

TWO NEW MISSISSIPPIAN CAMERATE (BATOCRINIDAE)
CRINOID GENERAN. GARY LANE
University of California, Los AngelesUCLA Type Collection
REPRINT
Do Not Remove From This Room

ABSTRACT—The genera *Batocrinus* and *Dizygocrinus* of the monobathrid camerate crinoid family Batocrinidae are restricted respectively to species of post-Keokuk and post-Burlington Mississippian age. The new genera *Abatocrinus*, type species *Actinocrinus turbinatus* Hall, and *Azygocrinus*, type species *Actinocrinus dodecadactylus* Meek and Worthen, are proposed for older species in the family long assigned to the two former genera. Revised synonymies of species judged valid in all four genera are included, based on study of infraspecific variation in numbers of arms in these crinoids.

THE Family Batocrinidae of the monobathrid camerate crinoids includes eight genera of which the genus *Batocrinus* was the first described and includes the greatest number of species. *Batocrinus* was first described by S. A. Casseday in 1854 in a German periodical. In the original description of the genus Casseday named two new species, *Batocrinus icosidactylus* and *B. irregularis*, designating the former as type of the genus. Both of these species are from the Salem or "Spergen" limestone of Indiana. The genus did not gain immediate employment by mid-19th century paleontologists, some of whom considered it a subgenus or junior synonym of *Actinocrinites*, but gradually all, or almost all, of the species in the Batocrinidae came to be included in *Batocrinus*. Eventually several close-knit species groups were recognized with the establishment of *Eretmocrinus* Lyon & Casseday, 1859; *Macrocrinus* Wachsmuth & Springer, 1897; *Dizygocrinus* Wachsmuth & Springer, 1897; *Eutrochocrinus* Wachsmuth & Springer, 1897; *Uperocrinus* Meek & Worthen, 1865; as well as the monotypic genera *Alloprosallocrinus* Casseday & Lyon, 1862; and *Globocrinus* Weller, 1920.

Several species of *Batocrinus* other than Casseday's have been described from the Salem and other Meramecian units in the central United States. These species, together with Casseday's, are a closely related group that deserve to be set aside as a genus distinct from other, generally older, batocrinids. Not only are the Meramecian species of *Batocrinus* morphologically distinct from Osagean and Kinderhookian forms now included in the genus, but they are judged on considerable evidence to be part of a distinct phylogenetic line within the family. Consequently it is necessary to provide a new name for the older Mississippian species that have been included within *Batocrinus* up to this time, and the name *Abatocrinus* is proposed for these taxa below.

Batocrinus, as here restricted, is related to and derived from *Dizygocrinus*. The dizygocrinoid stock had its inception in the upper Burlington

limestone where three species have been recognized. These earliest species differ from later representatives in ornament, arms, and other important points, and are segregated as a new genus, *Azygocrinus*. The suggested phylogenetic relationships and ranges of genera in the family are shown in text-fig. 1. As shown in this figure the family is judged to be polyphyletic in origin, because genera included in the family evolved separately from three genera of the ancestral Coelocrinidae. Ubahgs' (1953) suggested three sections of genera within the batocrinids is an artificial scheme that does not express true ancestor-descendant relationships. If subfamilies were to be erected there is little doubt that the *Azygocrinus-Globocrinus* line should be segregated from other genera in the family.

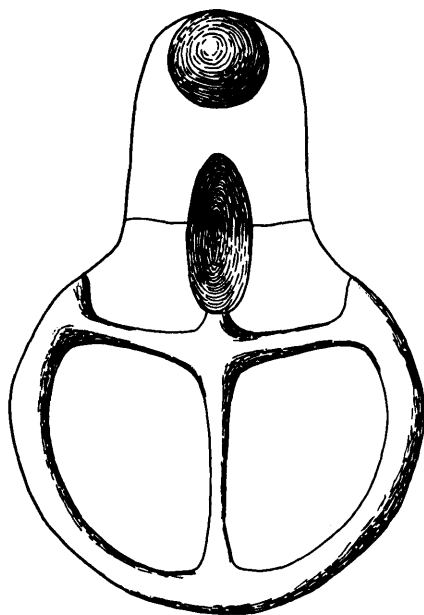
As here conceived *Batocrinus* includes seven valid species, and *Abatocrinus* fifteen, or a total of 22 species that previously have been placed in the former genus. This small number of species is in sharp contrast to the 134 species listed as *Batocrinus* by Bassler & Moody (1943). There are several reasons for the large number of species previously placed in the genus and the small number here considered valid, the foremost of which is that 104 of the 134 species listed were named during a four year period (1894-1897) by Miller & Gurley. At the time of this interval of species-making by these two authors, they did not recognize Lyon & Casseday's *Eretmocrinus*, considering it a synonym of *Batocrinus*, and the other genera in the family had not as yet been named by Wachsmuth & Springer. Consequently all of the species named by Miller & Gurley that belong in the family Batocrinidae were called *Batocrinus* and many of them now are placed in other genera in the family.

In addition, Miller & Gurley operated on the principle that all specimens of a species must have the same number of arms in each ray and the same total number of arms. This belief necessarily means that there will be exactly the same number of fixed-brachials in the dorsal cup

crinidae and in which morphological varieties have been described as several separate species. Among 46 specimens studied that represent *A. aequalis* two had 20 arms; five, 21 arms; 25, 22 arms; seven, 23 arms; five, 24 arms, and one, 25 arms. The distribution of arm openings to the calyx is such to lead one to infer that previously named species are variations within a single population, and are so considered here.

An even more extreme example of the extent to which Miller & Gurley carried their typological approach is seen in the Warsaw crinoid *Dizygocrinus mediocris* (Miller). Although *Dizygocrinus* is characterized by having some paired arms, many specimens possess both paired and single free arms; therefore, Miller & Gurley utilized the relative number and placement of paired and single arms in specimens of Warsaw dizygocrinoids to erect a number of species. For instance, their *Batocrinus sampsoni* has nine paired, and seven single arms; *Batocrinus mediocris* has 12 paired, and three single arms; and *Batocrinus boonwillensis* has 12 paired and four single arms. These three species are all alike in every respect except this character, and all three were described from material taken from the same bed at the same locality. Although there are not enough specimens to show that the variation takes the form of a bell-shaped curve, as in *Abatocrinus aequalis* above, the differing numbers of paired and single arms, common in other species of the genus, are judged to represent individual variation within a single species population. Many other examples of infraspecific variation in arms could be given, especially in such common species as *Macrocrinus verneuillianus* and *Azygocrinus rotundus*.

This report represents research undertaken as a part of graduate studies at the University of Kansas. The project was supervised by Raymond C. Moore, whose help and thoughtful criticism is gratefully acknowledged. The collections utilized include crinoids in the University of Kansas Department of Geology and Kansas Geological Survey collections, and in the University of Illinois Department of Geology and Illinois Geological Survey collections which are on loan at the University of Kansas. The latter collection includes Worthen's crinoids, many of which are James Hall's types, as well as R. R. Rowley's crinoids. In addition, an excellent plastotype collection made by Raymond C. Moore of crinoid types in the U. S. National Museum and the American Museum of Natural History was invaluable. Some type material was loaned for study by the Walker Museum, University of Chicago. The text figures were prepared by Mrs. Opal Kurtz. All morphological abbreviations are in accord with Moore, La-



TEXT-FIG. 2.—Diagrammatic sketch of the arm facet of *Batocrinus icosidactylus* Casseday showing peripheral, median, and lateral ridges. Univ. Illinois Worthen Collection, No. 8184, $\times 10$.

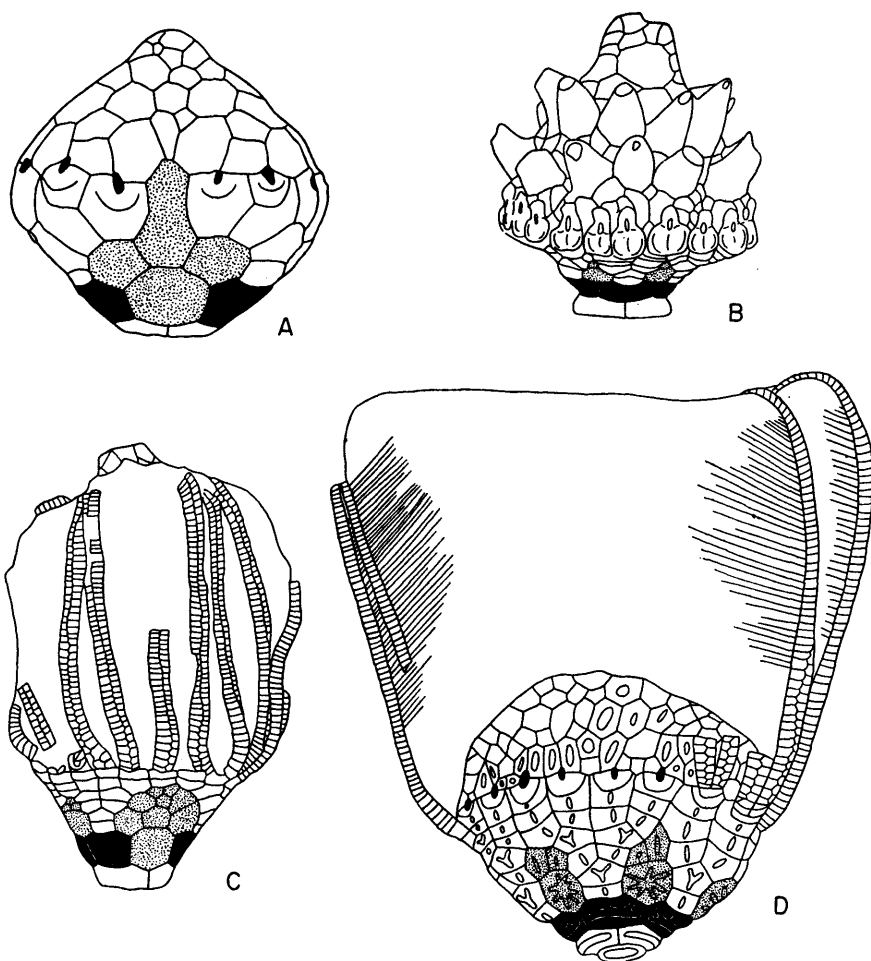
licker, and Fischer (1952, Fig. 18-2), except that *fixed brachial* (FBrr) is used instead of *cup-brachial* and *primanal* instead of *tergal*, to accord with morphologic nomenclature in the forthcoming crinoid volume of the Treatise on Invertebrate Paleontology (R. C. Moore, personal communication, 1961).

SYSTEMATIC PALEONTOLOGY

Family BATOCRINIDAE Wachsmuth & Springer, 1897

Definition.—Monocyclic; BB three, subequal; primanal in line with RR, succeeded by three anals; IBrr₁ quadrangular. Free arms 10 to 40, single or paired, unbranched, biserial upward from the base. Anal opening at the end of a long anal tube. Interrays may or may not be in contact with the tegmen. Rays typically have unequal number of arms within the same specimen. Genera: *Batocrinus* Casseday, 1854; *Eretmocrinus* Lyon & Casseday, 1859; *Alloprosallocrinus* Casseday & Lyon, 1862; *Uperocrinus* Meek & Worthen, 1865; *Dizygocrinus* Wachsmuth & Springer, 1897; *Macrocrinus* Wachsmuth & Springer, 1897; *Globocrinus* Weller, 1920; and the two new genera, *Abatocrinus* and *Azygocrinus*, proposed herein.

Remarks.—As here defined the family Batocrinidae includes only the genera cited in the first paragraph above. Laudon, Parks, & Spreng's (1952) genus *Sunwapticrinus* is excluded because



TEXT-FIG. 3—A. Posterior view of calyx of *Azygocrinus dodecadactylus* (Meek & Worthen); holotype, Univ. Illinois No. X-824, $\times 2.6$. B. Right-anterior view of calyx of *Batocrinus icosidactylus* Casseday; Univ. Illinois No. 8184, basal and radial plates reconstructed from U.C.L.A. No. 1293, $\times 1.3$. C. Postero-left view of crown of *Abatocrinus turbinatus* (Hall); holotype, Univ. Illinois No. X-839, $\times 1.3$. D. Right-anterior view of crown of *Dizygocrinus indianaensis* (Lyon & Casseday); Univ. Illinois No. E1501A, $\times 1.3$.

it has the free arms branching isotomously at least twice after leaving the calyx; this genus must be included either in a more primitive, or new, family of the superfamily Desmidocriniticae. Except for possession of an anal tube and biserial arms, *Sunwaptocrinus brazauensis*, the only species, resembled *Desmidocrinus* in having quadrangular IB_{rr1}, iRR in contact with tegmen and arms that branch high above the calyx. The former genus, however, is found only in Lower Mississippian rocks and the latter genus is restricted to the Silurian.

Genus BATOCRINUS Casseday, 1854

Batocrinus CASSEDAY, 1854, p. 237. MEEK & WORTHEN, 1873, p. 364. ZITTEL, 1879, p. 370. WACHSMUTH & SPRINGER, 1881, p. 162; 1897, p. 366. MILLER, 1892b, p. 23; 1894, p. 277. BATHER, 1900, p. 167. SPRINGER, 1913, p. 195.

Type Species.—*Batocrinus icosidactylus* Casseday, 1854. Original designation.

Diagnosis.—Dorsal cup low; tegmen conical, high, spinose or tuberculate; arms 18 to 22; arm facets with transverse, peripheral, or longitudinal ridges.

Description.—Calyx small to medium size with broad flat dorsal cup; sutures indistinct or beveled; plates smooth or ornamented with fine granules; ridges on FB_{rr} and RR are present in some species; B circlet flat, low, straight-sided, not distinctly lobed or rimmed; regular iRR one to four; Post interray consists of primanal and three to six plates, all interrays arched by fixed brachials; tegmen sides straight or convex, anal tube stout and central; arms 18 to 22, two or four in Ant ray; arm facets relatively large, directed horizontally, having distinct ridges on

articulating surfaces; ridges are peripheral, transverse, vertical, or combination of these.

Remarks.—Many species of Burlington and older crinoids have been assigned to this genus. These species are judged here not to be congeneric with *Batocrinus* and are placed in a new genus, *Abatocrinus*. The former genus differs from the latter in having a lower, wider dorsal cup; a more prominent tegmen, which is strongly spinose or nodose; a low basal cirlet; and in having large, ridged arm facets (text-fig. 2). The only important similarity between the two genera is that both have all interrays arched by FBrr. Other batocrinid genera also have this characteristic, and presence of arched interrays alone is not considered sufficient justification for including otherwise dissimilar species in the same genus. As here defined *Batocrinus* is restricted to beds of Warsaw, Salem, and Ste. Genevieve age. No batocrinoid has been reported or described from the St. Louis limestone.

Batocrinus is judged to have evolved from Keokuk species of *Dizygocrinus*. The retention of dizygocrinoid ornamentation, such as ridges on fixed brachials in *B. decoris*, finely granulose plates in *B. unionensis* and *B. calyculus*, and a further development of the nodose dizygocrinoid tegmen to a more spinose tegmen in *B. icosidactylus* and *B. irregularis* all point toward relationship with the dizygocrinoids. Both genera have a low inconspicuous B cirlet and a low, broad, gently convex, bowl-shaped dorsal cup. *Batocrinus* differs from *Dizygocrinus* in possession of ridged arm facets, higher more prominent tegmen, and in lacking double, or paired, arms. The arms have not been reported from most of the species, but it is judged that the arms are single and that ridges present on arm facets served to surround ligament areas that aided in arm movement.

Species that are included in the genus are as follows:

BATOCRINUS ICOSIDACTYLUS Casseday

Text-fig. 3B

Batocrinus icosidactylus CASSEDAY, 1854, p. 238, pl. 2, figs. 1a-c, 3. MILLER, 1892b, p. 24, pl. 4, figs. 1-5; 1894, p. 278, pl. 4, figs. 1-5. ROWLEY, 1904, p. 173, 174, pl. 51, figs. 16-21, 24-28. WACHSMUTH & SPRINGER, 1897, p. 368, pl. 27, fig. 3a-c. BEEDE, 1906, p. 1243, pl. 12, figs. 6-6b; pl. 15, figs. 16-21, 24-28.

Batocrinus pileus MILLER & GURLEY, 1895b, p. 18, pl. 2, figs. 6-8.

Type.—Casseday's original specimen cannot be located and apparently is lost.

Salem Limestone, Indiana.

BATOCRINUS CALYCVLUS (Hall)

Actinocrinus calyculus HALL, 1860, p. 55, pl. 1, fig. 1a-c.

Actinocrinus calyculus var. *hardinensis* MEEK & WORTHEN, 1866b, p. 253.

Batocrinus irregularis ROWLEY (*non* Casseday) 1904, p. 171, pl. 51, figs. 4-6. BEEDE, 1906, p. 1224, pl. 12, fig. 1; pl. 15, figs. 4-6.

Batocrinus salemensis MILLER & GURLEY, 1896a, p. 8, pl. 1, figs. 10-12. BEEDE, 1906, p. 1245, pl. 12, figs. 2-2b.

Salem limestone; Spergen Hill, Indiana and Hardin County, Illinois.

BATOCRINUS DECORIS Miller

Batocrinus decoris MILLER, 1891, p. 61, pl. 10, figs. 7, 8; 1892a, p. 671, pl. 10, figs. 7, 8.

Dizygocrinus decoris WACHSMUTH & SPRINGER, 1897, p. 420, pl. 35, fig. 6. BEEDE, 1906, p. 1253, pl. 12, figs. 5, 5a; pl. 16, fig. 4.

Salem limestone; Spergen Hill, Indiana.

BATOCRINUS EUCONUS (Meek & Worthen)

Actinocrinus (Alloprosallocrinus) euconus MEEK & WORTHEN, 1865b, p. 164.

non Dizygocrinus euconus WACHSMUTH & SPRINGER, 1897, p. 407, 430, pl. 35, fig. 7. BEEDE, 1906, p. 1252, pl. 12, fig. 3; pl. 16, fig. 2.

non Batocrinus subconicus Worthen (WACHSMUTH & SPRINGER), 1897, p. 430 (= *Dizygocrinus montgomeryensis*).

St. Louis or Salem limestone; six miles south of Anna, Illinois.

BATOCRINUS IRREGULARIS Casseday

Batocrinus irregularis CASSEDAY, 1854, p. 240, pl. 2, fig. 2a-c. MILLER, 1892b, p. 26, pl. 4, figs. 6-9; 1894, p. 280, pl. 4, figs. 6-9. WACHSMUTH & SPRINGER, 1897, p. 369, pl. 27, figs. 4a-c.

Batocrinus crassitestus ROWLEY, 1904, p. 172, pl. 51, figs. 10-12. BEEDE, 1906, p. 1249, pl. 15, figs. 10-12.

Batocrinus magnirostris ROWLEY, 1904, p. 170, pl. 51, figs. 1-3. BEEDE, 1906, p. 1244, pl. 15, figs. 1-3.

Batocrinus davisii var. *lanesvillensis* ROWLEY, 1904, p. 172, pl. 51, figs. 13-15. BEEDE, 1906, p. 1249, pl. 15, figs. 13-15.

Dizygocrinus unionensis lanesvillensis ROWLEY, BASLER & MOODEY, 1943, p. 431 (*non D. unionensis*).

Batocrinus arcuata MILLER & GURLEY, 1895a, p. 16, pl. 2, figs. 3-5.

non Batocrinus irregularis ROWLEY, 1904; BEEDE, 1906 (= *B. calyculus*).

Salem limestone; Spergen Hill, Lanesville, and other localities in southern Indiana.

BATOCRINUS SPERGENENSIS Miller

Batocrinus spergenensis MILLER, 1891, p. 60, pl. 10, figs. 5, 6; 1892a, p. 670, pl. 10, figs. 5, 6. ROWLEY, 1904, p. 188, pl. 57, figs. 3, 4 (*non Dizygocrinus whitei* WACHSMUTH & SPRINGER, 1897. BEEDE, 1906).

Batocrinus sacculus MILLER & GURLEY, 1894, p. 52, pl. 5, figs. 7-9. BEEDE, 1906, p. 1246, pl. 12, figs. 7, 7b.

Dizygocrinus sacculus WOOD, 1909, p. 72, pl. 5, figs. 1-6.

Actinocrinites fibula TROOST, 1849, *nomen nudum*.

Salem limestone; central and southern Indiana.

BATOCRINUS UNIONENSIS Worthen

Batocrinus unionensis Worthen, 1890, p. 84, pl. 13, fig. 3 (non pl. 12, figs. 5,5a = *Globocrinus unionensis* WELLER).

Dizygocrinus unionensis WACHSMUTH & SPRINGER, 1897, p. 424, pl. 35, figs. 16-20. BEEDE, 1906, p. 1253, pl. 16, figs. 1-1d.

Batocrinus davisii ROWLEY & HARE, 1891b, p. 116, pl. 3, fig. 9. ROWLEY, 1904, p. 171, pl. 51, figs. 7-9; 1906, p. 29, pl. 6, figs. 9,17,18. BEEDE, 1906, p. 1248, pl. 15, figs. 7-9.

Batocrinus davisii var. *sculptus* ROWLEY, 1904, p. 174, pl. 51, figs. 22,23. BEEDE, 1906, p. 1250, pl. 15, figs. 22,23.

Dizygocrinus persculptus ULRICH, 1917, p. 246, pl. 2, figs. 24-26. WELLER, 1920, p. 327, pl. 5, figs. 15-17.

Dizygocrinus superstes ULRICH, 1917, p. 246, pl. 2, figs. 21-23. WELLER, 1920, p. 329, pl. 5, figs. 13,14.

Ste. Genevieve limestone; Union and Hardin Counties, Illinois; Salem limestone, Indiana; "Warsaw" limestone, Missouri; Tennessee; Princeton, Kentucky; Lee County, Virginia.

Genus ABATOCCRINUS n. gen.

Type species.—*Actinocrinus turbinatus* Hall, here designated.

Diagnosis.—Dorsal cup and tegmen of medium height; dorsal cup plates convex or nodose; BB wide, relatively high, straight- or convex-sided; arm facets small, smooth; arms 18 to 26.

Description.—Dorsal cup relatively high and broad, sides straight or gently convex; plates flat, smooth, convex or strongly nodose; R and B circlets relatively prominent; BB of medium height; RR low, broad; tegmen low to medium height, sides straight, plates convex or nodose; anal tube stout and central; arms 18 to 26, single and narrow; two to four arms in Ant ray, four in LAnt and RAnt rays, and four to seven in LPost and RPost rays; arm facets small, semicircular with fine radial striations, touching at sides, forming a continuous ring around dorsal cup.

Remarks.—These species, here grouped under the new genus *Abatocrinus*, were originally included in *Batocrinus* but differ from that genus as follows: a relatively higher, narrower dorsal cup; less prominent tegmen, which is not spinose and may be smooth; a more prominent B circlet and lack of large ridged arm facets.

Abatocrinus is the oldest genus in the family, two species being known from the Hampton formation of the Kinderhook. The genus reaches its climax in the lower Burlington and continues through the upper Burlington into the Keokuk limestone, where the genus becomes extinct. The Keokuk species, *A. steropes* and *A. grandis*, are larger, more nodose, and commonly have more arms and fewer iRR than Burlington species. *Abatocrinus aequalis* is the most common species, shows considerable variation in the number of arms, and would have been chosen type for the

genus if the holotype of the species could have been located.

The two Kinderhookian species, *A. macbridei* and *A. poculum*, exhibit complete abatocrinoid development. Each species has 20 arms, all inter-rays arched by FBrr, and a prominent anal tube. In size and gross appearance the two Hampton species closely resemble several species of associated *Aorocrinus* and it seems that abatocrinoids have an ancestral form close to aorocrinoids, especially because *Aorocrinus* is known from the Devonian as well as from the Mississippian. The only important morphologic features separating *Aorocrinus* from Kinderhookian *Abatocrinus* are development of an anal tube and arching of inter-rays in the latter genus. If phylogenetic conclusions are correct the abatocrinoids evolved from *Aorocrinus*, *Eretmocrinus* from a *Dorycrinus*-like ancestor, and *Alloprosallocrinus* from *Agaricocrinus*, establishing the polyphletic nature of the family.

Species that are included in the new genus are as follows:

ABATOCCRINUS TURBINATUS (Hall)

Text-fig. 3C

Actinocrinus turbinatus HALL, 1858, p. 587, pl. 11, fig. 1.

Batocrinus turbinatus WACHSMUTH & SPRINGER, 1897, p. 375, pl. 27, fig. 5a-c.

Batocrinus laetus MILLER & GURLEY, 1893, p. 24, pl. 5, figs. 10-12.

Actinocrinus turbinatus var. *elegans* HALL, 1858, p. 587, pl. 11, fig. 5, text-fig. 87.

Batocrinus turbinatus var. *elegans* WACHSMUTH & SPRINGER, 1897, p. 376, pl. 27, fig. 6a,b.

Holotype.—Univ. Illinois collection, No. X-839.

Lower Burlington limestone; Missouri, Iowa, and Illinois.

ABATOCCRINUS AEQUALIS (Hall)

Actinocrinus aequalis HALL, 1858, p. 592, pl. 11, fig. 4a,b; text-fig. 90.

Batocrinus aequalis WACHSMUTH & SPRINGER, 1897, p. 371, pl. 28, figs. 5,6.

Actinocrinus formosus HALL, 1860, p. 30, text-fig.; 1872, pl. 3-A, fig. 1.

Actinocrinus subaequalis MCCHESENEY, 1860, p. 17; 1865, pl. 5, fig. 7a,b; 1868, p. 13, pl. 5, fig. 7a,b; p. 14, text-fig.

Batocrinus subaequalis WACHSMUTH & SPRINGER, 1897, p. 369, pl. 4, fig. 10; pl. 28, figs. 7-9.

Batocrinus aequalis MILLER & GURLEY, 1893, p. 25, pl. 5, figs. 13-15.

Lower Burlington limestone; Missouri, Iowa, and Illinois.

ABATOCCRINUS CALVINI (Rowley)

Batocrinus calvini ROWLEY, 1890, p. 146, text-fig. KEYES, 1894, p. 180, pl. 23, fig. 4. WACHSMUTH & SPRINGER, 1897, p. 373, pl. 46, fig. 8a,b.

Lower Burlington limestone; Louisiana and Hannibal, Missouri.

ABATOCRINUS CLAVIGERUS (Hall)

Actinocrinus clavigerus HALL, 1860, p. 44, text-fig. (non *Batocrinus mundulus* (Hall) WELLER, 1898; BASSLER & MOODY, 1943).

Keokuk limestone; Nauvoo, Hancock County, Illinois.

ABATOCRINUS CLYPEATUS (Hall)

Actinocrinus clypeatus HALL, 1860, p. 12, text-fig.; 1872, pl. 3, fig. 12.

Batocrinus clypeatus WACHSMUTH & SPRINGER, 1897, p. 380, pl. 27, fig. 8a-e.

Actinocrinus inornatus HALL, 1860, p. 24.

Batocrinus inornatus WHITFIELD, 1893, p. 15, pl. 2, figs. 1-3.

Actinocrinus papillatus HALL, 1860, p. 29, text-fig.; 1872, pl. 3-A, figs. 10,11.

Batocrinus quasillus MEEK & WORTHEN, 1868, p. 351; 1873, p. 367, pl. 5, fig. 2a,b. WACHSMUTH & SPRINGER, 1897, p. 372, pl. 28, fig. 4a,b.

Batocrinus comparilis MILLER & GURLEY, 1892b, p. 32, pl. 5, figs. 18,19; 1894, p. 286, pl. 5, figs. 18,19

Batocrinus aspratilis MILLER & GURLEY, 1893, p. 21, pl. 5, figs. 4-6.

Lower Burlington limestone; Missouri, Iowa, and Illinois.

ABATOCRINUS CURIOSUS (Rowley)

Batocrinus curiosus ROWLEY (non MILLER & GURLEY), 1908, p. 98, pl. 20, figs. 13,14.

Lower Burlington limestone; Louisiana, Missouri.

ABATOCRINUS GRANDIS (Lyon & Casseday)

Actinocrinus sp. nobis (*grandis*) LYON & CASSEDAY, 1859, p. 240,241.

Batocrinus grandis WACHSMUTH & SPRINGER, 1897, p. 381, pl. 1, fig. 2; pl. 27, figs. 1a,b, 2a,b; p. 567.

Actinocrinus wachsmuthi WHITE, 1880, pl. 162, pl. 40, fig. 1a,b; 1881, p. 510, pl. 7, fig. 6.

Actinocriniles urna TROOST, 1849, p. 419, *nomen nudum*.

Edwardsville formation, Montgomery County, Indiana; Clear Creek, Hardin County, Kentucky.

ABATOCRINUS LEPIDUS (Hall)

Actinocrinus lepidus HALL, 1860, p. 32, text-fig.

Batocrinus lepidus WHITFIELD, 1893, p. 16, pl. 1, figs. 16-18. WACHSMUTH & SPRINGER, 1897, p. 372, pl. 28, figs. 2,3.

Lower Burlington limestone; Iowa, Missouri, and Illinois.

ABATOCRINUS LAURA (Hall)

Actinocrinus laura HALL, 1861, p. 15.

Batocrinus laura WHITFIELD, 1893, p. 17, pl. 1, figs. 15,16. WACHSMUTH & SPRINGER, 1897, p. 384, pl. 29, fig. 5a-d.

Actinocrinus sinuosus HALL, 1860, p. 26; 1872, pl. 3A, figs. 8,9.

Batocrinus laura var. *sinuosus* WACHSMUTH & SPRINGER, 1897, p. 385.

Batocrinus scyphus MILLER & GURLEY, 1893, p. 23, pl. 5, figs. 7-9.

Batocrinus selectus MILLER & GURLEY, 1896b, p. 37, pl. 2, figs. 3-5.

Batocrinus remotus MILLER & GURLEY, 1896b, p. 43, pl. 2, figs. 15-17.

Batocrinus repositus MILLER & GURLEY, 1896b, p. 45, pl. 2, figs. 18-20.

Upper Burlington limestone; Iowa, Missouri, and Illinois.

ABATOCRINUS MACBRIDEI (Wachsmuth & Springer)

Batocrinus macbridei WACHSMUTH & SPRINGER, 1890, p. 172, pl. 15, fig. 4; pl. 17, figs. 11,12; 1897, p. 376, pl. 30, figs. 1-3. LAUDON & BEANE, 1937, p. 244, pl. 15, figs. 13,14.

Hampton formation; LeGrand, Iowa.

ABATOCRINUS PISTILLUS (Meek & Worthen)

Actinocrinus pistillus MEEK & WORTHEN, 1865, p. 152.

Actinocrinus (Batocrinus) pistillus MEEK & WORTHEN, 1868, p. 472, pl. 16, fig. 4a,b.

Batocrinus pistillus WACHSMUTH & SPRINGER, 1897, p. 378, pl. 31, fig. 4a,b.

Upper Burlington limestone; Burlington, Iowa.

ABATOCRINUS POCULUM (Miller & Gurley)

Batocrinus poculum MILLER & GURLEY, 1890, p. 352, pl. 6, figs. 6,7; 1890, p. 34, pl. 6, figs. 6,7. WACHSMUTH & SPRINGER, 1897, p. 378, pl. 30, fig. 6. LAUDON & BEANE, 1937, p. 244, pl. 15, fig. 15.

Hampton formation; LeGrand, Iowa.

ABATOCRINUS ROTADENTATUS (Rowley & Hare)

Batocrinus rotadentatus ROWLEY & HARE, 1891a, p. 102, pl. 2, figs. 17,18. WACHSMUTH & SPRINGER, 1897, p. 374, pl. 46, fig. 7.

Lower Burlington limestone; Louisiana and Hannibal, Missouri.

ABATOCRINUS STEROPES (Hall)

Actinocrinus steropes HALL, 1860, p. 43.

Batocrinus sayi WOOD, 1909, p. 65, pl. 13, figs. 7,8.

Batocrinus gibbosus WOOD, 1909, p. 64, pl. 15, fig. 9.

Actinocriniles gibbosus TROOST, 1849, p. 419, *nomen nudum*.

Keokuk limestone; Hancock County, Illinois; Fort Payne Chert, Tennessee, and Barren County, Kentucky.

ABATOCRINUS TUBERCULATUS (Wachsmuth & Springer)

Batocrinus tuberculatus WACHSMUTH & SPRINGER, 1897, p. 379, pl. 28, fig. 10a,b.

Lower Burlington limestone; Burlington, Iowa and Louisiana, Missouri.

Genus AZYGOCRINUS n. gen.

Type species.—*Actinocrinus dodecadactylus* Meek & Worthen, 1861, here designated.

Diagnosis.—Calyx low, dorsal cup bowl-shaped with flat smooth plates and indistinct sutures; B cirlet low, inconspicuous, not rimmed; anal tube narrow, excentric; arms single, 12 to 23.

Description.—Calyx subspherical, small to medium sized; dorsal cup low and broad, sides gently convex, plates smooth and flat; B cirlet rounded, not flattened or depressed at base, nor rimmed; RR relatively high; interrays, especially Post interray, may be slightly depressed below ray areas at level of arm openings; tegmen low, rounded, plates smooth, flat, or gently convex; anal tube short, located toward Post side of tegmen; arms 12 to 23, arranged with more arms in Post rays, short, single; arm facets small, depressed, flush with surface of fixed brachials, or recessed, not projecting or elevated beyond cup margins.

Remarks.—*Azygocrinus* is proposed to include Burlington limestone batocrinid species that are judged to represent the forerunners of Keokuk and Warsaw dizygocrinoids. *Azygocrinus* differs from *Dizygocrinus* in lacking paired arms, basis for the new name; having perfectly smooth calyx plates, indistinct sutures, and a low rounded B cirlet, whereas dizygocrinoids typically have paired arms, radial ridges on FBrr, granulose or nodose plates, and a rimmed B cirlet. The genus includes three species: *A. rotundus*, *A. dodecadactylus*, and *A. andrewsianus*. The first species has specialized in development of 20 or more arms, more arms than are present in Keokuk dizygocrinoids, which commonly have only 16 arm openings to the calyx. The type species of *Azygocrinus* is judged to represent the ancestral form for the azygocrinoids and to be close to a hypothetical ancestor for *Dizygocrinus*. This species is also similar to Burlington aorocrinoids and was probably derived directly from *Aorocrinus* during the late Kinderhook or in the lower Burlington.

Partly because of the large number of specimens available, *A. rotundus* was found to exhibit the most extreme variation in size and number of arm openings to the calyx known in the Batocrinidae. The number of arms in this species varies from 17 to 23, and most specimens have either 20 or 21 arms.

The genus is restricted to the upper Burlington limestone of Iowa, Illinois, and Missouri.

AZYGOCRINUS DODECADACTYLUS (Meek & Worthen)
Text-fig. 3A

Actinocrinus dodecadactylus MEEK & WORTHEN, 1861, p. 131.

Actinocrinus (Batocrinus) dodecadactylus MEEK & WORDEN, 1866a, p. 205, pl. 15, fig. 3a-c.
Dizygocrinus dodecadactylus WACHSMUTH & SPRINGER, 1897, pl. 432, pl. 29, fig. 1a-c.

Type.—Univ, Illinois No. X-824.

Upper Burlington limestone; Iowa, western Illinois.

AZYGOCRINUS ANDREWSIANUS (McChesney)

Actinocrinus andrewsianus MCCHESENEY, 1860, p. 27; 1865, p. 20, pl. 5, fig. 5a,b; pl. 10, fig. 2; 1868, p. 20, pl. 5, fig. 5.

Dizygocrinus andrewsianus WACHSMUTH & SPRINGER, 1897, p. 433, pl. 29, fig. 2a-d.

Upper Burlington limestone; Burlington, Iowa.

AZYGOCRINUS ROTUNDUS (Shumard)

Actinocrinus rotundus SHUMARD, 1855, p. 191, pl. A, fig. 2a,b. HALL, 1860, pl. 3, fig. 1.

Batocrinus rotundus KEYES, 1894, p. 182, pl. 23, fig. 6a-b.

Dizygocrinus rotundus WACHSMUTH & SPRINGER, 1897, p. 431, pl. 29, figs. 3a-g,4.

Actinocrinus oblatum HALL, 1860, p. 38.

Batocrinus oblatum WHITFIELD, 1893, p. 12, pl. 1, figs. 21,22.

Batocrinus enodis MILLER & GURLEY, 1896b, p. 25, pl. 1, figs. 16-18.

Batocrinus complanatus MILLER & GURLEY, 1896b, p. 27, pl. 1, figs. 19,20.

Batocrinus levigatus MILLER & GURLEY, 1896b, p. 29, pl. 1, figs. 21,22.

Batocrinus glaber MILLER & GURLEY, 1896b, p. 32, pl. 1, figs. 26-28.

Batocrinus subrotundus MILLER & GURLEY, 1896b, p. 48, pl. 2, figs. 27-29.

Batocrinus subovatus MILLER & GURLEY, 1896b, p. 50, pl. 2, figs. 30,31.

Upper Burlington limestone; Missouri, Iowa, and Illinois.

Genus DIZYGOCRINUS Wachsmuth & Springer, 1897

Dizygocrinus WACHSMUTH & SPRINGER, 1897, p. 413, BATHER, 1900, p. 168. SPRINGER, 1913, p. 196. UBAGHS, 1953, p. 740.

Type Species.—*Actinocrinus indianaensis* Lyon & Casseday, 1860. Original designation, Wachsmuth & Springer, 1897.

Diagnosis.—Dorsal cup small, bowl-shaped; anal tube small; arms commonly 16, all or partly paired.

Description.—Calyx small to medium sized; dorsal cup low, broad, sides convex, fixed brachials commonly have ridges from IBrr to arm openings, plates granulose or bearing transverse nodes; B cirlet low, broad, extended into proximal rim; regular iRR two to five; Post interray consists of primanal and five to 12 annals, commonly in contact with tegmen; tegmen low, sides convex; anal tube short, slender, and subcentral; arms 14 to 20, commonly 16, paired with two arms from each Amb opening to the calyx in all

or part of each ray, slightly spatulate at distal tips; arm facets small, semicircular, elevated above margins of dorsal cup.

Remarks.—Burlington species formerly referred to *Dizygocrinus* are here grouped together as a new genus, *Azygocrinus*. These older Burlington forms differ from true dizygocrinoids in having indistinct sutures between plates of the dorsal cup, no cup plate ornamentation such as nodes, ridges, or granules, no rim on the B cirlet, and especially in lacking paired arms. As here defined the genus *Dizygocrinus* is restricted to beds of Warsaw and Keokuk age, and is one of the most common elements in the crinoid fauna of these rocks. Most species have 16 arms, although three species have 18 arms, two have 14 arms, and one has 20 arms. The most remarkable and characteristic feature of the genus is the presence of paired arms issuing from single Amb openings to the calyx. In contrast to *Eutrochocrinus*, which also has paired arms, many dizygocrinoids do not have all the arms of specimens paired, but both single and paired arms commonly occur on the same specimen. Like other Keokuk batocrinids, this genus is commonly ornamented with granules, nodes, or raised radial ridges. There is no evidence that the paired arms are incorporated into the dorsal cup, resulting in an increased number of single arms, as in *Eutrochocrinus*. Those species judged to occur in the supposed Warsaw formation or equivalent beds, do not show any consistent differences from species reported from the Keokuk.

Dizygocrinus is like *Eretmocrinus* in commonly having 16 arms openings to the calyx, arranged 2-4-3-Post-3-4. Both single and double arms are present on many specimens and no consistent placement of paired arms with respect to individual rays, or to position within rays, can be detected.

Distal portions of dizygocrinoid arms are commonly slightly flattened and wider than proximal free brachials. The expanded arm tips resemble spatulate arms of *Eretmocrinus*, and probably are analogous in keeping fecal debris from fouling the tegmen, but are judged to have an independent origin.

The genus is restricted to beds of the Keokuk and Warsaw limestones, and equivalent beds in Indiana, Illinois, Missouri, Kentucky, and Tennessee.

DIZYGOCRINUS INDIANAENSIS (Lyon & Casseday)
text-fig. 3D

- Actinocrinus indianaensis* LYON & CASSEDAY, 1860, p. 75.
Dizygocrinus indianensis (misspelling) WACHSMUTH & SPRINGER, 1897, p. 415, pl. 33, fig. 6a,b; pl. 35, fig. 5.
Dizygocrinus indianensis var. *simplex* WACHSMUTH & SPRINGER, 1897, p. 416, pl. 33, fig. 7.

Type.—U. S. National Museum No. S-841. Edwardsville formation, Montgomery County, Indiana.

DIZYGOCRINUS BITURBINATUS (Hall)

- Actinocrinus biturbinatus* HALL, 1858, p. 616, pl. 16, fig. 6a-c. (non fig. 5 = *Eretmocrinus mutabilis*).
Dizygocrinus biturbinatus WACHSMUTH & SPRINGER, 1897, p. 427, pl. 33, fig. 9.
Batocrinus abscessus ROWLEY & HARE, 1891b, p. 115, pl. 3, fig. 6. (non *D. euconus* WACHSMUTH & SPRINGER, 1897).
Batocrinus gurleyi ROWLEY & HARE (non Miller), 1891b, p. 115, pl. 3, fig. 7 (non *D. montgomeryensis* WACHSMUTH & SPRINGER, 1897).
Batocrinus sweeti ROWLEY & HARE, 1891b, p. 116, pl. 3, fig. 8. (non *D. montgomeryensis* WACHSMUTH & SPRINGER, 1897).
Batocrinus lyonanus MILLER & GURLEY, 1893, p. 18, pl. 3, figs. 4,5.
Batocrinus burketi MILLER & GURLEY, 1895a, p. 19, pl. 2, fig. 9.
Dizygocrinus montgomeryensis unibrachiatus WACHSMUTH & SPRINGER, 1897, p. 429, pl. 33, fig. 5a,c.
Dizygocrinus whitei var. *didactylus* WACHSMUTH & SPRINGER, 1897, p. 420, pl. 35, figs. 12,13.

Keokuk limestone; Nauvoo and Hamilton, Illinois; Keokuk, Iowa; Pike County, Missouri; Hardin County, Kentucky.

DIZYGOCRINUS CANTONENSIS Wachsmuth & Springer

- Dizygocrinus cantonensis* WACHSMUTH & SPRINGER, 1897, p. 423, pl. 33, fig. 8a,b.

Harrodsburg limestone; Canton, Indiana.

DIZYGOCRINUS CAROLI (Hall)

- Actinocrinus caroli* HALL, 1860, p. 54, pl. 1, fig. 11. non *Dizygocrinus unionensis* (Worthen) WACHSMUTH & SPRINGER, 1897, p. 424.
Batocrinus veterator MILLER & GURLEY, 1895b, p. 8, pl. 1, fig. 4.
Batocrinus venustus MILLER & GURLEY, 1895b, p. 12, pl. 1, fig. 7.

Warsaw limestone; Hancock County and Warsaw, Illinois; Boonville, Missouri.

DIZYGOCRINUS CRAWFORDSVILLENSIS (Miller)

- Batocrinus crawfordsvillensis* MILLER, 1891, p. 64, pl. 10, figs. 11,12; 1892a, p. 674, pl. 10, fig. 11,12.
Dizygocrinus crawfordsvillensis WACHSMUTH & SPRINGER, 1897, p. 417.
Batocrinus decrepitus MILLER, 1892b, p. 34, pl. 5, fig. 24; 1894, p. 288, pl. 5, fig. 24.

Edwardsville formation; Montgomery County Indiana.

DIZYGOCRINUS INTERMEDIUS (Wachsmuth & Springer)

- Eretmocrinus intermedius* WACHSMUTH & SPRINGER, 1881, p. 174; 1897, p. 404, pl. 33, fig. 2a-c.
Eretmocrinus varsoviensis WORTHEN, 1882, p. 30; 1883, p. 306, pl. 28, fig. 14 (non *Dizygocrinus originarius* WACHSMUTH & SPRINGER, 1897).
Batocrinus nitidulus MILLER & GURLEY, 1895b, p. 17, pl. 1, figs. 12,13.

Harrodsburg limestone; Bono and Canton, Indiana; Warsaw limestone; Boonville, Missouri and Warsaw, Illinois.

DIZYGOCRINUS MEDIOCRIS (Miller)

- Batocrinus mediocris* MILLER, 1891, p. 62, pl. 10, fig. 9; 1892a, p. 672, pl. 10, fig. 9.
Batocrinus boonvillensis MILLER, 1891, p. 65, pl. 10, fig. 13; 1892a, p. 675, pl. 10, fig. 13.
Batocrinus modestus MILLER & GURLEY, 1895b, p. 30, pl. 1, figs. 34-36.
Batocrinus ignotus MILLER & GURLEY, 1895b, p. 28, pl. 1, figs. 31-33.
Batocrinus sampsoni MILLER & GURLEY, 1895b, p. 7, pl. 1, figs. 2,3.
Batocrinus broadheadi MILLER & GURLEY, 1895b, p. 15, pl. 1, figs. 10,11.

?Warsaw limestone; Boonville, Missouri.

DIZYGOCRINUS MONTGOMERYENSIS (Worthen)

- Batocrinus montgomeryensis* WORTHEN, 1884, p. 25; 1890, p. 83, pl. 12, figs. 2,2a.
Dizygocrinus montgomeryensis WACHSMUTH & SPRINGER, 1897, p. 428, pl. 33, figs. 3,4; pl. 46, fig. 10.
Batocrinus subconicus WORTHEN, 1884, p. 26; 1890, p. 84, pl. 13, figs. 4, 4a.
non Batocrinus gurveyi Rowley & Hare, WACHSMUTH & SPRINGER, 1897.
non Batocrinus sweeti Rowley & Hare, WACHSMUTH & SPRINGER, 1897.
non Dizygocrinus montgomerensis var. *unibrachiatus* WACHSMUTH & SPRINGER, 1897 (= *D. biturbinatus*).

Edwardsville formation; Montgomery County, Indiana.

DIZYGOCRINUS MUTABILIS Wachsmuth & Springer

- Dizygocrinus mutabilis* WACHSMUTH & SPRINGER, 1897, p. 429, pl. 35, figs. 8-11.

Edwardsville formation; Montgomery County, Indiana.

DIZYGOCRINUS ORIGINARIUS (Wachsmuth & Springer)

- Eretmocrinus originarius* WACHSMUTH & SPRINGER, 1881, p. 174.
Dizygocrinus originarius WACHSMUTH & SPRINGER, 1897, p. 421, pl. 33, fig. 1a,b.
Eretmocrinus adultus WACHSMUTH & SPRINGER, 1881, p. 175.
Dizygocrinus originarius var. *adultus* WACHSMUTH & SPRINGER, 1897, p. 422, pl. 35, figs. 14,15.
non Eretmocrinus varsoviensis WORTHEN, 1883 (= *D. intermedius*).
non Batocrinus mediocris MILLER, 1891.
non Batocrinus boonvillensis MILLER, 1891.

Harrodsburg limestone; Bono and Canton, Indiana; ?Warsaw limestone; Boonville, Missouri.

DIZYGOCRINUS VENUSTUS (Miller)

- Batocrinus venustus* MILLER, 1891, p. 67, pl. 11, figs. 11,12; 1892a, p. 676, pl. 11, figs. 11,12 (*non D. euconus abscissus* WACHSMUTH & SPRINGER, 1897).

- Batocrinus polydactylus* MILLER & GURLEY, 1895b, p. 5, pl. 1, fig. 1.
Batocrinus inconsuetus MILLER & GURLEY, 1895b, p. 25, pl. 1, figs. 25-27.
Batocrinus serratus MILLER & GURLEY, 1895b, p. 27, pl. 1, figs. 28-30.
Batocrinus heteroclitus MILLER & GURLEY, 1895b, p. 31, pl. 1, figs. 37-39.
Batocrinus inopinatus MILLER & GURLEY, 1895b, p. 36, pl. 2, figs. 4-6.
Batocrinus stelliformis MILLER & GURLEY, 1896a, p. 9, pl. 1, figs. 13-15. ?Warsaw limestone, Boonville, Missouri

DIZYGOCRINUS WHITEI (Wachsmuth & Springer)

- Batocrinus whitei* WACHSMUTH & SPRINGER, 1881, p. 169.
Dizygocrinus whitei WACHSMUTH & SPRINGER, 1897, p. 419, pl. 33, figs. 10a,b,11. BEEDE, 1906, p. 1251, pl. 12, figs. 4,4a.
non Batocrinus spergenensis MILLER 1891, 1892.
non Dizygocrinus whitei didactylus WACHSMUTH & SPRINGER, 1897, (= *D. biturbinatus*).
Batocrinus facetus MILLER & GURLEY, 1890, p. 35, pl. 6, fig. 8; 1890, p. 353, pl. 6, fig. 8.
Dizygocrinus facetus WACHSMUTH & SPRINGER, 1897, p. 418, pl. 33, fig. 12.
Batocrinus gorbyi MILLER, 1891, p. 63, pl. 10; fig. 10; 1892a, p. 673, pl. 10, fig. 10.
?Dizygocrinus gorbyi WACHSMUTH & SPRINGER, 1897, p. 426.
Batocrinus pulchellus MILLER, 1891, p. 68, pl. 11, figs. 13,14; 1892a, p. 678, pl. 11, figs. 13,14.
 Harrodsburg limestone; Bono and Canton, Indiana; ?Warsaw limestone; Boonville, Missouri.

REFERENCES

- BASSLER, R. S., & MOODEY, M. W., 1943, Bibliographic and faunal index of Paleozoic pelmatozoan echinoderms: Geol. Soc. America, Spec. Paper 45, p. 1-733.
 BATHER, F. A., 1900, The Crinoidea, in LANKESTER, E. R., A treatise on Zoology, London, pt. 3, p. 38-204, text-figs. 1-127.
 BEEDE, J. W., 1906, Fauna of the Salem limestone: 30th Rept. Indiana Dept. Geol., p. 1243-1272.
 CASSEDAY, S., 1854, Beschreibung eines neues Crinoidengeschlechts aus dem Kohlenkalkstein Nordamerikas: Deutsch. geol. Gesell. Zeitschr., v. 6, p. 237-242, pls. 1-2.
 —, & LYON, S., 1862, Description of two new genera and eight new species of fossil Crinoidea from the rocks of Indiana and Kentucky: Am. Acad. Arts and Sci., Proc., v. 5, p. 16-31.
 HALL, JAMES, 1858, Contributions to the paleontology of Iowa: Geol. Rept. Iowa, v. 1, pt. 2, p. 473-724, pls. 1-29.
 —, 1860, Contributions to the paleontology of Iowa; being descriptions of new species of Crinoidea and other fossils: Suppl. to v. 1, pt. 2, Geol. Rept. Iowa, p. 1-94, pls. 1-3.
 —, 1861, Descriptions of new species of Crinoidea from the investigations of the Iowa Geol. Survey, Preliminary Notice: Albany, N. Y., p. 1-18 (Feb. 26, 1861).
 KEYES, C. R., 1894, Paleontology of Missouri, pt. 1: Missouri Geol. Survey, v. 4, p. 1-271, pls. 1-32.
 KLEM, M., 1900, The development of *Agaricocrinus*: St. Louis Acad. Sci., Trans., v. 10, p. 167-184, pls. 18-21, text-fig.

- LAUDON, L. R., & BEANE, B. H., 1937, The crinoid fauna of the Hampton formation at LeGrand, Iowa: Iowa Univ. Studies, Studies Nat. Hist., new ser., no. 345, p. 227-273, pls. 1-19, figs. 1-7.
- , PARKS, J. M., & SPRENG, A. C., 1952, Mississippian crinoid faunas from the Banff formation, Sunwapti Pass, Alberta: Jour. Paleontology, v. 26, p. 544-575, pls. 65-69.
- LYON, S. S., & CASSEDA, S. A., 1859, Description of nine new species of Crinoidea from the Subcarboniferous rocks of Indiana and Kentucky: Am. Jour. Sci. Arts, ser. 2, v. 28, p. 233-246.
- & —, 1860, Description of nine new species of Crinoidea from the Subcarboniferous rocks of Indiana and Kentucky: Am. Jour. Sci. Arts, ser. 2, v. 29, p. 68-79.
- MCCHESENEY, J. H., 1860, Descriptions of new species of fossils from the Palaeozoic rocks of the western states: private publ., Albany, N. Y., p. 1-76.
- MCCHESENEY, J. H., 1865, Plates illustrating in part the new species of fossils from the Palaeozoic rocks of the western states, and two new species noticed March, 1860: private publ., Albany, N. Y., title page and pls. 1-11, with explanations.
- , 1868, Descriptions of fossils from the Palaeozoic rocks of the western states, with illustrations: Chicago Acad. Sci., Trans., v. 1, p. 1-57, pls. 1-9.
- MEEK, F. B., & WORTHEN, A. H., 1861, Description of new Palaeozoic fossils from Illinois and Iowa: Philadelphia Acad. Nat. Sci., Proc. 1861, p. 128-148.
- , & —, 1865a, Description of new species of Crinoidea, etc., from the Palaeozoic rocks of Illinois and some of the adjoining states: Philadelphia Acad. Nat. Sci., Proc. 1865, p. 143-155.
- , & —, 1865b, Descriptions of new Crinoidea, etc., from the Carboniferous rocks of Illinois and some of the adjoining states: Philadelphia Acad. Nat. Sci., Proc. 1865, p. 155-166.
- , & —, 1866a, Descriptions of invertebrates from the Carboniferous system: Illinois Geol. Survey, v. 2, p. 143-411, pls. 14-32.
- , & —, 1866b, Contributions to the paleontology of Illinois and other western states: Philadelphia Acad. Nat. Sci., Proc. 1866, p. 251-275.
- , & —, 1868, Paleontology of Illinois: Illinois Geol. Survey, v. 3, p. 289-565, pls. 1-20.
- , & —, 1873, Invertebrates from the Carboniferous system: Illinois Geol. Survey, v. 5, pt. 2, p. 320-619, pls. 1-32.
- MILLER, S. A., 1891, Paleontology: Adv. Sheets, 17th Rept. Geol. Survey Indiana, p. 1-103, pls. 1-20.
- , 1892a, Paleontology: 17th Rept. Geol. Survey Indiana, p. 611-705, pls. 1-20.
- , 1892b, Paleontology: Adv. Sheets, 18th Rept. Geol. Survey Indiana, p. 1-79, pls. 1-12.
- , 1894, Paleontology: 18th Rept. Geol. Survey Indiana, p. 257-333, pls. 1-12.
- , & GURLEY, W. F. E., 1890, Description of some new genera and species of Echinodermata from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri, and Iowa: Cincinnati Soc. Nat. Hist. Jour., v. 13, p. 3-25; pls. 1-4 (April). Republished privately, Danville, Illinois, with additional descriptions and plates, p. 3-59, pls. 1-10 (June 1890). Republished, Indiana Dept. Geol. Nat. History, Ann. Rept. 16 (1888), p. 327-373, pls. 1-10 (1890).
- , & —, 1893, Description of some new species of invertebrates from the Palaeozoic rocks of Illinois and adjacent states: Illinois State Mus. Nat. Hist., Bull. 3, p. 1-81, pls. 1-8.
- , & —, 1894, New genera and species of Echinodermata: Illinois State Mus. Nat. Hist., Bull. 5, p. 1-53, pls. 1-5.
- , & —, 1895a, Descriptions of new species of Palaeozoic Echinodermata: Illinois State Mus. Nat. Hist., Bull. 6, p. 1-62, pls. 1-5.
- , & —, 1895b, New and interesting species of Palaeozoic fossils: Illinois State Mus. Nat. Hist., Bull. 7, p. 1-89, pls. 1-5.
- , & —, 1896a, New species of crinoids from Illinois and other states: Illinois State Mus. Nat. Hist., Bull. 9, p. 1-66, pls. 1-5.
- , & —, 1896b, New species of Echinodermata and a new crustacean from the Palaeozoic rocks: Illinois State Mus. Nat. Hist., Bull. 10, p. 1-91, pls. 1-5.
- MOORE, R. C., LALICKER, C. G., & FISCHER, A. G., 1952, Invertebrate Fossils: xiii+766 p., McGraw-Hill Book Co., Inc., N. Y.
- ROWLEY, R. R., 1890, *Batocrinus calvini*. Description of a new species of Burlington crinoid: Am. Geologist, v. 5, p. 146-147.
- , 1904, Descriptions of fossils, in GREENE, G. K., Contributions to Indiana paleontology: New Albany, Indiana, v. 1, pts. 1-20, 204 p.; v. 2, pts. 1-3, 38 p. (1906).
- , 1908, The geology of Pike County, Missouri: Missouri Bur. Geol. and Mines: ser. 2, v. 8, 122 p., map.
- , & HARE, S. J., 1891a, Descriptions of some new species of Echinodermata from the Subcarboniferous rocks of Pike County, Missouri: The Kansas City Scientist, v. 5, p. 97-103, pl. 2.
- , & —, 1891b, Description of some new species of crinoids and blastoids from the Subcarboniferous rocks of Pike and Marion counties, Missouri, and Scott county, Virginia: The Kansas City Scientist, v. 5, p. 113-118, pl. 3.
- SHUMARD, B. F., 1855, Description of new species of organic remains: Missouri Geol. Survey, 1st and 2nd Ann. Rept., pt. 2, p. 185-208, pls. A-C.
- SPRINGER, F., 1913, Crinoidea, in ZITTEL-EASTMAN, Textbook of palaeontology, 2d ed., MacMillan, London, N. Y., v. 1, p. 173-243, figs. 267-346.
- , 1921, The fossil crinoid genus *Dolatocrinus* and its allies: U. S. Natl. Mus., Bull. 115, p. 1-78, pls. 1-16.
- TROOST, G., 1849, A list of the fossil crinoids of Tennessee: Am. Jour. Sci. and Arts, ser. 2, v. 8, p. 419. Republished with additions, Am. Assoc. Adv. Sci., Proc., v. 2, p. 59-64 (1850).
- UBAGHS, G., 1953, Classe des Crinoïdes, in PIVETEAU, J., Traite de Paleontologie, v. 3, p. 658-773.
- ULRICH, E. O., 1917, Mississippian formations of western Kentucky: Kentucky Geol. Survey, p. 1-272.
- WACHSMUTH, C., & SPRINGER, F., 1881, Revision of the Palaeocrinoidea, pt. 2: Philadelphia Acad. Nat. Sci., Proc. 1881, p. 177-411, pls. 17-19 (separate repaged, p. 1-237, pls. 17-19).
- , & —, 1890, New species of crinoids and blastoids from the Kinderhook group of the Lower Carboniferous rocks at LeGrand, Iowa, and a new genus from the Niagara group of western Tennessee: Illinois Geol. Survey, v. 8, p. 155-208, pls. 15-17.
- , & —, 1897, North American Crinoidea Camerata: Harvard College Mus. Comp. Zool., Mem., v. 21, 22, p. 1-897, pls. 1-83, figs. 1-21.
- WELLER, S., 1898, A bibliographic index of North American Carboniferous invertebrates: U. S. Geol. Survey, Bull. 153, p. 1-653.
- , 1920, Paleontology (of Hardin County, Illinois): Illinois Geol. Survey, Bull. 41, p. 313-377, pls. 4-11.

- WHITE, C. A., 1880, Fossils of the Indiana rocks: 2nd Ann. Rept. Geol. Survey Indiana, p. 471-522.
- , 1881, Contributions to invertebrate paleontology, no. 8; Fossils from the Carboniferous rocks of the Interior States: U. S. Geol. Survey Terr. (Hayden), Ann. Rept. 12, pt. 1, p. 155-171.
- WHITFIELD, R. P., 1893, Republication of descriptions of Lower Carboniferous Crinoidea from the Hall Collection now in the American Museum of Natural History, with illustrations of the original type specimens not hitherto figured: Am. Mus. Nat. Hist., Mem., v. 1, pt. 1, p. 1-37, pls. 1-3.
- WOOD, E., 1909, A critical summary of Troost's unpublished manuscript on the crinoids of Tennessee: U. S. Natl. Mus., Bull. 64, 150 p.
- WORTHEN, A. H., 1882, Descriptions of fifty-four new species from the Lower Carboniferous limestone and Coal Measures of Illinois and Iowa: Illinois State Mus. Nat. Hist., Bull. 1, p. 3-38.
- , 1883, Description of fossil invertebrates: Illinois Geol. Survey, v. 7, p. 269-322, pls. 27-30.
- , 1884, Descriptions of two new species of Crustacea, 51 species of Mollusca, and three species of crinoids from the Carboniferous formation of Illinois and adjacent states: Illinois State Mus. Nat. Hist., Bull. 2, p. 1-27.
- , 1890, Description of fossil invertebrates: Illinois Geol. Survey, v. 8, p. 69-154, pls. 9-14, 18-28.
- ZITTEL, K. A. VON, 1879, Handbuch der Palaeontologie, Bd. 1, Paläozoologie, Abt. 1 (Munich).

MANUSCRIPT RECEIVED MARCH 27, 1962