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TWO NEW CRINOIDS OF THE FAMILY SCYTALOCRINIDAE
FROM THE MIDDLE DEVONIAN SILICA FORMATION
OF NORTHWESTERN OHIO

BY

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TWO NEW CRINOIDS OF THE FAMILY SCYTALOCRINIDAE FROM THE MIDDLE DEVONIAN SILICA FORMATION OF NORTHWESTERN OHIO

ROBERT V. KESLING

ABSTRACT—Two new crinoids are here added to the extensive echinoderm fauna of the Middle Devonian Silica Formation. Each is small and the only known specimen of its kind. The first is the second specimen to be described in the genus *Kophinocrinus* and only one to show the arms above the PBr₁ and the pinnules. The new species, *Kophinocrinus magrumi*, has a cup similar to that of the type species, *K. spiniferus* Goldring, except for its shallower ornamentation and narrower X. The spine-bearing BB and the crested RR and X form a bowl set atop the stellate disk formed by the flattened circlet of firmly joined IBB. The large PBrBr taper gradually from their junction with the RR; the first three have distal spoonlike flanges projecting horizontally from their sides; the fourth PBr of each ray is axillary, flaring to sharp lateral tips to form wide bases for the substantial SBrBr. The high-arched SBrBr bear alternate pinnules beginning on SBr₂, with each pinnule hinged on a small lateral flange set far down the side of the Br at about midlength and scarcely visible in direct (dorsal) view of the arm. The ten arms extend nearly six times the height of the cup.

The second specimen is classified as a new subspecies of *Decadocrinus*, *D. wrightae silicaensis*. It differs from *D. wrightae* of the Arkona Shale in its smaller size and more elongate and slender BrBr. It is not known whether this small holotype is mature.

INTRODUCTION

WITHIN THE LAST FEW YEARS my friends have presented me with several new echinoderms from the famous and daily-searched collecting areas in the quarries of the Medusa Portland Cement Company in northwestern Ohio, where exposures of the Silica Formation weather to produce a continuous crop of excellently preserved fossils. Nevertheless, I am amazed and delighted by each new species. Recently Mr. Larry Magrum brought me two small crinoids, one of which proved to be a new subspecies of *Decadocrinus wrightae* and the other to be a new species of *Kophinocrinus*. The latter contributes greatly to our understanding of the genus, which was previously known only from the holotype of the type species. For the first time, the arms of *Kophinocrinus* are available for study; their structure proves that Doctor Winifred Goldring was right in assigning the genus to the family Scytalocrinidae.

The usual willing and efficient help of Mrs. Helen Mysyk in typing, Mr. Karl Kutasi in photographing, and Mrs. Gladys Newton in proofreading aided in the preparation of this paper. Their efforts are greatly appreciated.

LOCALITY

Both little crinoids were found by Larry Magrum in 1970 in the North Quarry of the Medusa Portland Cement Company at Silica,

about 3 miles west-southwest of Sylvania in Lucas County, Ohio. They came from unit 9 of the Middle Devonian Silica Formation, a 7-foot-6-inch layer of bluish-gray shale which weathers to a sticky clay when wet. Unlike many of the invertebrates from this highly fossiliferous bed, the crinoids show no signs of pyritization.

SYSTEMATIC DESCRIPTION

Subclass INADUNATA

Order CLADOIDEA Moore & Laudon

Suborder DENDROCRINOIDEA Bather

Family SCYTALOCRINIDAE Moore & Laudon

The original description of the family Scytalocrinidae was inaccurate. Moore & Laudon (1943, p. 59) stated that the arms were "branching isotomously on PBr₁ or unbranched." Nevertheless, they assigned to the family, among other genera, *Decadocrinus* and *Histocrinus*, both of which branch isotomously on PBr₂.

When Goldring (1954) created the genus *Kophinocrinus*, she did not hesitate to assign it to the Scytalocrinidae. However, her holotype and only specimen of *K. spiniferus*, the type and only species of the genus, incorporates only RA and X in the dorsal cup; according to Moore & Laudon (1943, p. 59), crinoids of the Scytalocrinidae have three anal plates incorporated in the cup. Goldring did not amend the

family description, nor did she comment upon the inconsistency.

The new species of *Kophinocrinus* described here has arms that branch on PBr_4 . To my knowledge, no other crinoids placed in the Scytalocrinidae have more than two $PBrBr$ in each ray.

Nevertheless, I must agree with Goldring in the familial assignment of her genus *Kophinocrinus*. As demonstrated by *K. spiniferus* and/or the new *K. magrumi*, *Kophinocrinus* agrees closely with *Decadocrinus*: the ten arms originate from isotomous bifurcation, an RA and X are incorporated in the cup, the $PBrBr$ are free of pinnules, starting with SBr_2 the pinnules alternate to the end of each arm, and the anal sac is principally supported by a stout anal series. In turn, *Decadocrinus* shows similarity to *Scytalocrinus* in the number of arms and the arrangement of pinnules.

When the Scytalocrinidae is revised, therefore, reference to the point of branching should be omitted and the number of anal plates in the cup should be listed as two or three. Another point for consideration is the width of the R facets. In their revision of the Inadunata, Moore & Laudon (1943) classified these facets as "wide" or "narrow" in each family; even though their term "wide" included facets which did not extend the full width of the RR plates, the facets in *Kophinocrinus magrumi* are so restricted that they can scarcely qualify as "wide" under these rules. They are not much wider than those of some species of *Botryocrinus*, which are said to be "narrow." Perhaps the family definition should read "R facets medium to wide."

Genus KOPHINOCRINUS Goldring 1954

Type species.—By monotypy, *K. spiniferus* Goldring, 1954, p. 37, 38, pl. 5, figs. 2–6.

KOPHINOCRINUS MAGRUMI n. sp.

Text-fig. 1; pl. 1, figs. 1, 2

Material.—Only the holotype specimen is known. The total height of preserved plates is about 9.8 mm, including 1.7 mm of column, 2.4 mm of cup, and 5.7 mm of arms in the E ray. As exposed on the slab of shale (pl. 1, fig.

1), the E ray lies closest to the center of the specimen. The BB of the DE and AE interrays have been forced away from their junctions with the RR of the E and A rays, and displaced somewhat from their shallow notches in the IBB ring. The arms are complete as high as $SBrBr_3$ in the E ray and as high as $SBrBr_2$ in the C ray.

To examine the other side of the specimen, it was freed from the matrix and cleaned. Drawings were made of the preserved anal series and other plates. The left arm of the C ray is complete as high as SBr_8 , the longest section of arm preserved; however, the external mold of the distal part of the crown shows that arms extended much farther (pl. 1, fig. 1). The BB of the BC and CD interrays and the RR of the B and C rays are displaced downward and turned so that their full outline cannot be established without completely disarticulating the specimen. The parts which are visible indicate that they are about the same size and shape as the other BB and RR. No part of an RA plate could be seen. The lower edge of X seems to have a slight bevel on the right corner, indicating that a small RA may have been present. This can only be proved or disproved by better specimens.

After the camera lucida drawings were complete (text-fig. 1), the fragile specimen was reassembled on the slab of shale to protect it and fastened in place with dilute casein glue.

Cup.—The dorsal cup includes a ring of IBB, five BB, five RR, a large X, and perhaps a small RA. The cup is small in relation to the size and length of the arms. The general shape is that of a bowl set upon a stellate trivet, with the BB and RR forming the bowl and the flat disk of IBB forming the trivet.

The ring of IBB at first appears to be a terminal thick columnal. The IBB form a disk only about 0.5 mm high (thick) and about 2.0 mm wide. In the position of each ray this disk has one large linguloid extension or two more acute extensions. In the holotype (text-fig. 1) the E ray has two well-separated extensions, the C ray nearly confluent extensions, and the other rays one large extension each. These lobes alternate with the apices of the pentastellate

EXPLANATION OF PLATE 1

- FIGS. 1, 2.—*Kophinocrinus magrumi* n. sp. Holotype UMMP 57904. 1, view showing preserved part of crown and the external impression of the missing distal sections of the arms, $\times 4$. 2, enlargement of cup with attached parts of column and arms, $\times 10$. As seen here, the A, E, and D rays are uppermost, and the edges of the anal series and C ray can be seen at the right; after this photograph was made, the crown was removed from the matrix and cleaned to show the other arms and the anal area.
- 3.—*Decadocrinus wrightae silicaensis* n. subsp. Holotype UMMP 57905, a crown with E, D, and C rays exposed, $\times 10$. The anal series is clearly visible as far as the second $SBrBr$. BB plates in the CD and DE interrays are missing.

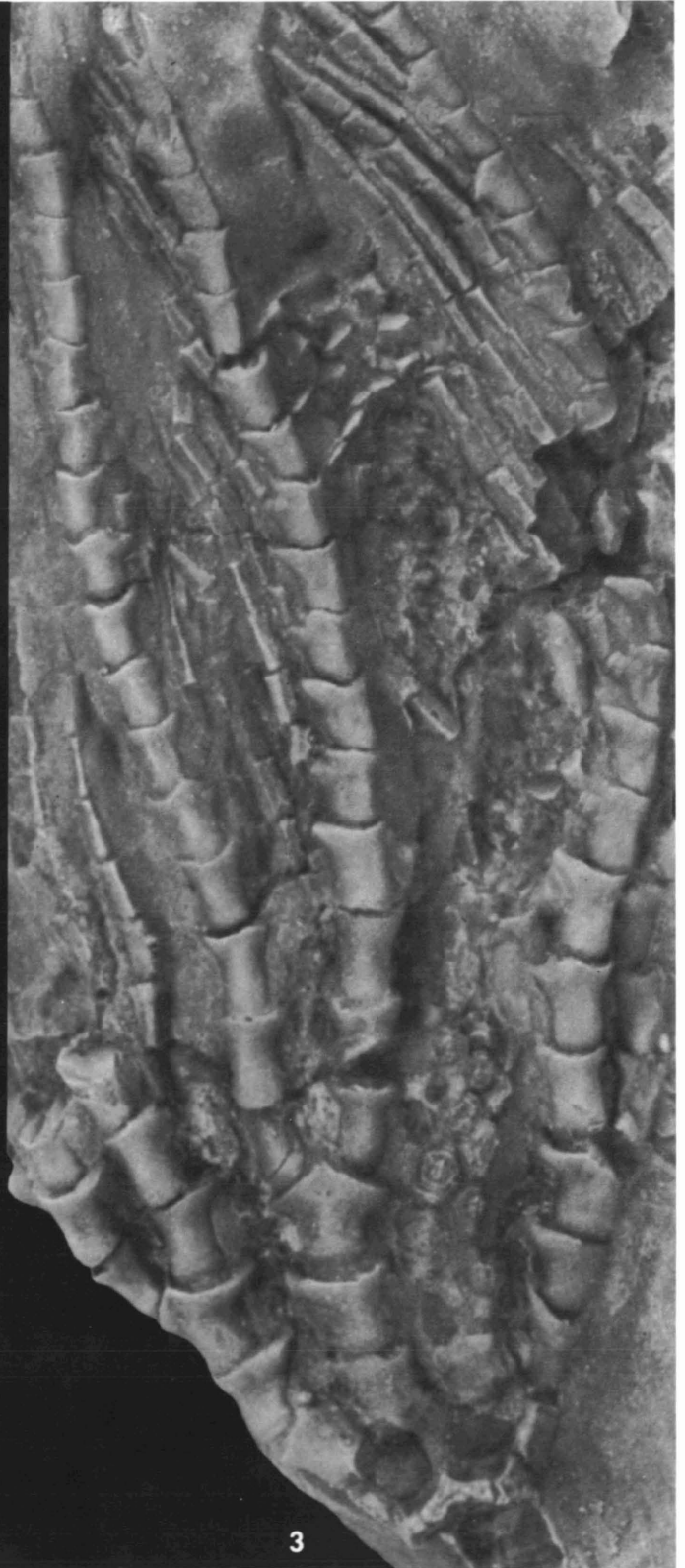
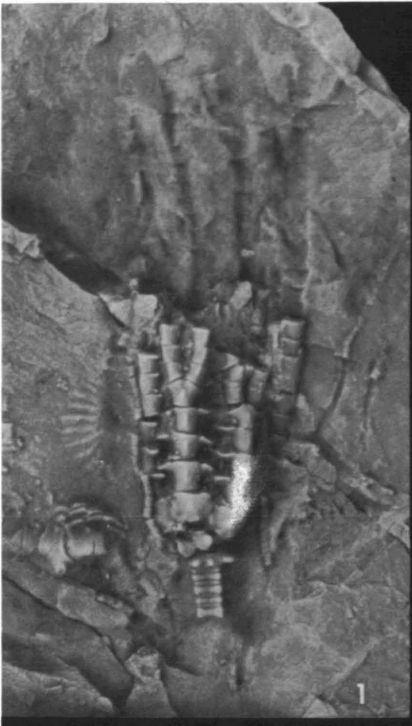


PLATE 1

columnar facet. Only one suture is clearly discernible (between C and D rays) in the IBB disk, and it would appear that fusion of the IBB is far advanced.

The five BB have the same general shape as those in all related inadunates. Each B is about 1.1 mm wide and 0.85 mm high. Its base is bluntly acuminate and sets into a very shallow notch in the IBB ring, set back from the edge of the latter and situated nearly above one of the edges of the column under the ring. This base is about 0.7 mm wide. The sides of each B diverge upward, since the plate lies at an angle to the axis of the cup. The junction with the adjacent B is about 0.4 mm long; the junction with each adjacent R is about 0.6 mm long. A stout vertically elongate blunt spine is present on the middle of each B, its flaring base blending very smoothly into the rest of the surface of the plate (pl. 1, fig. 2).

The RR and X together form the upper margin of the cup. Each R is about 1.55 mm wide and 1.15 mm high, bordered by two BB, two RR (or, in the case of the C- and D-ray RR, one R and X), and the PBr₁ of the arm. Hence, the shape is basically pentagonal, but it approaches heptagonal because of the beveled upper corners (text-fig. 1). The sutures with BB, other RR, and with X are each about 0.6 mm long; the R-PBr₁ suture or R facet is about 1.0 mm long. Each R is rather thick at its center, where a subtriangular blunt pyramidal projection lies along the midline. This projection seems to be the fusion of ridges to PBr₁ above and the two BB below, forming a smooth pyramid with poorly defined flared base. The rest of the surface of the R is subcylindrical, like that of the adjoining PBr series, except that low rounded cylindrical ridges connect the plate to adjoining RR and BB. These connecting ridges form a faint crease where they depart from the rest of the surface (pl. 1, fig. 2). The upper margin of each R flares slightly outward to form a poorly defined lip below the R-PBr₁ suture.

X is a large tall plate set between the RR of the C and D rays. It measures about 1.1 mm wide and 1.3 mm high. Hence, it extends well above the level of the RR. The base is nearly horizontal, but the lower right corner seems to show a suture across the preserved material; if this is really a suture, then a small RA was present. The top is horizontal and joins X₂ as the start of a uniserial stack of very large anal plates. From the tops of the X-R sutures to the X-X₂ suture, the upper part of the X plate tapers slightly like a neck. Like the succeeding plates in the anal series, X is a rather strongly arched plate, with a smooth crest along its mid-

line which dies out before reaching the margins of the plate.

Arms.—Each ray gives rise to only two arms. As shown by the external mold, the arms extended at least 15 mm above the cup. The greatest extent of an arm is the left arm of the C ray, which totals about 9.8 mm as reconstructed and extends to the SBr₈ (text-fig. 1).

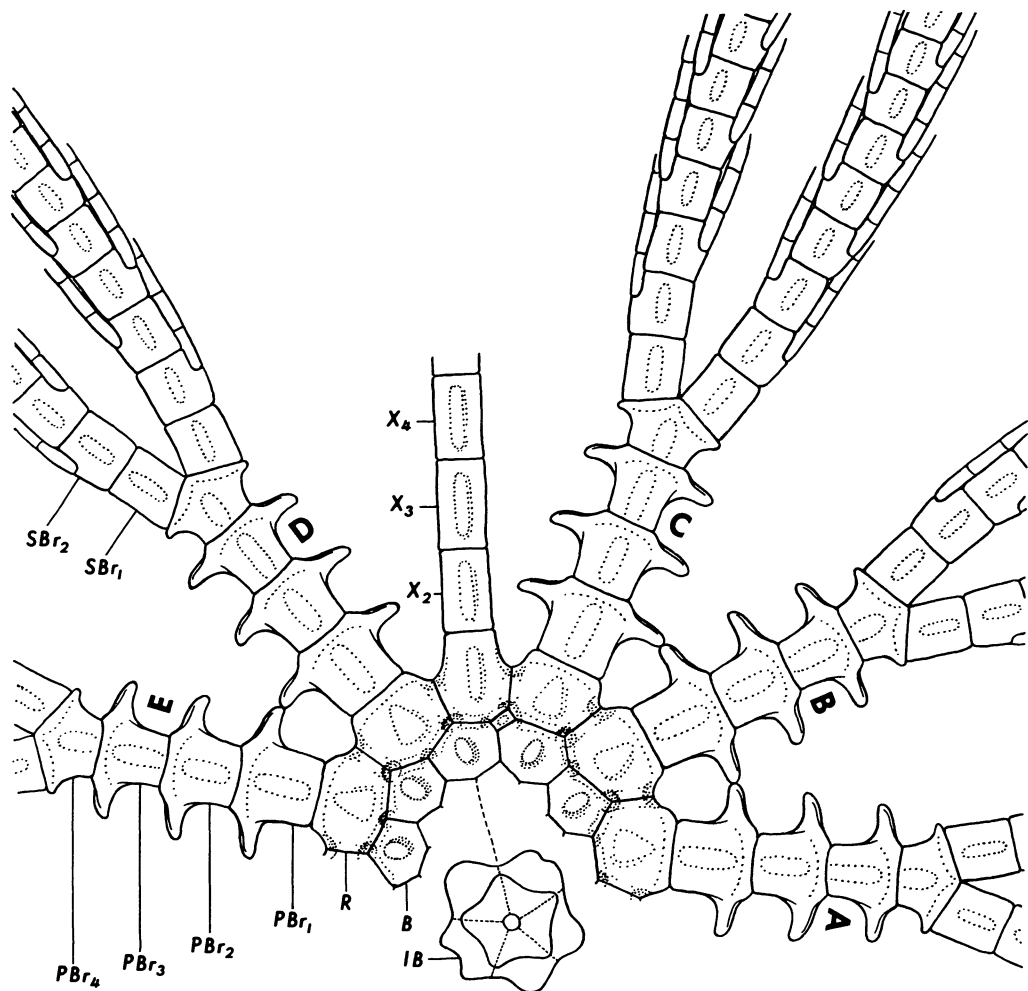
Each ray contains four PBrBr, none of which bear pinnules. The first three are alike except for their gradual decrease in size distally. PBr₁ is about 0.9 mm wide at its base and about 1.05 mm high; PBr₃ is about 0.7 mm wide at its base and about 0.9 mm high; and PBr₂ is intermediate. Each PBr is strongly arched and deep, subcylindrical, with a distinct but low longitudinal crest that does not reach the top or bottom of the plate. The distal margin is slightly flared to form a low lip below the junction with the next plate. Each side of the plate flares sharply outward in its distal third to form a spoonlike flange. Each flange has a rather large concave upper surface. The lateral extent of the two flanges is so great that those of adjacent rays must overlap when the arms are held upright; the extent of the flanges in PBr₁ makes the distance between the tips about 2.0 mm, more than twice the basal width of the plate.

PBr₄ is axillary, about 0.8 mm wide at its base and 0.95 mm high. It flares distally to sharp lateral tips, reaching there a maximum width of about 1.5 mm. Its distal sides form an angle of nearly 130°, with a large SBr₁ joined to each side. Like the other PBrBr, the axillary is strongly arched and deep. Its longitudinal crest is confined to the lower half of the plate.

The long arms are uniserial, composed of SBrBr. They taper very gradually. From the external molds (pl. 1, fig. 1) it can be estimated that each of the ten arms had about 30 SBrBr; inasmuch as the molds do not show definite terminations, the arms may have been even longer and contained more SBrBr. In the left branch of the C ray, eight SBrBr are preserved; together, they extend nearly 5.5 mm.

The proximal SBrBr, and presumably those beyond SBr₈, are deep and strongly arched plates. From a very low longitudinal crest, the plate slopes down and around each side. Its shape conveys the impression of a cylindrical trough that has been slightly buckled by compression. A distal lip is present, like that in a PBr, but it is very low and inconspicuous.

Pinnules begin on SBr₂ and thereafter alternate left and right on succeeding SBrBr. The first pinnule is set on the side of the arm away from the midline of the ray. Hence, on the two



TEXT-FIG. 1.—Plate diagram of *Kophinocrinus magrumi* n. sp. The IBB in this species are nearly fused into a disklike circllet; they are shown in basal view, with the outline of the columnar facet. The shapes of BB in the BC and CD interrays and RR in the B and C rays are inferred from the shapes of similar plates in other rays and from the dimensions of adjacent plates.

arms of a ray, the pinnules are symmetrically arranged: outside on all even-numbered SBrBr and inside on all odd-numbered SBrBr except SBrBr₁. Each pinnule is articulated to a small flange or platform just past the midlength of the SBr and set so far down on the surface of the plate that the pinnule is scarcely visible in direct (dorsal) view of the arm. In text-figure 1, the pinnule-bearing sides of the SBrBr are turned slightly outward to show the nature of these lateral flanges. The side of the plate flares and then is sharply recessed to articulate with the pinnule; as a result, the outer edge of the pinnule is confluent with the outline of the lower part of the SBr.

Pinnules have the same general shape as the SBrBr except for their narrower width. They are deep and intermediate between V- and U-

shape in cross section, with a longitudinal faint crest and deep curved sides. The first pinnule is about two-thirds the length of the SBr to which it articulates. The second and third pinnules show little decrease in length, indicating that the pinnules are much longer.

Anal series.—As mentioned, X is a very large and prominent plate in the cup, projecting above the level of the RR. The presence or absence of RA is not established definitely; if present, it is a very small plate. Three plates follow X in a vertical series. Each is a stout oblong plate with curved sides and a longitudinal crest that terminates short of the top or bottom of the plate. X₂ is about 0.6 mm wide at its base and X₄ is very slightly if any narrower. X₂, X₃, and X₄ are each about 1.2 mm long. They do not articulate with any right or left

XX plates. The whole space enclosed by the arms shows scattered irregular ossicles, most of them smaller than 0.2 mm in diameter. Some of these ossicles can be seen between the PBrBr in plate 1, figure 2.

The structure of the anal sac or tube in this species is like that in *Kophinocrinus spiniferus*. The support and rigidity of the sac was derived from the stout vertical series of XX, and the rest of the integument around the sac was pliable, being reinforced only by small isolated ossicles.

Column.—The short section still attached to the cup is heteromorphic; both large and small columnals are pentastellate with rounded corners. The crenularium is distinct and more sharply pentastellate than the outline of the columnal.

Remarks.—*Kophinocrinus magrumi* agrees with *K. spiniferus* in the general shape of plates, the stout anal series, the disklike cirlet of IBB, and the pentastellate column. On the other hand, the two differ in the depth of plate ornamentation, the degree of fusion in the IBB cirlet, and the proportions of plates. In *K. magrumi* the plates of the cup are ornamented only by smooth ridges between RR and BB, smooth vertically elongate spines on BB, and smooth blunt pyramidal projections on RR, leaving the plate corners with shallow depressions; by contrast, in *K. spiniferus* the ridges are strongly arched and bear small blunt tubercles on the lower part of the RR, the spines on BB are higher and more acuminate, and the RR lack central projections, with the plate corners deeply indented by the high bordering ridges. The IBB in *K. magrumi* are irregularly lobate and lack distinct sutures, whereas those in *K. spiniferus* are regularly lobate and have definite sutures.

As shown in table 1, the proportions of plates also differ. In constructing this table, the average width of RR plates was selected as the most reliable measurement and used as a standard for comparison of all other measurements; therefore, even though the two crinoid holotypes are of different size, their relative dimensions can be compared as ratios. It is obvious that the dorsal cup of *K. magrumi* is narrower and higher than that of *K. spiniferus*; the difference in width of the cup is primarily due to the narrower X in *K. magrumi*. The BB of *K. magrumi* are also shown to be relatively much larger than those of *K. spiniferus*; its IBB cirlet is also significantly wider than that of *K. spiniferus*. Another difference which is emphasized in table 1 is the wider R facet in *K. magrumi*.

TABLE 1—RELATIVE DIMENSIONS OF *Kophinocrinus spiniferus* AND *K. magrumi*. In each species, the dimension is compared to the width of the R as a standard measurement. Actual width of R in *K. spiniferus*, 4.2 mm; actual width of R in *K. magrumi*, 1.55 mm.

Structure	<i>K. spiniferus</i> Width × Height	<i>K. magrumi</i> Width × Height
Dorsal cup	2.19 × 1.31	2.06 × 1.55
IBB cirlet	1.19 × 0.31	1.29 × 0.32
B	0.55 × 0.43	0.71 × 0.55
R	1.00 × 0.72	1.00 × 0.74
X	0.81 × 0.84	0.71 × 0.84
X ₂	0.42 × 0.72	0.39 × 0.78
X ₃	0.39 × 0.60	0.39 × 0.78
R facet width	0.55	0.65

I do not believe that these differences can be attributed to ontogeny; hence, I consider *K. magrumi* of the Silica Formation in Ohio to be a distinct species from *K. spiniferus* of the Moscow Formation (Kashong Member) in New York.

Type.—Holotype UMMP 57904, the only known specimen.

Genus DECAOCRINUS Wachsmuth & Springer

DECAOCRINUS WRIGHTAE Goldring

DECAOCRINUS WRIGHTAE SILICAENSIS n. subsp.

Pl. 1, fig. 3

The small crinoid from the Silica Formation illustrated here differs from the holotype of *Decadocrinus wrightae* Goldring in minor respects. Goldring (1954, p. 32–34; pl. 4, figs. 8,9) described *D. wrightae* in considerable detail and published photographs of the holotype in anterior and posterior views. In general, *D. wrightae* is a small crinoid with a low cup of unornamented plates, robust arms of numerous SBrBr, and an anal series of distinctly polygonal plates gradually decreasing in size distally. The arms are especially large in proportion to the cup. The holotype was found in the Arkona Shale near Arkona, Ontario.

The crinoid from the Silica Formation is smaller than the holotype of *D. wrightae*. Its cup is 4.3 mm wide and 2.3 mm high, whereas that of *D. wrightae* is 5.7 mm wide and 3.2 mm high. The chief difference is in the proportions of the arm plates: those of *D. wrightae silicaensis* are more slender and longer than those of *D. wrightae*. In the Silica specimen, the pinules attach to the SBrBr a little way below the end of the plate, and the sutures are very little affected by the alternation of the pinules; in contrast, Goldring (1954, p. 33) recorded, "The brachials also show a collarlike thickening at the distal edge with an extension

on the side where the pinnule is borne, which gives the upper edge a width greater than the height and a zig-zag effect to the brachials." In addition, the pinnules of the new subspecies are much thinner and more fragile than those in the Arkona *Decadocrinus*.

Type.—Holotype UMMP 57905, the only known specimen.

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