.33	
Calyx		Depressed conical, expanding rapidly from base; finely granular	Narrower, more turbinate than most species; cup and arms finely papillose	Small, basin-shaped	Truncated cone; irregular nodes and ridges, nearly vertical on BB, oblique to subparallel on RR	
Anals† (X, X ₁ , X ₂ ...)		?	Unknown	Unknown	Unknown	
Remarks		Anals not described nor observed on specimen	BB less prominent, H/W cup greater than in <i>matutinus</i>	Description and figures poor	Moore and Ewers (1942) describe immature specimens	

* Height measured from base of BB to top of RR; width measured at top of RR.

† Except as noted, X approximately twice as long as wide.

‡ Slightly higher or longer than wide.

§ Slightly wider than high or long.

? Not described or observed.

COMPARISON OF SPECIES OF Sybathocrinus

<i>troosti</i> Wood	<i>wachsmuthi</i> Meek and Worthen	<i>wortheni</i> Hall	
Low, flaring outward	Rounded sides	Low, not inflated	
<i>RR</i> and <i>BB</i> diverge at 127° central part flattened; sutures broad and shallow	Gently convex	Gently convex	
Unknown	Subangular dorsally	Subangular dorsally	
Unknown	Angular dorsally	Proximal angular, distal rounded	
1.5	1.5	1.6	
?	.88	.60	
?	.50	.50	
...	.50-.75	‡	
?	.33-.50	.25-.33	
Low spreading cup; smooth surface	Semiglobose; fine granular or vermicular markings	Obconical shape	
Unknown	X_1 apparently small, triangular	X much longer than wide	
<i>RR</i> of different shape, cup lower than in <i>robustus</i>	No ridges on <i>RR</i>	Column nearly width of <i>BB</i>	

Broad, beveled facet area extending across distal margin of each *R* and *RA* (Pl. I, Fig. 5). Each facet area divided into two facets: the outer facet narrow, sloping downward at about 45 degrees, forming a triangular area on radial plates having strong median ridges (Pl. I, Fig. 4), the inner facet much wider than the outer part, sloping upward at about 20 to 30 degrees in its outer part and about 50 degrees in its inner part (Pl. I, Figs. 5, 13, 20). Inner part of inner facet bisected by a narrow intermuscular furrow ending in a V-shaped or circular opening (Pl. I, Figs. 5, 20). Inner facets much more sharply elevated in some specimens (Pl. I, Figs. 7, 11, 20) than in others (Pl. I, Figs. 5, 9). Axial canal at junction of inner and outer facets, nearly or quite centered between corners of *R*, about $\frac{1}{3}$ to $\frac{1}{2}$ the width of facets (Pl. I, Figs. 13, 20).

Anal series.—*X* inserted into notch in dorsal cup, slightly longer than *PBrBr* (Pl. I, Figs. 1, 20), less than $\frac{1}{2}$ width of *PBr* above *RA* (Pl. I, Fig. 4), its base articulating with truncated corner of *RA*. Succeeding *XX* plates (*X*₁, *X*₂, *X*₃ . . .) about as long and half as wide as adjacent *BrBr*. All plates in uniserial row, each quadrangular in cross section with angular dorsal surface (Pl. I, Figs. 4, 15, 20). Series incomplete in known specimens; the greatest number of plates observed is six (Pl. I, Fig. 20).

Arms.—*PBrBr* trapezoidal in lateral view, slightly longer than *RR* or *RA*. Proximal width of each *PBr* about equal to height (Pl. I, Fig. 3) and to distal width of *RR* or *RA* on which it rests (Pl. I, Fig. 4). Distal width about $\frac{3}{4}$ proximal width (Pl. I, Fig. 3). Dorsal surface distinctly angular. Proximal articulation surface beveled in two planes; outer part broad, beveled at about 45 degrees; inner part beveled at about 30 to 40 degrees (Pl. I, Fig. 20). Axial canal at junction of the two parts, centered on base and about $\frac{1}{3}$ width of facet (Pl. I, Fig. 21).

BrBr nearly rectangular in lateral view. Dorsal surface angular (Pl. I, Figs. 1, 3), ventral surface with distinct ambulacral notch having depth equal to half the width of the plate. Length of each *Br* $1\frac{1}{4}$ to nearly $1\frac{1}{2}$ its width (Pl. I, Figs. 3, 15). Arms incomplete in known specimens, seven the greatest number of *BrBr* observed (Pl. I, Fig. 15).

Column.—Part of column preserved on few specimens (Pl. I, Figs. 4, 16, 20). Second columnal thicker and wider than first columnal (Pl. I, Fig. 20). Margins of columnals radially grooved (Pl. I, Fig. 4). Central canal $\frac{1}{6}$ to $\frac{1}{9}$ diameter of columnal (Pl. I, Figs. 8, 12).

Measurements.—Measurements of the holotype (BM E16581*b*; Pl. I, Figs. 20–21), one paratype (BM E16581*a*; Pl. I, Figs. 1–4), and another paratype (UMMP 23870; Pl. I, Figs. 15–16) in millimeters as follows: height of cup, 2.1, 2.3, 2.5; greatest cup width, 6.0, 6.8, 6.1; diameter of basal cirlet, 3.0, 3.3, 3.3; and total length of specimen, 13.6, 14.8, 21.2.

Remarks.—This species is characterized by short *BB*, shallow dorsal cup, and dorsally angular arms. The *RR* are 5.2 to 8.3 times the height of the *BB* (Table II). The height of the dorsal cup is only 0.33 its width (Table I).

As tabulated (Table I), the available information on several species is too meager to adequately establish the essential features. From what is known about these species, however, each seems to be distinct from *S. michiganensis*, sp. nov.

Synbathocrinus sulcatus is the only other species with a *BB/RR* height ratio comparable with that of *S. michiganensis*; it differs in having a greater height/width ratio of the dorsal cup, little if any distal taper in *PBrBr*, and papillose ornamentation on the cup and arms.

The other species having some resemblances to our new species is *S. matutinus*; in fact, some of the Michigan specimens were previously assigned to *S. matutinus*, as pointed out. Both have similar calices; but the *BB* in *S. michiganensis* are only .17 the height of the *RR*, whereas those in *S. matutinus* are .67 the height of the *RR*. Furthermore, the *BB* form a projecting, inflated ring in *S. matutinus* but not in *S. michiganensis*; and the length of the *BrBr* is about equal to the width in *S. matutinus* but is distinctly more than the width in *S. michiganensis*.

Types.—Holotype, BM E16581*b* (Locality 1, collected by I. G. Reimann; Pl. I, Figs. 20–21). Paratypes, BM E16581*a, c-g* (Locality 1, collected by I. G. Reimann; Pl. I, Figs. 1–4, 11–12, 7–8, 5–6, 9–10, 13–14, respectively and UMMP 23870 (Locality 1, collected by L. O. Pettyes; Pl. I, Figs. 15–16).

TABLE II

MEASUREMENT OF SPECIMENS OF *Synbathocrinus michiganensis*, SP. NOV.,*S.* SP. CF. *S. michiganensis*, AND *S. matutinus* HALL

RR—average height of *RR* (in millimeters) measured parallel to plate surface along median ridge; *BB*—average height of *BB* (in millimeters) measured vertically; *RR/BB*—ratio of height of *RR*/height of *BB*.

Species	Catalogue No.	<i>RR</i>	<i>BB</i>	<i>RR/BB</i>
<i>michiganensis</i>	BM E16581 <i>e</i>	2.48	0.37	6.7
<i>michiganensis</i>	BM E16581 <i>a</i>	2.40	.29	8.3
<i>michiganensis</i>	BM E16581 <i>c</i>	2.39	.35	6.9
<i>michiganensis</i>	BM E16581 <i>f</i>	2.29	.42	5.6
sp. cf. <i>michiganensis</i>	USNM 93201	2.26	.51	4.4
<i>matutinus</i>	UCWM 15853	2.25	1.28	1.7
<i>matutinus</i>	UCWM 11370	2.13	1.36	1.6
<i>michiganensis</i>	BM E16581 <i>g</i>	2.12	.40	5.3
<i>michiganensis</i>	UMMP 23870	2.06	.35	5.9
<i>michiganensis</i>	BM E16581 <i>b</i>	2.02	.34	6.0
<i>michiganensis</i>	BM E16581 <i>d</i>	2.01	.38	5.2

Synbathocrinus sp. cf. *S. michiganensis*, sp. nov.

(Pl. I, Figs. 17-19)

The specimen catalogued in the United States National Museum as USNM 93201, from the Thunder Bay Limestone at Partridge Point, differs in certain respects from the types of *Synbathocrinus michiganensis*, from the Dock Street Clay. The *RR/BB* height ratio is somewhat lower than that of *S. michiganensis* type specimens (Table II), the dorsal cup has less distal flare, and the three sutures between *RR* have deep subcircular depressions in sharp contrast with the two sutures between *RR* and *RA*. The surface of this specimen is rather worn, so that we cannot be certain that the *RR* depressions are not the results, in part at least, of preservation. This specimen shows much closer resemblance to *S. michiganensis* than to *S. matutinus*, however, particularly in the form of the *BB*.

Synbathocrinus matutinus Hall

(Pl. I, Figs. 22-23)

Synbathocrinus matutinus Hall, 1858, p. 483, Pl. I, Fig. 2; Hall, 1861, p. 18; Wachsmuth and Springer, 1885, p. 169; Thomas, 1920, pp. 475-76, Pl. 44, Fig. 9; Goldring, 1923, p. 330, Pl. 40, Fig. 18; Springer, 1923, p. 29; Bassler and Moodey, 1943, pp. 64, 695; Stumm, 1951, p. 23.

Two specimens of this species are known, both from the Hamilton of Iowa. The holotype was described by Hall in 1858 and 1861. The present location of the specimen is unknown, but a plastoholotype is in the Walker Museum of The University of Chicago, UCWM 15853. The second specimen is also in the Walker Museum, UCWM 11370, in the Gurley Collection. It is figured here (Pl. I, Figs. 22-23).

Hall's original description, as quoted by Thomas (1920, pp. 475-76), stated, "Basal plates undivided, forming a slightly projecting disc in the specimen; first radial plates wider than long; second radials longer than wide, obtusely angular along the centre; brachial plates quadrangular, and subangular longitudinally along the centre; column round, composed near the base of alternating larger and smaller rings."

From study of the two specimens in the Walker Museum, we offer the following revision and additions.

Dorsal cup.—Truncate conical, height about $\frac{1}{3}$ greatest width (height measured vertically from base of *BB* to axial canal on distal facet of *RR*; greatest width measured horizontally at level of axial canals on distal facets of *RR*).

BB circllet high, about $\frac{2}{3}$ height of *RR* as viewed laterally, about $\frac{1}{2}$ greatest diameter of cup as viewed basally, horizontally expanded and forming a prominent projecting ring. Number and position of *BB* not

observed. Proximal side of *BB* circling nearly flat. Greatest width of circling at mid-height of *BB*. Cup constricted along *BB-RR* suture.

RR subtrapezoidal in lateral view, its base slightly convex. *RA* and left posterior *R* not observed. *RR* sloping at 50 to 60 degrees from vertical. Distal width of *RR* about 1.5 times proximal width. Median ridges well developed. Sutures not depressed. Outer facet broadly beveled; inner facet not seen.

Anal series.—Unknown except for distal part of anal tube appearing as faint reticulation between distal sections of two arms.

Arms.—*PBrBr* trapezoidal in lateral view, slightly longer than *RR*. Proximal width slightly greater than length; distal width about $\frac{4}{5}$ proximal width. Dorsally angular; the outer articulation facet broad, triangular, beveled at about 45 degrees.

BrBr nearly square in lateral view, dorsally angular. Arms nearly complete on UCWM 11370 (Pl. I, Fig. 22), with 22 *BrBr* on one arm. Total length of arm, including *PBrBr*, 55 mm.

Column.—Well preserved, round, consisting of broad, thick columnals alternating with narrow, thin columnals. At junction with the cup, diameter of column $\frac{1}{2}$ greatest diameter of *BB* circling.

Measurements.—Measurements of plastoholotype (UCWM 15853) and other specimen (UCWM 11370; Pl. I, Figs. 22–23) in millimeters as follows: height of cup, 2.9, 2.8; greatest width of cup, 7.0, 7.2; diameter of *BB* circling, 4.3, 4.0; and total length exclusive of column, 33.1, 68.1.

Remarks.—In Hall's original description, quoted by Thomas (1920, pp. 475–76), he stated that the only specimen seen was a fragment, imperfect at the upper extremity, with the surface much broken, particularly the *BB* and *RR*, and the surface of the arms exfoliated. Comparison of the plastoholotype and Hall's figure reproduced by Thomas (1920, Pl. 44, Fig. 9) indicates that the latter was idealized. Hall's drawing does not show the exfoliation of the arms and calyx. The *BB-RR* sutures are shown as arcuate, whereas no such curvature is evident in the plastoholotype; in UCWM 11370, the sutures are also straight.

By coincidence, both the holotype and specimen UCWM 11370 are embedded in limestone blocks, partly exposed, and in approximately the same position. The posterior side of both crinoids are hidden in the matrix, thus making exact orientation of the specimens difficult.

Synathocrinus matutinus is characterized by the height of the basal circling and the prominence of the projecting *BB* ring. Its *RR* are only 1.6 to 1.7 times the height of the *BB*. *S. matutinus* closely resembles *S. michiganensis*; their differences are discussed above under the latter species.

Occurrence.—Thomas (1920, p. 476) listed the locality of the holotype

as Cedar Valley Limestone in the *Stropheodonta demissa* bed exposed near New Buffalo, Iowa. We have not identified the species in Michigan.

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PLATE

EXPLANATION OF PLATE I

(All figures $\times 2\frac{1}{2}$ except as noted)

	PAGE
<i>Synbathocrinus michiganensis</i> , sp. nov.	189
Figs. 1-4. Posterior, basal, anterior, and inclined posterior views of paratype BM E16581a. Upper left corner of <i>RA</i> and distal right border of left posterior <i>R</i> truncated and modified by <i>X</i> (Figs. 1, 4). Strong median ridges on <i>RR</i> and <i>RA</i> . Small circular columnar canal (Fig. 4). <i>RR</i> and <i>RA</i> beveled distally, <i>PBrBr</i> beveled proximally (Figs. 3-4). <i>PBrBr</i> and <i>BrBr</i> dorsally angular (Figs. 1, 3). Fig. 4, $\times 5$.	
Figs. 5-6. Anterior and basal views of paratype BM E16581e. Inner facets of <i>RR</i> broad and flat in their outer parts (Fig. 5). Strong median ridges on <i>RR</i> . Columnar facet in <i>BB</i> circllet round, radially grooved (Fig. 6).	
Figs. 7-8. Posterior and basal views of paratype BM E16581d. Contiguous margins of outer parts of inner facets on <i>RR</i> sharply elevated (Fig. 7).	
Figs. 9-10. Posterior and basal views of paratype BM E16581f. Median ridges on <i>RR</i> weak.	
Figs. 11-12. Anterior and basal views of paratype BM E16581c. Small <i>B</i> lies in left anterior interray. Ridges on <i>RR</i> poorly developed. Columnar canal small.	
Figs. 13-14. Anterior and basal views of paratype BM 16581g. Axial canals between outer and inner facets of <i>RR</i> (Fig. 13).	
Figs. 15-16. Posterior and basal views of paratype UMMP 23870. Arms partly disarticulated. Five <i>XX</i> preserved.	
Figs. 20-21. Posterior and basal views of holotype, BM E16581b. Median ridges on <i>RR</i> well developed. Six <i>XX</i> present. Arms dorsally angular; right anterior <i>PBr</i> with distinct axial canal (Fig. 21). Innermost parts of <i>RR</i> facets sharply elevated, bisected by narrow intermuscular furrow.	
<i>Synbathocrinus</i> sp. cf. <i>S. michiganensis</i> , sp. nov.	192
Figs. 17-19. Posterior, basal, and anterior views of USNM 93201. <i>BB</i> circllet low, not inflated. No median ridges developed on <i>RR</i> or <i>RA</i> , but deep sub-circular depressions along the three sutures between <i>RR</i> , possibly the result of unusual weathering, forming false median ridges (Figs. 18, 19).	
<i>Synbathocrinus matutinus</i> Hall	192
Figs. 22-23. Anterior views of UCWM 11370. <i>BB</i> circllet high, .67 height of <i>RR</i> , forming prominent projecting ring. Median ridges on <i>RR</i> . <i>PBrBr</i> and <i>BrBr</i> dorsally angular. Distal part of anal tube visible between upper extremities of arms. Columnals of two sizes, alternating. <i>RR-PBrBr</i> and <i>RA-PBr</i> sutures straight. Fig. 22, $\times 1$.	

PLATE I



