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LOWER PENNSYLVANIAN (MORROWAN) CRINOIDS FROM ARKANSAS, OKLAHOMA, AND TEXAS

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RAYMOND C. MOORE and HARRELL L. STRIMPLE

ABSTRACT

The Lower Pennsylvanian (Morrowan) crinoid fauna is large and notably varied in composition. In the mid-continent region of the United States it is surprisingly short-ranged stratigraphically, being confined in northwestern Arkansas and northeastern Oklahoma to a few feet of beds in the Brentwood Limestone Member of the Bloyd Formation or their equivalent and in east-central and southern Oklahoma to the lower part or lower middle part of the Wapanucka Formation, predominantly limestone associated with some shale.

The Morrowan crinoids are mostly inadunates, but a few flexible and camerate forms occur with them. This report describes and illustrates only part of the assemblage. As presently known, the Morrowan crinoid fauna contains 45 genera (3 new) distributed among 30 families (4 new); recognized species total 75 (38 new).

Several superfamilies are recognized in our classification of Morrowan crinoids. These are defined primarily by 1) dorsal cup shape—longitudinally straight-sided steep to moderately sloped cones, bowl-shaped (crateriform) with convex to flat or concave base, and shallow saucer-shaped (patelliform) with flat or concave base—and 2) width of radial articular facets—narrow (angustary), width distinctly but only slightly less than greatest radial width (peneplenary), and fully equal to summit radial width (plenary). Supplemental only are 3) cup anal plates (4 to 1, or none visible externally), 4) nature of anal sac, 5) arm structure (few or many-branched, with isotomous or heterotomous bifurcations, and recti-uniserial, obliqui-uniserial, or biserial arrangement of brachials), and 6) transverse shape of stem and presence or absence of cirri.

Finally, we may note that the Morrowan crinoids are linked to succeeding Pennsylvanian and Permian faunas more closely than to Mississippian assemblages of these echinoderms.

INTRODUCTION

The present study was initiated about 25 years ago and some of the illustrations were prepared soon thereafter under direction of the senior author. Meanwhile much additional material has been acquired so that now approximately 1,150 specimens are at hand, not including disarticulated ossicles. The vast majority of the crinoids come from Washington and Crawford Counties in northwestern Arkansas and from Cherokee, Mayes, Muskogee, Sequoyah, Wagoner, Pontotoc, Johnston, and Coal Counties in northeastern, east-central, and southeastern Oklahoma. A smaller number of forms represents deposits of Morrowan age in north-central Texas. Three new genera and 38 new species are recognized. The type specimens are reposited either in the Geology Department Repository, The University of Iowa, Iowa City, Iowa, or in the Paleontological Collections, University of Oklahoma, Norman, Oklahoma.

Strimple & Nassichuk (1965) correlated upper beds of the Wapanucka Formation of southeastern Oklahoma with the Brentwood Limestone of northwestern Arkansas and northeastern Oklahoma and with the Gene Autry Formation on the south flanks of the Arbuckle Mountains in Johnston and Carter Counties, southern Oklahoma. This correlation was based largely on the common presence of the ammonoid *Axinolobus quinni* McCaleb & Furnish (1964), which is thought to have a restricted stratigraphic range. Unfortunately, no crinoids have been found in the upper Wapanucka in the southern region and conversely only sparse crinoid remains are found in Morrowan rocks below the Brentwood interval in the northern region. In spite of probable slight difference in age between Morrowan faunas of the two areas, one might reasonably expect to find *Arkacrinus*, the most prolific and widespread crinoid in the northern area, in the southern area, particularly since most other crinoid genera are present in both areas. Apparently access between the two regions was not completely open, thus accounting for the diversity of species.

The ammonoid species *Branneroceras branneri* Smith (1896), typically occurs in the Brentwood Limestone Member of the Bloyd Formation (personal communication from W. M. Furnish to Strimple). One of us (Strimple) has found *B. branneri* in rocks containing articulated crinoid cups at the following Oklahoma localities given herein: Greenleaf Lake spillway (Loc. 8a and 8c), Union Mission (Loc. 9), Lake of the Cherokees (Loc. 16), Gore (Loc. 40), and Tenkiller Lake (Loc. 25). In Arkansas, *B. branneri* has been found in association with a large crinoid fauna at Frog Bayou (Loc. 21).

Rock samples in association with crinoid faunas collected by R. H. Lane at Lake of the Cherokees (Loc. 16) and at Union Mission (Loc. 9) contain a Brentwood conodont fauna (personal communication from R. H. Lane to Strimple).

All of the material from Oklahoma, with the possible exception of that collected by Sutherland and Henry (Loc. 36 and 37) are from what we consider to be the Bloyd Formation and mostly from the Brentwood interval.

The exposures collected by Sutherland and Henry have not been examined by us and Sutherland (personal communication to Strimple) does not recognize either the Hale or Bloyd Formation in Oklahoma. G. G. Huffman (1958), in a comprehensive study *Geology of the flanks of the Ozark uplift*, traced and recognized both the Hale and Bloyd Formation in northeastern Oklahoma.

Most of the crinoids observed in Morrowan deposits are similar to species found in younger Pennsylvanian rocks or related to them. Exceptions are *Strongylocrinus hansoni*, *S. ornatus*, *Calycocrinus symmetricus*, and *C. furnishi*. *Strongylocrinus* and *Calycocrinus* have previously been reported only from Permian strata of the East Indies. Some species, notably *Arkacrinus dubius* and *Affinocrinus progressus*, are so highly specialized that further evolution can scarcely be anticipated.

PREVIOUS STUDIES OF MORROWAN CRINOIDS

The first-published study of Morrowan faunas was by Kirtley F. Mather (1915) who included in it four species of crinoids: *Cromyocrinus grandis* Mather, *Delocrinus pentanodus* Mather (=*Utharocrinus pentanodus*), *Delocrinus dubius* Mather (=*Arkacrinus dubius*) and *Stereobrachicrinus pustulosus* Mather. The last-mentioned form is based on a very curious type of arm composed of semifused brachials not yet found attached to a dorsal cup, belonging to *Allocatillocrinus*. If this is verified, *Allocatillocrinus* will be a junior synonym of *Stereobrachiocrinus*.

G. D. Morgan (1924) in a study *Geology of the Stonewall quadrangle, Oklahoma*, figured four crinoid specimens from the Wapanucka Formation of the Ardmore region as follows: *Agassizocrinus conicus* (=*Paragassizocrinus turris* Strimple), *Ceriocrinus* sp. (=*Cibolocrinus bellus* Moore & Strimple, n. sp.), *Eupachycrinus* cf. *magister* (=*Ethelocrinus oklahomensis* Moore & Plummer, =*Paracromyocrinus oklahomensis*), and *Stereobrachicrinus pustulosus* Mather (arm).

Frank Springer (1926) added two species to the list of described crinoids, *Zeacrinus girtyi* Springer (=*Alcimocrinus girtyi*), and *Ulrichicrinus oklahomae* Springer.

R. C. Moore & F. B. Plummer (1938) made the first comprehensive study of Morrowan crinoids from northeastern Oklahoma and northwestern Arkansas. Species described were as follows:

Morrowan Crinoids Described by Moore & Plummer (1938)

Acrocrinus pirum Moore & Plummer (=*Globacrocrinus pirum*)
Acrocrinus brentwoodensis Moore & Plummer (=*Platyacrocrinus brentwoodensis*)
Cibolocrinus tumidus Moore & Plummer
Cibolocrinus regularis Moore & Plummer
Hydriocrinus? rosei Moore & Plummer (=*Phacelocrinus rosei*)
Morrowcrinus fosteri Moore & Plummer
Scytalocrinus sansabensis Moore & Plummer (Atokan of Texas)
Agassizocrinus magnus Moore & Plummer (=*Paragassizocrinus magnus*)
Agassizocrinus caliculus Moore & Plummer (=*Paragassizocrinus caliculus*)
Ethelocrinus oklahomensis Moore & Plummer (=*Paracromyocrinus oklahomensis*)
Ethelocrinus papulosus Moore & Plummer (=*Metacromyocrinus papulosus*)
**Ethelocrinus costalis* Moore & Plummer
**Ethelocrinus hispidus* Moore & Plummer
**Ethelocrinus subsinuatus* Moore & Plummer
**Xystocrinus? acicularis* Moore & Plummer (=*Zeacrinites acicularis*)
**Sciadiocrinus? crassacanthus* Moore & Plummer
Plaxocrinus strigosus Moore & Plummer (=*Lasanocrinus strigosus*)
Perimestocrinus pumilus Moore & Plummer
Perimestocrinus teneris Moore & Plummer
Delocrinus matheri Moore & Plummer (=*Endelocrinus matheri*)
**Delocrinus? pendens* Moore & Plummer
Paradelocrinus aequabilis Moore & Plummer
**Paradelocrinus? simus* Moore & Plummer
Diphuicrinus croneisi Moore & Plummer

* Based on disarticulated plates.

H. L. Strimple (1940) described the following species from the Wapanucka Formation (Morrowan) of southern Oklahoma: *Amphicrinus divergens* Strimple, *Catillocrinus morrowensis* Strimple *(=Allocatillocrinus morrowensis)*, *Hydreionocrinus daileyi* Strimple *(=Lasanocrinus daileyi)*, *Delocrinus convexus* Strimple *(=Ampelocrinus convexus)*. A crown of *Paracromyocrinus oklahomensis* (Moore & Plummer) was also reported.

R. C. Moore (1940) in a revision of the Allagecrinidae proposed the genus *Allocatillocrinus* with *A. rotundus* Moore (1940) as the type species. Ontogenetic stages were discussed and one form was described as *A. rotundus multibrachiatus* Moore (1940). Most of the material used in the study was recovered from Morrowan rocks in northeastern Oklahoma, but some specimens are known from Bloyd (Brentwood) rocks in northwestern Arkansas.

R. C. Moore & F. B. Plummer (1940) described two types of dorsal cups from Morrowan rocks of northeastern Oklahoma as *Lasanocrinus daileyi* (Strimple) which are referred herein to *Lasanocrinus nodatus* Moore & Strimple, n. sp., and *L. multinodulus*, n. sp. Two new species from Morrowan rocks of Texas were proposed as *Ethelocrinus texasensis* Moore & Plummer *(=Dicromyocrinus texasensis)* and *Cibolocrinus punctatus* Moore & Plummer.

R. C. Moore & L. R. Laudon (1942) described *Megaliocrinus aplatus* Moore & Laudon from Morrowan rocks of northeastern Oklahoma.

H. L. Strimple (1951) described three species from Morrowan rocks of northeastern Oklahoma as *Dicromyocrinus optimus* Strimple, *Megaliocrinus exotericus* Strimple, and *Plummericrinus braggsi* Strimple *(=Anobasicrinus braggsi)*.

H. L. Strimple (1961) included crowns of two Morrowan (Wapanucka Formation) species in a study of *Late Desmoinesian crinoid faunule from Oklahoma* as *Stenopecrinus rugosus* Strimple (1961), and *Anobasicrinus obscurus* Strimple, 1961.

H. L. Strimple (1961) described a monotypic species as *Stuartwellercrinus praedecta* Strimple from the middle Wapanucka of southern Oklahoma.

N. Gary Lane (1964) in a study *New Pennsylvanian crinoids from Clark County, Nevada* described two species from Morrowan strata of the Callville Formation as *Polusocrinus pachyplax* Lane and *Polusocrinus calyculoides* Lane *(=Paragassizocrinus calyculoides)*. Webster & Lane (1970) considered *P. pachyplax* to belong to *Paragassizocrinus* as a synonym of *P. calyculoides*; however, the well-defined stem impression and unfused infrabasal plates of the holotype of *P. pachyplax* have led us to consider the species to be a valid representative of *Polusocrinus*.

H. L. Strimple & W. D. Knapp (1966) described a fauna from the Kendrick Shale, Breathitt Formation (Morrowan) of eastern Kentucky, including *Paragassizocrinus kendrickensis* Strimple & Knapp, *Paragassizocrinus* cf. *P. disculus* Strimple, *Paragassizocrinus* cf. *P. turris* Strimple, *Metacromyocrinus oklahomensis* (Moore & Plummer) *(=Paracromyocrinus oklahomensis)*. In the same study *Diphuicrinus patina* Strimple & Knapp was proposed for specimens from the Magoffin beds (of Morse, 1931) which may be of Atokan age. Reference was made to Morrowan species of *Diphuicrinus* from Oklahoma.

A. T. Washburn (1968) described a crinoid fauna from the Bridal Veil Falls Member, Oquirrh Formation (Morrowan) from eastern Utah County, Utah, as follows: *Aesiocrinus secundus* Washburn *(=Proallosocrinus secundus)*, *Cymbiocrinus anotonus* Washburn *(=Proallosocrinus anatonus)*, *Cymbiocrinus cuneatus* Washburn *(=Proallosocrinus cuneatus)*, *Globocrinus bulbus* Lane *(=Paragassizocrinus calyculoides)*, *Synarmocrinus depressus* Washburn, *Delocrinus* cf. *D. matheri* Moore & Plummer *(=Palmerocrinus profundus* Moore & Strimple, n. sp.), *Delocrinus* aff. *D. subhemisphericus* Moore & Plummer *(=Stenopecrinus* sp.), *Phanocrinus vadosus* Washburn *(=Goleocrinus vadosus)*, *Hypselocrinus defendus* Washburn *(=Morrowcrinus defendus)*, *Hypselocrinus? superus* Washburn *(=Morrowcrinus superus)*, *Hypselocrinus? cavus* Washburn *(=Morrowcrinus cavus)*. The last two species may be variants of *M. defendus*.

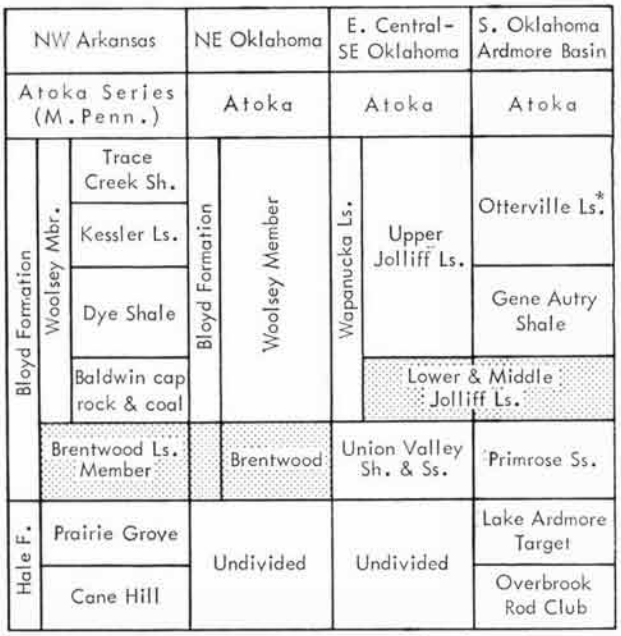
H. L. Strimple & W. T. Watkins (1969) recorded the following species from Morrowan rocks of Texas: *Cymbiocrinus contentus* Strimple & Watkins, *Oxynocrinus spicatus* Strimple & Watkins, *Graffhamicrinus antiquus* Strimple & Watkins, and *Dicromyocrinus optimus* Strimple.

R. C. Moore & H. L. Strimple (1969) in a review of the Acrocrinidae introduced the following Morrowan species: *Globacrocrinus rotundus* Moore & Strimple (lower Wapanucka Formation), *Planacrocrinus conicus* Moore & Strimple, *P. minutus* Moore & Strimple (Bloyd Formation), and *P. ambix* Moore & Strimple (middle Wapanucka Formation).

G. D. Webster & N. Gary Lane (1970) in a study *Carboniferous echinoderms from the southwestern United States* described the following species from Morrowan rocks: *Endelocrinus solus* Webster & Lane, *Kallimorphocrinus inhumectus* Webster & Lane, *K. inaquosus* Webster & Lane, *Metaperimestocrinus verrucosus* Webster & Lane, *M. squarrosus* Webster & Lane, *Perimestocrinus quintorus* Webster & Lane. The dorsal cup of *M. verrucosus* closely resembles that of *Goleocrinus* Strimple & Watkins, 1969.

STRATIGRAPHIC SETTING

Lower Pennsylvanian deposits of Arkansas and Oklahoma classed as belonging to the Morrow group consist



*Otterville at type locality, Desmoinesian; elsewhere, Morrowan.

FIG. 1. Correlation chart of Lower Pennsylvanian (Morrowan) deposits in Arkansas and Oklahoma (chief crinoid-bearing divisions shaded).

predominantly of shale with which sandy and calcareous beds are associated. In eastern areas total thickness ranges from 190 to 225 feet but westward the group is progressively thinner, partly owing to an unconformity at the base of the Middle Pennsylvanian (Atokan) which bevels Morrowan strata. Classification of deposits between Upper Mississipian and Middle Pennsylvanian encounters the difficulties of areal stratigraphic variation combined with poor exposures. Consequently, general agreement has not yet been reached. A correlation chart showing the positions of main crinoid-bearing beds is given in Figure 1.

Bloyd and Hale Formations, Northwestern Arkansas and Northeastern Oklahoma.—The Bloyd Formation, which is recognized in northwestern Arkansas and northeastern Oklahoma as the main division of Morrowan strata, was named and first defined by Purdue (1907, U.S. Geol. Survey, Geol. Atlas, Folio 154). Huffman, *et al.* (1958) reported as much as 225 feet of strata in the Stillwell (Payne County), Oklahoma, area and 58 feet at Braggs Mountain, southeast of Muskogee (Muskogee County), Oklahoma. Prolific crinoid faunas occur in the Brentwood Limestone Member of the Bloyd (type locality near Brentwood Station, Washington County, Arkansas) but many geologists consider the Brentwood Limestone to be indistinguishable in Oklahoma. Because of this we have used the term "Brentwood interval" in Oklahoma. *Branneroceras branneri* is commonly found in this interval.

The Hale Formation was proposed by Adams & Ulrich (1905, U.S. Geol. Survey Geol. Atlas, Folio 119). It occurs in northwestern Arkansas, northeastern and east-central Oklahoma, and southern Missouri. Huffman, *et al.* (1958) reported as much as 136 feet of strata at Ross Mountain (sec. 1, T. 14 N., R. 26 E., and secs. 35 and 36, T. 15 N., R. 26 E.), 57.7 feet at Braggs Mountain, but absent to the north especially in portions of Mayes and Craig Counties, Oklahoma.

Wapanucka Limestone, Pontotoc, Coal and Johnston Counties, Oklahoma.—The Morrowan Wapanucka Limestone underlies the Atoka Group (Middle Pennsylvanian) and overlies the Caney Shale (Upper Mississippian). It was named by Taff (1901) and, by original definition, its strata in descending order consist of: 1) white massive limestone, oolitic in many places; 2) cherty sandy limestones and shales; 3) massive white limestone, absent in places; 4) calcareous and cherty sandstones grading into shales and into nearly pure ferruginous sandstones. The type locality is near Wapanucka, Johnston County, Oklahoma.

A resumé of subsequent emendations and refinements of Wapanucka divisions has been given by Strimple & Nassichuk (1965) and is not repeated here, but mention may be made of recognition by Rowett & Sutherland (1964) of two coral zones in the Wapanucka. *Barytichisma*, which characterizes the lower faunal zone, had been reported by Plummer (1945) as occurring primarily in the Sloan Member of the Marble Falls Formation, of Morrowan age in central Texas. *Barytichisma* was not reported from the lowermost Wapanucka by Rowett & Sutherland but apparently appears in the lower part of the middle Wapanucka of the present report. *Koninckophyllum* (described as *Neokoninckophyllum* by Moore & Jeffords, 1945) and *Amplexocarinia* were reported from above the *Barytichisma* Zone (middle Wapanucka of this report) but in Texas the genera are from the Lemons Bluff Member, Marble Falls Formation, of Atokan age.

The reference to lower Wapanucka sandy strata by Taff is interpreted to correspond mostly to the Union Sandstone below the Wapanucka Formation (Fig. 1).

Rowett & Sutherland (1964, p. 174) reported 181 feet of strata at Canyon Creek (loc. 3) which is the maximum known thickness of this unit. The upper cherty limestone and oolite of the Wapanucka is not present at the exposure and could add considerably to the total thickness of the formation if ever present in the area.

The lower part of the Wapanucka as differentiated in this report is restricted to a dark shale at the base of the Wapanucka Formation. It is equivalent to Unit A (locs. 3, and 4) of Rowett & Sutherland (1964, p. 73-75), which, according to those authors, comprises about 43 feet. The interval is not recognized elsewhere in the

outcrop belt, its upper portion with a large crinoid fauna. Middle Wapanucka beds include limestones and shale above the lower shale up to the occurrence of cherty or oolitic limestones or both; these upper massive limestones are classed as upper Wapanucka. All other observed crinoids apparently occur in the middle Wapanucka. Northwestward in the outcrop belt shales predominate with only a few limestone stringers present so that division of the formation is not practical, if possible.

Strimple & Nassichuk (1965, p. 288, 289) have reported the occurrence of *Axinolobus quinni* McCaleb & Furnish, which has a highly restricted range, from NE ¼ NE ¼ sec. 33, T. 3 N., R. 7 E., Pontotoc County (Rowett & Sutherland, 1964, loc. 7) and from a massive oolitic limestone of the upper Wapanucka beds are exposed in NE ¼ SE ¼ NE ¼ sec. 5, T. 2 S., R. 8 E., Johnston County, Oklahoma (Rowett & Sutherland, 1964, loc. 28). The goniatitid species *Axinolobus quinni* was also reported from the Gene Autry Shale, sec. 34, T. 3 S., R. 4 E. in Johnston County, Oklahoma. Strimple & Nassichuk (1965, p. 289) concluded that the upper part of the Wapanucka Limestone and Gene Autry Shale correlate with the lower middle part of the Bloyd Formation (below upper Kessler Limestone and above the Brentwood Limestone of Arkansas).

The Wapanucka Formation is considered to be post-Brentwood because the cephalopod and conodont faunas of the underlying Union Valley are of Brentwood age.

SUMMARY OF MORROWAN STRATIGRAPHIC UNITS IN ARKANSAS AND OKLAHOMA

Bloyd Formation.—Strata assigned to the Bloyd Formation are described from exposures on Bloyd Mountain, near West Fork, Washington County, Arkansas, first named by Purdue (1907). Henbest (1962a, p. 40) designated the type locality as center E ½ sec. 3 to center north side sec. 4, T. 14 N., R. 30 W., where the formation is about 250 feet thick.

The *Brentwood Limestone Member* was proposed by Ulrich (1904, p. 109) to replace "Pentremital Limestone" of previous authors. Although named for Brentwood Station, Washington County, Arkansas, Henbest (1962a, p. 40) designated a better exposure in center N ½ sec. 16, T. 14 N., R. 30 W. as the reference section. At the type section, the Brentwood is 40 to 45 feet thick, the upper 25 feet consisting of fossiliferous marine limestone with thin shales and the lower 18 feet consisting of dark shale. Lithologically the limestone units are highly variable, that is, they feather out, thicken, or coalesce laterally. However, the fossil content is distinctive, with the ammonoid *Brannerоceras branneri* as the primary zone fossil for the horizon. The crinoid *Arkacrinus dubius* is also a very common form in the horizon. C. A. Moore (1947) recognized the Brentwood in northeastern Oklahoma.

At Evansville Mountain, Henbest (1962a) designated the upper limits of the type Prairie Grove to be the base of the first shale two or more feet thick above a honeycomb sandstone which is the top of the Hale Formation. A crinoid fauna is found in the dark, argillaceous shale well above the honeycomb sandstone on Evansville Mountain and is also considered herein to be of Brentwood age, Bloyd Formation.

The *Woolsey Member* of the Bloyd Formation was proposed by Henbest (1953, p. 1943) for exposures near Woolsey, Washington County, Arkansas, and a type section was designated by Henbest (1962a, p. 40) on the south and east side of Bloyd Mountain, i.e., from center E ½ sec. 3 to center north side sec. 4, T. 14 N., R. 30 W. In the type area the Woolsey has a thickness between 30 and 45 feet.

The *Dye Shale Member* was named by Henbest (1962b, p. 42) for exposures on Bloyd Mountain drained by Dye Creek with the type section designated as E ½ sec. 3, to center of north side sec. 4, T. 14 N., R. 30 W., which is also the type locality of the Bloyd Formation. The basal unit of the Dye Shale Member is the "cap rock" of the Baldwin coal. The "cap rock" is a useful, easily recognized stratigraphic marker in the Bloyd Formation of northwestern Arkansas.

The *Kessler Limestone Member* was named by Simonds (1891) for exposures on Kessler Mountain in Washington County, Arkansas. A type reference section was proposed by Henbest (1962a, p. 41) near the center SE ¼ sec. 25, T. 16 N., R. 31 W., where it varies from 5 to 30 feet in thickness.

The *Trace Creek Shale Member* was named by Henbest (1962b, p. 44) from an area on Bloyd Mountain partially drained by Trace Creek and is also in the type area of the Bloyd Formation. Average thickness of the member is 20 to 125 feet.

Hale Formation.—The Hale Formation was first proposed in a formational rank by Purdue (1907) although the name Hale appeared in two geologic folios published in 1905. Adams & Ulrich (1905, p. 4) stated that the unit was not differentiated in the field by them. Taff (1905, p. 4) clearly stated that the Hale was proposed to replace the preoccupied name "Washington Shale and Sandstone" of Simonds (1891) and mapped the Hale Sandstone Lentil in the Tahlequah Quadrangle. Two type sections have been proposed, one by Giles & Brewster (1930) on Hale Mountain and one by Henbest (1962a) consisting of a ravine heading at Hale Mountain School on the north side of Hale Mountain. The former exposures are now poorly exposed. Manger (1971, p. 23) gave an approximate thickness of 180 feet for the formation on Evansville Mountain, Washington County, Arkansas. It is interesting to note that Manger (*ibid.*, p. 22) stated "The base of the Hale Formation is an unconformity marked by a thin conglomerate composed of fragments derived from the subjacent formation."

The same condition exists in the Hale exposed on Oklahoma Hwy. 10, on Braggs Mountain, Muskogee County, Oklahoma, i.e., a thin conglomerate is at the base of the Hale. This was shown as 0.5 feet by Huffman (1958, p. 169). Lithologies are variable and poorly predictable in northwestern Arkansas and even more so in northeastern Oklahoma. However, C. A. Moore (1947) and Huffman (1958) have recognized both the Hale and Bloyd Formations in northeastern Oklahoma.

The *Cane Hill Member* of the Hale Formation was proposed by Henbest (1953) for a series of alternating shaly siltstone and fine grained sandstone beds typically found near Cane Hill, southern Washington County, Arkansas. Henbest (1962a) designated a type locality on Evansville Mountain, SW ¼ SE ¼ sec. 35, T. 13 N., R. 33 W., where about 45 feet is exposed. The Cane Hill is not present in northeastern Oklahoma.

The *Prairie Grove Member* was named by Henbest (1953) for calcareous sandstones exposed east and south of Prairie Grove, Washington County, Arkansas. The sandstones are characterized by a distinctive honeycomb appearance, which is also readily observed on Braggs Mountain, Muskogee County, Oklahoma. Later, Henbest (1962a), designated a type locality on Evansville Mountain, Washington County, Arkansas, which is the same series of exposures (type area) of the Cane Hill Member (E ½ sec. 35, T. 13 N., R. 33 W.). Manger (1971, p. 65) gives a maximum thickness of 135 feet for the Prairie Grove Member on Evansville Mountain.

AGE RELATIONSHIPS OF MORROWAN CRINOIDS

A survey of the distribution of genera belonging to the Morrowan crinoid assemblage demonstrates an overwhelming affinity with succeeding, rather than preceding, faunas of these echinoderms. First we may segregate genera which as presently known are confined to Morrowan deposits, classified on various grounds as Lower Pennsylvanian. The genera of this group, numbering nine, may be utilized by interpreting their morphological characters compared to those of geologically older and younger crinoids, but conclusions derived from such studies cannot be relied on very strongly. The nine crinoids are *Zenocrinus* (Flexibilia), *Megaliocrinus* (Camerata), and *Allocatillocrinus*, *Morrowcrinus*, *Proallosocrinus*, *Metutharocrinus*, *Arkacrinus*, *Diphuicrinus*, and *Oxynocrinus* (all Inadunata). They include 15 species.

Two long-ranging crinoids, *Platycrinites* (Camerata) and *Ampelocrinus* (Inadunata) are represented by two species in Morrowan beds. *Platycrinites* is abundant in Mississippian formations and virtually worldwide in distribution.

Two inadunate crinoids, *Phacelocrinus* and *Scytalocrinus*, are found in pre-Pennsylvanian rocks but are not reported from deposits younger than Morrowan. They contain three Morrowan species.

Lastly, attention may be turned to crinoid genera found both in the Morrowan and geologically younger rocks including some of Late Permian age and omitting the previously cited through-going forms. This Lower Pennsylvanian and younger group includes *Cibolocrinus*, *Calycocrinus*, and *Paramphicrinus* (Flexibilia), and *Lecythiocrinus*, *Spaniocrinus*, *Strongylocrinus*, *Paragassizocrinus*, *Cromyocrinus*, *Metacromyocrinus*, *Plummericrinus*, *Anchicrinus*, *Athlocrinus*, *Lasanocrinus*, *Utharocrinus*, *Affinocrinus*, *Stenopecrinus*, *Sciadiocrinus*, *Heliosocrinus*, *Erisocrinus*, *Dicromyocrinus*, *Paracromyocrinus*, *Goleocrinus*, *Atokacrinus*, *Palmerocrinus*, *Endelocrinus*, and *Lecobasicrinus* (all Inadunata). The total of flexible crinoid species is seven and that of inadunate species is 44. The great preponderance of the crinoids just listed amply indicates age affinity of the Morrowan fauna with post-Morrowan assemblages.

SOME MORPHOLOGICAL TERMS

Attention needs to be drawn to a few morphological terms used for descriptions of fossil crinoids in this article because to some extent they differ in meaning from previous general usage and because we wish to avoid obscurities and ambiguities. Our aim also is to achieve greatest simplicity combined with consistency by rejecting several synonymous terms.

Cup.—This term (equivalent to dorsal cup and aboral cup) indicates the lowermost two or three circlets (or rarely single circlet) of plates which are fastened together next above the stem of stalked crinoids or at base of the skeleton in stemless crinoids. On the posterior side the cup may include additional plates called anals, all or part of which reach below the summit edges of radial plates.

Calyx, *Tegmen*, *Theca*, and *Crown.*—The term calyx is applied to crinoid cup joined firmly with fixed brachials, and fixed anals which may be present.

The tegmen is composed of all plates, including orals (located interradially), ambulacrals (placed radially), and interambulacrals, as well as irregular or serially arranged plates of an anal sac or tube raised above the general surface of the tegmen. In camerate crinoids the tegmen is a stoutly constructed rigid roof above the visceral cavity enclosed basally and laterally by the cup or calyx. In other crinoids it is less firm and may be a mere leathery integument containing small calcareous platelets and minute ossicles.

The crinoid cup and tegmen or calyx and tegmen comprise the theca.

The theca and free arms, including ramules and pinnules if present, make up the crinoid crown.

Anal Plates.—Directly or obliquely at left below the *C* radial is found in many inadunate and flexible cri-

noids, but not in the Camerata and Articulata, a lowermost so-called anal plate. This has come to be known as the radianal. Another anal plate placed above and left of the radianal has been designated generally by the letter *X* and a third anal at right and somewhat higher than the *X* plate has been termed "right tube plate" (or *RX*).

Nomenclature of anal plates now is changed by adopting different terms which can be used in uniform manner for all crinoids as follows: The first (lowermost) of these extra plates in a crinoid cup or calyx is called **primanal** whether recognized as a radianal or *X* plate in former terminology and successive extra plates of the posterior interray are designated respectively as **secundanal, tertanal, quartanal,** and so on. Such procedure furnishes simplest means of designating different anal plates objectively and uniformly rather than subjectively, divergently and uncertainly. For example, the large primanal of *Araeocrinus* (a cladid inadunate) is almost surely a radianal, for its sutural contact with the *CD* basal slopes obliquely left-upward, whereas the primanals of other cladids disposed squarely above the *CD* basal (e.g., *Delocrinus*, *Graphiocrinus*, *Oklahomacrinus*, and many more) are possibly or probably *X* plates. Among flexible crinoids, the large secundanal of *Lecanocrinus* is equivalent to *X*, but in closely similar *Cibolocrinus* and *Calycocrinus* the primanal definitely corresponds to the secundanal of *Lecanocrinus*.

Comparative studies of specimens belonging to widely dissimilar genera (e.g., *Zeacrinites*, *Cadocrinus*) and species have demonstrated clearly that the radianal not only may alter in shape, size, and lateral-upward displacement but also vanish from the cup in the course of evolution. The disappearance has been shown to occur in two ways: 1) by resorption, or alternatively 2) by upward migration out of the cup. Among crinoids which retain one or two anal plates partly or entirely within the cup, identification of their equivalents in antecedent forms may be difficult or impossible.

MODIFICATIONS IN FORM OF INADUNATE CUPS

Change in the length and width of cup plates strongly affects cup shape; for example, long upflared infrabasals rising evenly from the columnar attachment area and followed by long basals produce a high, steep-sided, cone-shaped cup. Reduction in the proportionate length of basals affects proportionate width of cup and in conjunction with reduction in length of the infrabasals produces a low wide cone-shaped cup.

A truncate base of the cup is first produced by change of the infrabasals to a subhorizontal attitude in the area around the columnar attachment facet, with only distal tips of the infrabasals flexed upward so as to be visible in side view. Reduction in size of the infrabasals or flattening of their distal tips accompanies curvature of proximal ends of basals into the basal plane of the cup. As long as sides of the cup expand upward straightly from the basal plane, one may recognize the primary conical cup shape. Curvature of the basals and radials leads to a round-sided bowl-shaped cup which, with development of a basal concavity, produces a form far removed from the primordial cone shape.

A shallow basal concavity in a bowl-shaped cup tends to evolve toward a deep concavity by expansion of the curved basal plates and increased length of their proximal portions. Depth of the concavity may be augmented by long downflared infrabasals or conversely may be reduced by shortening of the infrabasals.

Knapp's (1969) interpretation of the presence or absence of a shelf (forefacet) below the outer ligament area of radials as a significant morphologic character is considered to be diagnostic in taxonomy. Other characters not commonly taken into account are height of the proximal tip of radials above the basal plane and length of sutures between basal plates. Shortening of interbasal sutures leads to their disappearance and junction of radials with infrabasals and diminution in size of the basals. To shorten the distance between the basal plane of the cup and proximal tips of radials either on elongation of the radials or lowering of the cup height must occur. Usually proportionate lowering of cup height is an evolutionary trend reflected by position of proximal tips of the radials.

Some forms (e.g., *Arkacrinus*, *Diphuicrinus*) develop very thick cup plates. *Paragassizocrinus*, after diminution or disappearance of the stem in ontogeny, develops fused infrabasals having a thick semiovoid or conical shape. Another specialization, which increases height of the cup, is found among pirasocrinids having projected parts of the radials (*Lasanocrinus*), or basals (*Utharocrinus*), or both radials and basals (*Metutharocrinus*). It is reasonably certain that heavy-based stemless crinoids (e.g., *Agassizocrinus*, *Paragassizocrinus*) were bottom-dwellers which could move from place to place, as likewise were some eleutherozoic stem-bearing genera (e.g., *Ancyrocrinus*, *Eifelocrinus*).

PHYLOGENY

Comparative morphology clearly indicates the validity of crinoid orders named Inadunata, Flexibilia, and Camerata, as well as suborders defined in each. Not yet determined, however, are the nature of their interrelationships or how and when one developed from another, although it is reasonably certain that the Flexibilia branched off from cladid Inadunata at an early stage in crinoid evolution. The Disparida (monocyclic) are considered to be another stock derived from the Cladida (dicyclic) and among camerates the Diplobathrida (di-

cyclic) appear to have been the source of the Monobathrida (monocyclic).

The Articulata surely are descendants of Paleozoic ancestors, but whether they are mono- or polyphyletic is not yet answerable in any trustworthy manner. No post-Paleozoic crinoid can be interpreted plausibly as a camerate, for the Late Cretaceous *Marsupites* and *Uintacrinus*, which alone are acceptable candidates for such classification, are too different from Permian and older representatives of this order. Neither post-Permian fossil nor living Flexibilia are recognizable. Hence the Inadunata remain as suspected sources.

DISCRIMINATION OF SUPERFAMILIES

Just as individuals, including adults and presumed juveniles, are assigned to species and species to genera, likeness of morphological characters is relied on for classification. Similarly, genera are associated in families and families may be combined in superfamilies.

Throughout the Crinoidea, superfamilies are discriminated in different ways, with stress laid primarily on some selected feature or set of features which comparative studies indicate to be most important; then definition of superfamily units may take account of secondary features. In nearly all crinoid orders general form of the crown and cup is considered to outweigh other characters of families.

Superfamilies of the suborder Disparida (order Inadunata) are discriminated basically by the location of their planes of bilateral symmetry, which may be highly accentuated (e.g., Calceocrinacea, with symmetry plane bisecting the *E* ray and opposite *BC* interray).

In the suborder Cladida (also Inadunata) shape of the cup is ranked first as a basis for grouping of families characterized by possession in common of cup 1) steeply conical in form, longitudinally straight-sided, outwardly flared at the rim and lacking a basal concavity (e.g., Poteriocrinitacea, Scytalocrinacea), 2) shaped similarly or bowl-like in form with longitudinally curved sides subvertical to incurved at the summit (e.g., Mollocrinacea), 3) low or medium high bowl-shaped with outflared rim, and no basal concavity (e.g., Lophocrinacea), 4) like 2) but much lower, nearly discoid, and having a pronounced basal concavity (e.g., Pirasocrinacea), and several other assemblages of families.

Next, width and slope of the radial articular facets provide significant criteria for classification of cladid families. They are divided into types called 1) **angustary** (narrowly rounded horseshoe-shaped) and declivate (sloping outward-downward); 2) **peneplenary** (facets wide but less than greatest width of radials) with surfaces declivate or planate (subhorizontal); and 3) **plenary** (equal to full maximum width of radials), with surfaces almost universally planate or uncommonly sursumate (sloping outward-upward).

Supplementary characters variable in taxonomic value include 1) number of anal plates in cup ranging from as many as four (e.g., Agassizocrinacea) to normal three, two, one, or none visible externally. Also having value are 2) nature of the anal sac—large recurved tube, balloonlike, tall cylindrical, mushroom-shaped with umbrellalike summit platform girdled by sideward outspread spines, low and moundlike, or absent —and 3) arm structure ranging from multitomous (many-branched), to paucitomous (few-branched), and atomous (unbranched) patterns, the first two types with isotomous (equal bifurcations), heterotomous (unequal arms borne by axillary brachials), including endotomous and exotomous kinds or both together, and 4) arrangement of brachials recti-uniserial (brachials rectangular in external view), obliqui-uniserial (brachials wedge-shaped in external view), or biserial (double rows of interlocking wedge-shaped brachials). Added to these are 5) features of the stem, including homeomorphic (successive columnals essentially identical) and heteromorphic (successive columnals dissimilar, with alternating nodals and groups of internodals), transverse outline (circular, pentagonal, quinquestellate), and bearing or lacking cirri. All of these morphological characters need to be observed, compared, and evaluated in the diagnoses of families and efforts to group them in superfamilies.

Four superfamilies are differentiated in the subclass Flexibilia. These are named Taxocrinacea, containing all genera of the order Taxocrinida; Lecanocrinacea, characterized by distinctness of the cup followed directly by free arms without associated interradials; Sagenocrinitacea with large calyx composed of fixed brachials, fixed interradials with fixed interbrachials; and Icthyocrinacea with large calyx which mostly lacks fixed interradials and fixed interbrachials. The last three superfamilies belong to the order Sagenocrinida.

Superfamilies of the Camerata are omitted from discussion here because this subclass is virtually unrepresented in Morrowan crinoid faunas.

Accordingly, families of the dicyclic Inadunata are grouped in 14 superfamilies, all but two of them here first discriminated. The superfamilies are being adopted in the forthcoming crinoid volumes of the *Treatise on Invertebrate Paleontology*.

As presently known, the Morrowan crinoid fauna contains 45 genera (3 new) distributed among 30 families (4 new); recognized species total 75 (38 new). A break-down of these figures into summations for crinoid subclasses is as follows: genera of Inadunata, 41 (2 new), assigned to 23 families (2 new) including 64 species (36 new); genera of Flexibilia, four (1 new), belonging to four families (2 new), and representing eight species (7 new); Camerata, three genera, three families, three species. Through-going families (19) and genera (9) outnumber those which range downward only (families, 0, genera, 2), upward only (families, 10,

genera, 27), or which are confined to deposits of Morrowan age (families, 1, genera, 7).

CLASSIFICATION OF FLEXIBLE AND INADUNATE CRINOIDS

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This outline shows the arrangement of taxonomic units belonging to the subclasses Flexibilia and Inadunata as developed to December, 1972, proposed for adoption in the *Treatise on Invertebrate Paleontology*, Part T.

Class **CRINOIDEA** Miller, 1821 [=Stylastritidae Martin, 1809; Stylasteritae Goldfuss, 1826-33; Asterencrinidae de Blainville, 1834-37; Pinnigrada Forbes, 1841; Pinnastella Austin & Austin, 1842; Brachiata Burmeister, 1856; Encrines Pictet, 1857; Actinoidea Roemer, 1852-54; Eucrinoidea Zittel, 1879] (L. Ord.-Holocene, Rec.).

Subclass **FLEXIBILIA** Zittel, 1895 [*pro* Articulata Zittel, 1879 (*non* Miller, 1821)] [=suborder Articulosa Wachsmuth & Springer, 1879 (*partim*); Articulata Impinnata Wachsmuth & Springer, 1885; grade Impinnata Bather, 1899; Flexibilida Pearse, 1947].——Cup or calyx dicyclic beneath circlet of radials, with three infrabasals, azygous, small one almost universally in *C* ray, or fused together; anals one to several; arms free or proximally composed of fixed brachials, incurved at crown summit, with or without fixed interradials and interbrachials. (M.Ord.-U.Perm.).

Order **TAXOCRINIDA** Springer, 1913 [*nom. correct.* Moore, 1952 (*pro* Taxocrinoidea Springer, 1913)] [=suborder Taxocrinites Jaekel, 1918].——Longitudinal series of anals well separated from laterally adjacent arm plates. (M.Ord.-U.Penn.).

Superfamily **TAXOCRINACEA** Angelin, 1878 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Taxocrinidae Angelin, 1878)].——Coextensive with Taxocrinida (M.Ord.-U.Penn.).

Family Taxocrinidae Angelin, 1878 (M.Ord.-U.Miss.). Genera: *Taxocrinus* Phillips in Morris, 1843 (M.Dev.-U.Miss.).——*Eutaxocrinus* Springer, 1906 (U.Sil.-L.Miss.).——*Gnorimocrinus* Wachsmuth & Springer, 1879 (1880) (U.Sil.).——*Meristocrinus* Springer, 1906 (U.Sil.).——*Parichthyocrinus* Springer, 1902 (L.Miss.).——*Protaxocrinus* Springer, 1906 (M.Ord.-L.Dev.).

Family Synerocrinidae Jaekel, 1918 (L.Miss.-U.Penn.). Genera: *Synerocrinus* Jaekel, 1897 (U.Carb.).——*Enascocrinus* Strimple & Watkins, 1969 (L.Carb.).——*Euonychocrinus* Strimple, 1940 (U.Penn.).——*Onychocrinus* Lyon & Cassedav, 1860 (L.Miss.-U.Miss.).

Order **SAGENOCRINIDA** Springer, 1913 [*nom. correct.* Moore in Moore, Lalicker & Fischer, 1952 (*pro* Sagenocrinoidea Springer, 1913)].——Bowl-shaped large calyx composed of fixed cup plates; brachials, interradials and interbrachials; anal series joined to adjacent arm plates (U.Sil.-U.Perm.).

Superfamily **LECANOCRINACEA** Springer, 1913 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Lecanocrinidae Springer, 1913)].——Cup distinct from free arms next above it, no fixed interradials and interbrachials. (U.Sil.-U.Perm.).

Family Lecanocrinidae Springer, 1913 (U.Sil.-M.Dev.). Genera: *Lecanocrinus* Hall, 1852 (U.Sil.-L.Dev.).——*Geroldicrinus* Jaekel, 1918 (M.Dev.).——*Miracrinus* Bowsher, 1953 (L.Dev.).——*Mysticocrinus* Springer, 1918 (U.Sil.).

Family Nipterocrinidae Jaekel, 1918 (U.Sil.-L.Miss.). Genera: *Nipterocrinus* Meek & Worthen, 1868 (L.Miss.).——*Cholocrinus* Springer, 1906 (U.Sil.).——*Hormocrinus* Springer, 1920 (U.Sil.).——*Pycnosaccus* Angelin, 1878 (U.Sil.-U.Dev.).

Family Mespilocrinidae Jaekel, 1918 (L.Miss.-U.Perm.). Genera: *Mespilocrinus* de Koninck & Lehon, 1854 (L.Miss.-up.L. Carb.).——*Cibolocrinus* Weller, 1909 (L.Penn.-L.Perm.).——*Loxocrinus* Wanner, 1916 (U.Perm.).——*Petrocrinus* Wanner, 1924 (U.Perm.).——*Syntomocrinus* Wanner, 1916 (U.Perm.).

Family Calycocrinidae Moore & Strimple, n. fam. (M.Dev.-U. Perm.). Genera: *Calycocrinus* Wanner, 1916 (L.Penn.-U.Perm.).——*Ammonicrinus* Wanner, 1926 (M.Dev.).——*Plagiocrinus* Wanner, 1924 (U.Perm.).

Family Gaulocrinidae Moore & Strimple, n. fam.——Cup low bowl-shaped, with flat to slightly concave base and longitudinally convex sides, small infrabasal in *C* ray, all plates exceptionally thick, with broad, nearly featureless facets. Arms composed of very wide short brachials, branching isotomously on primibrachs 2, succeeded in each branch by five or more secundibrachs, tertibrachs unknown; arms slope inward with gentle convexity to meet at center of crown. No radianal or primanal in cup. (L.Miss.). Genus: *Gaulocrinus* Kirk, 1945 (L.Miss.).

Family Prophyllocrinidae Moore & Strimple, n.fam.——Crown moderately small, globose; cup with flat or somewhat concave base formed by pentagonal completely fused infrabasal circlet, arm facets much narrower than width of plates, bordered on one or both sides by pronglike projections, which may be symmetrical or decidedly asymmetrical, with projection on left side of facet most extended; quadrangular primanal (radianal) directly below *C* radial, pentagonal secundanal on distally truncate *CD* basal or both of these plates lacking. Arms short, narrow, bifurcating isotomously once or twice. (U.Perm.). Genera: *Prophyllocrinus* Wanner, 1916 (U.Perm.).——*Ancistrocrinus* Wanner, 1924 (U.Perm.).——*Proapsidocrinus* Wanner, 1924 (U.Perm.).

Family Palaeoholopodidae Wanner, 1916 (U.Perm.). Genera: *Palaeoholopus* Wanner, 1916 (U.Perm.).——*Permobrachypus* Moore & Strimple, *nom. subst.* 1973 [*pro Brachypus* Wanner, 1929, p. 320 (*non* Von Meyer, 1814; *nec* Swainson, 1824; *nec* Meigen, 1824; *nec* Schoenherr, 1825; *nec* Gray, 1825; *nec* Fitzinger, 1826; *nec* Guilding, 1828)] [**Brachypus adhaerens* Wanner, 1929, p. 320; M].——Essentially similar to *Palaeoholopus* but radials proportionally wider and shorter and arms forming relatively higher more evenly rounded summit of crown. Peduncle very short and with sides tending to flare outward from base of cup. Arms composed of only 3 brachials which progressively decrease in width upward (U.Perm.).

Superfamily **ICTHYOCRINACEA** Angelin, 1878 [*nom. transl.* Moore & Strimple, herein (*ex* Icthyocrinidae Angelin, 1878)] (Moore & Strimple, n. superfam.).——Like Sagenocrinitacea except for sparseness or lack of fixed interradials and interbrachials. (L.Sil.-L.Perm.).

Family Icthyocrinidae Angelin, 1878 [*nom. correct.* Moore & Strimple, herein (*pro* Ichthyocrinidae Angelin, 1878)] (L.Sil.-L.Miss.). Genera: *Icthyocrinus* Conrad, 1842 (U.Sil.-L.Dev.).——*Cleistocrinus* Springer, 1920 (U.Sil.) ——*Clidochirus* Angelin, 1878 (L.Sil.-L.Dev.).——*Metichthyocrinus* Springer, 1906 (L.Miss.).——*Synaptocrinus* Springer, 1920 (M.Dev.-U.Dev.).

Superfamily **SAGENOCRINITACEA** Bassler, 1938 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Sagenocrinitidae Bassler, 1938) (Roemer, 1854)].——Large calyx composed of cup followed above by many fixed brachials, interradials, and interbrachials; anals interlocked with adjacent brachials. (U.Sil.-U.Perm.).

Family Sagenocrinitidae Bassler, 1938 [*nom. correct.* Bassler, 1938 (*pro* Sagenocrinidae Roemer, 1854)] (Roemer, 1854) (U.Sil.-L.Perm.). Genera: *Sagenocrinites* Austin & Austin, 1842 (U.Sil.).——*Forbesiocrinus* de Koninck & Lehon (low.L.Carb.) (L.Miss.).——*Trampidocrinus* Lane & Webster, 1966 (L.Perm.).

Family Homalocrinidae Angelin, 1878 (U.Sil.). Genera: *Homalocrinus* Angelin, 1878 (U.Sil.).——*Anisocrinus* Angelin, 1878 (U.Sil.).——*Asaphocrinus* Springer, 1920 (U.Sil.).

Family Dactylocrinidae Bather, 1899 (U.Sil.-U.Perm.). Genera: *Dactylocrinus* Quenstedt, 1876 (M.Dev.-L.Miss.).——*Aexitrophocrinus* Strimple & Watkins, 1969 (M.Penn-U.Penn.). ——*Calpiocrinus* Angelin, 1878 (U.Sil.).——*Lithocrinus* Wachsmuth & Springer, 1879 (1880) (U.Sil.).——*Nevadacrinus* Lane & Webster, 1966 (L.Perm.).——*Rumphiocrinus* Wanner, 1924 (U.Perm.).——*Temnocrinus* Springer, 1902 (U.Sil.).——*Wachsmuthicrinus* Springer, 1902 (L. Miss., low.L.Carb.).——*Zenocrinus* Moore & Strimple, new genus (L.Penn.).

Family Euryocrinidae Moore & Strimple, new family (M.Dev.-U.Penn.). Genera: *Euryocrinus* Phillips, 1837 (M.Dev.-up.L.Carb.).——*Ainacrinus* Wright, 1939 (up.L.Carb.). ——*Amphicrinus* Springer, 1906 (up.L.Carb.).——*Artichthyocrinus* Wright, 1923 (up.L.Carb.).——*Caldenocrinus* Wright, 1946 (up.L.Carb.).——*Dieuryocrinus* Wright, 1954 (up.L.Carb.).——*Paramphicrinus* Strimple & Moore, 1971 (L.Penn.-U.Penn.).

Subclass **INADUNATA** Wachsmuth & Springer, 1855 [*nom. transl.* Moore & Laudon, 1943 (*ex* suborder Inadunata Wachsmuth & Springer, 1885)] [=order Pentacrinoidea Jaekel, 1894 (*partim*)].——Crown with arms free above theca; cup conical, or bowl-shaped to discoid, with convex, flat, or concave base; arm facets angustary, peneplenary, or plenary; anal sac generally prominent. (L.Ord.-M.Trias.).

Order **DISPARIDA** Moore & Laudon, 1943 [*nom. correct.* Moore in Moore, Lalicker & Fischer, 1952 (*pro* Disparata Moore & Laudon, 1943)] [=order Myelodactyloidea S. A. Miller, 1883; order Larviformia Wachsmuth & Springer, 1885].—— Monocyclic inadunates, mostly with long slender arms, cup typically steep-sided conical. (M.Ord.-U.Perm.).

Superfamily **HOMOCRINACEA** Kirk, 1914 (Ubaghs, 1953) [*nom. correct.* Moore & Lane, herein (*pro* superfam. Homocrinicae Ubaghs, 1953, p. 746, *nom. transl. ex* Homocrinidae Kirk, 1914)].——Cup and crown with *E*-ray bilateral symmetry. (M.Ord.-U.Sil., ?Dev.).

Family Homocrinidae Kirk, 1914 (M.Ord.-U.Sil., ?Dev.). Genera: *Homocrinus* Hall, 1851 (1852) (U.Sil.).——*Daedalocrinus* Ulrich, 1924 (1925) (M.Ord.).——*Drymocrinus* Ulrich, 1924 (1925) (U.Ord.).——*Ectenocrinus* S. A. Miller, 1889 (M.Ord.-U.Ord.).——*Ibexocrinus* Lane, 1970 (M.Ord.).——*Sygcaulocrinus* Ulrich, 1924 (1925) (U. Ord.).

Superfamily **CALCEOCRINACEA** Meek & Worthen, 1869 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Calceocrinidae Meek & Worthen, 1869)].—— "Bent-crown" crinoids with pronounced *E*-ray bilateral symmetry with transverse hinge crossing cup beneath *E* interradial. (M.Ord.-L.Perm.).

Family Calceocrinidae Meek & Worthen, 1869 (M.Ord.-L. Perm.). Genera: *Calceocrinus* Hall, 1852 [=*Cheirocrinus* Hall, 1860; *Eucheirocrinus* Meek & Worthen, 1869; *Proclivocrinus* Ringueberg, 1889; *Euchirocrinus* Bather, 1893] (M.Ord.-U.Sil.).——*Anulocrinus* Ramsbottom, 1960 (U. Ord.-U.Sil.).——*Chirocrinus* Angelin, 1878 [=*Calceocrinus* auctt.] (L.Sil.).——*Chiropinna* Moore, 1962 (U.Sil.).—— *Cremacrinus* Ulrich, 1886 (M.Ord.-U.Sil).——*Cunctocrinus* Kesling & Sigler, 1969 (M.Dev.).——*Deltacrinus* Ulrich, 1886 (L.Sil.-U.Sil.).——*Epihalysiocrinus* Arendt, 1965 (L.Perm.).——*Grypocrinus* Strimple, 1963 (U.Sil.).—— *Halysiocrinus* Ulrich, 1886 (M.Dev.-L.Miss.).——*Senariocrinus* Schmidt, 1934 (L.Dev.).——*Synchirocrinus* Jaekel, 1918 [=*Cheirocrinus* Salter, 1873 (*non* Eichwald, 1856)] (L.Sil.-U.Sil.).

Superfamily **PISOCRINACEA** Angelin, 1878 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Pisocrinidae Angelin, 1878)].——Cup globose, with *E*-ray bilateral symmetry. (U.Sil.-U.Dev.).

Family Pisocrinidae Angelin, 1878 (U.Sil.-U.Dev.). Genera: *Pisocrinus* de Koninck, 1858 [=*Triacrinus* Ringueberg, 1884 (*non* Münster, 1839)] (U.Sil.-L.Dev.).——*Calycanthocrinus* Follman, 1887 (L.Dev.-M.Dev.).——*Cicerocrinus* Sollas, 1900 (U.Sil.).——*Jaekelicrinus* Yakovlev, 1949 (U. Dev.).——*Parapisocrinus* Mu, 1954 (U.Sil.-L.Dev.).—— *Triacrinus* Münster, 1838 (U.Sil.-U.Dev.).

Superfamily **ALLAGECRINACEA** Carpenter & Etheridge, 1881 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Allagecrinidae Carpenter & Etheridge, 1881)].——Cup bowl-shaped, multiple slender unbranched arms borne by some radials, *E*-ray bilateral symmetry. (U. Dev.-U.Perm.).

Family Allagecrinidae Carpenter & Etheridge, 1881 (U.Dev.-Perm.). Genera: *Allagecrinus* Carpenter & Etheridge, 1881 [=*Hybochilocrinus* J. M. Weller, 1930] (U.Dev.-L.Miss.) (L.Carb.).——*Desmacriocrinus* Strimple, 1966 (U.Dev.-L.Miss.).——*Isoallagecrinus* Strimple, 1966 (M.Penn.-L. Perm.).——*Kallimorphocrinus* J. M. Weller, 1930 [=*Aidemocrinus* J. M. Weller, 1930; *Callimorphocrinus* Peck, 1936)] (L.Miss.-L.Penn.) (L.Carb.).——*Metallagecrinus* Strimple, 1966 (L.Perm.-U.Perm.).——?*Stereobrachicrinus* Mather, 1915 (L.Penn.).——*Thaminocrinus* Strimple & Watkins, 1969 (L.Carb.).——*Trophocrinus* Kirk, 1930 (L. Miss.).——*Wrightocrinus* Moore, 1940 (U.Perm.).

Family Catillocrinidae Wachsmuth & Springer, 1886 [=Catillocrininae Moore, 1940] (M.Dev.-U.Perm.). Genera: *Catillocrinus* Shumard, 1866 (1868) [actually Oct., 1865] [=*Nematocrinus* Meek & Worthen, 1866] (L.Miss.).—— *Allocatillocrinus* Wanner, 1937 (U.Miss.-L.Penn.) (L.Carb.). ——*Eucatillocrinus* Springer, 1923 (L.Miss.).——*Isocatillocrinus* Wanner, 1937 (U.Perm.).——*Metacatillocrinus*

Moore & Strimple, 1942 (M.Penn.).——*Mycocrinus* Schultze, 1866 (1867) (M.Dev.).——*Neocatillocrinus* Wanner, 1937 (U.Perm.).——*Paracatillocrinus* Wanner, 1916 (U.Perm.).——*Xenocatillocrinus* Wanner, 1937 (U. Perm.).

Family Anamesocrinidae Goldring, 1923 (M.Dev.). Genus: *Anamesocrinus* Goldring, 1923 (M.Dev.).

Family Haplochinitidae Bassler, 1938 [*nom. correct.* Bassler, 1938 (*pro* Haplocrinidae Roemer, 1855)] [=Aplocrinidae d'Orbigny, 1852] (?Sil., Dev., ?L.Carb.). Genus: *Haplocrinites* Steininger, 1837 [=*Haplocrinus* Roemer, 1855; *Aplocrinus* d'Orbigny, 1849 (1852)] (?Sil., Dev., L.Carb.).

Family Tunguskocrinidae Arendt, 1963 (Ord.). Genus: *Tunguskocrinus* Arendt, 1963 (Ord.).

Superfamily **HETEROCRINACEA** Zittel, 1879 (Ubaghs, 1953) [*nom. correct.* Moore & Lane, herein (*pro* Heterocrinicae Ubaghs, 1953, p. 747, *nom. transl. ex* Heterocrinidae Zittel, 1879)].——Cup steeply conical, *D*-ray bilateral symmetry. (M.Ord.-U.Ord.).

Family Heterocrinidae Zittel, 1879 (M.Ord.-U.Ord.). Genera: *Heterocrinus* Hall, 1847 [=*Stenocrinus* Wachsmuth & Springer, 1886] (M.Ord.-U.Ord.).——*Atopocrinus* Lane, 1970 (M.Ord.).——*Atyphocrinus* Ulrich, 1924(1925) (U. Ord.).——*Columbicrinus* Ulrich, 1924(1925) (M.Ord.). ——*Dystactocrinus* Ulrich, 1924(1925) (U.Ord.).——*Isotomocrinus* Ulrich, 1924(1925) (M.Ord.).——*Ohiocrinus* Wachsmuth & Springer, 1886 (M.Ord.-U.Ord.).

Superfamily **MYELODACTYLACEA** S. A. Miller, 1883 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Myelodactylidae S. A. Miller, 1883)] [=Iocrinicae Ubaghs, 1953 (*nom. transl. ex* Iocrinidae Moore & Laudon, 1943)]. ——Crown tall and slender, cup steeply conical, *C*-ray bilateral symmetry. (L.Ord.-L.Dev., ?U.Dev.).

Family Myelodactylidae S. A. Miller, 1883 (L.Sil.-L.Dev., ?U.Dev.). Genera: *Myelodactylus* Hall, 1852 (U.Sil.-L. Dev.,?U.Dev.).——*Brachiocrinus* Hall, 1858 (L.Dev.).—— *Crinobrachiatus* Moore, 1962 (U.Sil.).——*Eomyelodactylus* Foerste, 1919 (L.Sil.).——*Herpetocrinus* Salter, 1873 (U. Sil.).

Family Iocrinidae Moore & Laudon, 1943 (M.Ord.-U.Ord.). Genera: *Iocrinus* Hall, 1866 (?L.Ord., M.Ord.-U.Ord.). ——*Caleidocrinus* Waagen & Jahn, 1899 (M.Ord.).

Family Eustenocrinidae Ulrich, 1924(1925) (L.Ord.-U.Ord.). Genera: *Eustenocrinus* Ulrich, 1924(1925) (M.Ord.).—— *Peniculocrinus* Moore, 1962 (M.Ord.).——*Ramseyocrinus* Bates, 1968 (L.Ord.).——*Ristnacrinus* Öpik, 1934 (M. Ord.).

Superfamily **ANOMALOCRINACEA** Wachsmuth & Springer, 1886 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Anomalocrinidae Wachsmuth & Springer, 1886)]. Cup bowl-shaped, *C*-ray bilateral symmetry. (M.Ord.-U.Ord.).

Family Anomalocrinidae Wachsmuth & Springer, 1886 (M. Ord.-U.Ord.). Genera: *Anomalocrinus* Meek & Worthen, 1865 [=*Ataxiacrinus* Lyon, 1869; *Ataxocrinus* Bather, in Lankester, 1900] (U.Ord.).——*Geraocrinus* Ulrich, 1924(1925) (M.Ord.).——*Glaucocrinus* Parks & Alcock, 1912 (M.Ord.).

Superfamily **BELEMNOCRINACEA** S. A. Miller, 1883 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Belemnocrinidae S. A. Miller, 1883)].——Cup conical, *A*-ray bilateral symmetry. (U.Sil.-L.Miss.).

Family Belemnocrinidae S. A. Miller, 1883 [=Belemnocrinidae Wachsmuth & Springer, 1886] (L.Miss.). Genera: *Belemnocrinus* White, 1862 (L.Miss.).——*Whiteocrinus* Jaekel, 1918 (L.Miss.).

Family Holynocrinidae Bouška, 1948 (M.Dev.). Genus: *Holynocrinus* Bouška, 1948 (M.Dev.).

Family Perissocrinidae Strimple, 1963 (M.Dev.). Genera: *Perissocrinus* Goldring, 1936 (M.Dev.).——*Hypocrinus* Springer & Slocum, 1906 (M.Dev.).——*Quiniocrinus* Schmidt, 1941 (1942) (M.Dev.).

Family Pygmaeocrinidae Strimple, 1963 (U.Sil.-M.Dev.). Genera: *Storthingocrinus* Schultze, 1867 (L.Dev.-M.Dev.).—— *Pygmaeocrinus* Bouška, 1946 (U.Sil.-M.Dev.).

Family Synbathocrinidae S. A. Miller, 1889 [=Symbathocrinidae Bather, 1899] (U.Sil.-U.Perm.). Genera: *Synbathocrinus* Phillips, 1836 [=*Donaeicrinus* Bather in Lankester, 1900; *Symbathocrinus* d'Orbigny, 1849 (1852); *Symbathocrinites* Austin & Austin, 1842] (M.Dev.-U.Penn.). ——*Abyssocrinus* Strimple, 1963 (U.Sil.).——*Phimocrinus* Schultze, 1866 (L.Dev.-M.Dev.).——*Stylocrinus* Sandberger & Sandberger, 1856 (U.Sil.-M.Dev.).——*Taidocrinus* Tolmachev, 1924 (U.Carb.-U.Perm.)——*Theloreus* Moore, 1962 (M.Dev.).

Family Zophocrinidae S. A. Miller, 1892 [=Tiaracrinidae Bather in Lankester, 1900] (U.Sil.-M.Dev.). Genera: *Zophocrinus* S. A. Miller, 1891 (U.Sil.).——*Parazophocrinus* Strimple, 1963 (U.Sil.).——*Tiaracrinus* Schultze, 1867 [=*Staurosoma* Barrande, 1887] (L.Dev.-M.Dev.).

Order **HYBOCRINIDA** Jaekel, 1918 [*nom. transl. et correct.* Moore in Moore, Lalicker & Fischer, 1952, p. 613 (*pro* suborder Hybocrinites Jaekel, 1918)].——Cup bowl-shaped (trigonal in Cornucrinidae), some or all arms suppressed, with ambulacra on surface of cup. (L.Ord.-U.Sil.).

Superfamily **HYBOCRINACEA** Zittel, 1879 (Regnéll, 1948) [*nom. correct.* Moore & Sprinkle, 1973, *pro* superfam. Hybocrinida Regnéll, 1948, *nom. transl. ex* Hybocrinidae Zittel, 1879].——Coextensive with order. (L.Ord.-U.Ord.).

Family Hybocrinidae Zittel, 1879 (M.Ord.-U.Ord.). Genera: *Hybocrinus* Billings, 1857 (M.Ord.).——*Hoplocrinus* Grewingk, 1867 (M.Ord.-U.Ord.).——*Revalocrinus* Jaekel, 1918 (M.Ord.).

Family Hybocystitidae Jaekel, 1918 (M.Ord.). Genus: *Hybocystites* Wetherby, 1880 [=*Hybocystis* Bather, 1890] (M. Ord.).

Family Baerocrinidae Jaekel, 1918 (L.Ord.-M.Ord.). Genus: *Baerocrinus* Volborth, 1864 (L.Ord.-M.Ord.).

Family Cornucrinidae Regnéll, 1948 (M.Ord.). Genera: *Cornucrinus* Regnéll, 1948 (M.Ord.).——*Tripatocrinus* Sprinkle, 1973 (M.Ord.).

Order **CLADIDA** Moore & Laudon, 1943 [*nom. correct.* Moore in Moore, Lalicker & Fischer, 1952 (*pro* Disparata Moore & Laudon, 1943)] [=Dicyclica Inadunata Bather, 1890].—— Inadunates with two plate circlets beneath radials; free arms rarely none or 1 to 100, anal sac generally prominent. (L. Ord.-M.Trias.).

Suborder **CYATHOCRININA** Bather, 1899 [*nom. correct.* Moore in Moore, Lalicker & Fischer, 1952 (*pro* suborder Cyathocrinoidea Bather, 1899)].——Theca ovoid, no anal sac, anal vent through tegmen or side of cup, free arms commonly many-branched, joined together laterally in some genera, arm facets narrow (angustary or peneplenary, not plenary. (M. Ord.-U.Perm.).

Superfamily **CYATHOCRINITACEA** Bassler, 1938 (Lane, 1967) [*nom. transl.* Lane, 1967 (*ex* Cyathocrinitidae Bassler, 1938)] (*ex* Cyathocrinidae Roemer, 1854)].——Distinguished by short stout anal sac with vent at its top and large primanal or secundanal. (M.Ord.-U.Perm.).

Family Cyathocrinitidae Bassler, 1938 [*nom. correct.* Bassler, 1938 (*pro* Cyathocrinidae Roemer, 1854)] (M.Ord.-U. Perm.). Genera: *Cyathocrinites* Miller, 1821 [=*Cyathocrinus* Agassiz, 1835)] (U.Sil.-L.Miss., ?U.Perm.).——*Anarchicrinus* Jaekel, 1918 (M.Ord.).——*Ceratocrinus* Wanner, 1937 (U.Perm.).——*Gissocrinus* Angelin, 1878 (U.Sil.-L.Dev.).

Family Barycrinidae Jaekel, 1918 (L.Dev.-U.Miss.). Genera: *Barycrinus* Meek & Worthen, 1868 [=*Pottsicrinus* Jillson, 1960] (L.Miss.-U.Miss.).——*Pellecrinus* Kirk, 1939 [=*Vasocrinus* Lyon, pre-1939 auctt. (*non Vasocrinus* Lyon, 1857)] (L.Miss.).——*Situlacrinus* Breimer, 1962 (L.Dev.).

Family Euspirocrinidae Bather, May 1890 [=Ampheristocrinidae S. A. Miller, 1889 (Dec. 1890)] (M.Ord.-low.L.Carb.). Genera: *Euspirocrinus* Angelin, 1878 (M.Ord.-U.Sil.).——*Closterocrinus* Hall, 1852 (U.Sil.).——*Parisocrinus* Wachsmuth & Springer, 1880 (U.Sil.-L.Carb.).——*Vasocrinus* Lyon, 1857 (L.Dev.-M.Dev.).

Family Lecythocrinidae Kirk, 1934 (M.Dev.-L.Miss.). Genera: *Lecythocrinus* Müller, 1858 (M.Dev.).——*Cestocrinus* Kirk, 1940 (L.Miss.).——*Corynecrinus* Kirk, 1934 (M.Dev.).

Superfamily **GASTEROCOMACEA** Roemer, 1854 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Gasterocomidae Roemer, 1854)] [=Palaeocrinacea Lane, 1967, p. 9 (*nom. transl. ex* Palaeocrinidae Bather, 1899)].——Tegmen flat, anal vent located on tegmen or side of cup, arms atomous or branched and joined together laterally in some families. (M.Ord.-M.Dev.).

Family Gasterocomidae Roemer, 1854.——Stem with 3 or 4 peripheral canals around main central one (M.Dev.). Genera: *Gasterocoma* Goldfuss, 1839 [=*Ceramocrinus* Müller, 1855; *Epactocrinus* Müller, 1855; *Gastrocoma* Beyrich, 1871] (M.Dev.).——*Mictocrinus* Goldring, 1923 (M.Dev.).——*Myrtillocrinus* Sandberger & Sandberger, 1855 (1856) [=*Tripleurocrinus* Wood, 1904] (M.Dev.).——*Nanocrinus* Müller, 1856 (M.Dev.).——*Schultzicrinus* Springer, 1911 (M.Dev.).——*Scoliocrinus* Jaekel, 1895 (M.Dev.).

Family Sphaerocrinidae Jaekel, 1895 [=Palaeocrinidae Bather, 1899] (M.Ord.-M.Dev.). Genera: *Sphaerocrinus* Roemer, 1851 [=*Sphaerocrinites* Steininger, 1853] (M.Dev.).——*Palaeocrinus* Billings, 1859 (M.Ord.).——*Thalamocrinus* Miller & Gurley, 1895 (U.Sil.).

Family Porocrinidae Miller & Gurley, 1894 (M.Ord.-U.Ord.). Genera: *Porocrinus* Billings, 1856(1857) (M.Ord.-U.Ord).——*Triboloporus* Kesling & Paul, 1968 (M.Ord.).

Family Carabocrinidae Bather, 1899 (M.Ord.-U.Ord.). Genus: *Carabocrinus* Billings, 1857 [=*Strophocrinus* Sardeson, 1899] (M.Ord.-U.Ord.).

Family Crotalocrinitidae Bassler, 1938 (Angelin, 1878) (U.Sil.-M.Dev.). Genera: *Crotalocrinites* Austin & Austin, 1843 [=*Crotalocrinus* Morris, 1943; *Anthocrinus* Müller, 1853] (U.Sil.).——*Achradocrinus* Schultze, 1867 (U.Sil.-M.Dev.).——*Arachnocrinus* Meek & Worthen, 1866 (M.Dev.).——*Enallocrinus* d'Orbigny, 1849 (1850) (U.Sil.).——*Parapernerocrinus* Yakovlev, 1949 (L.Dev.).——*Pernerocrinus* Bouška, 1946 (L.Dev.).——*Syndetocrinus* Kirk, 1933 (U.Sil.).

Family Petalocrinidae Weller & Davidson, 1896 (U.Sil.). Genus: *Petalocrinus* Weller & Davidson, 1896 (U.Sil.).

Superfamily **CODIACRINACEA** Bather, 1890 (Lane, 1967) [*nom. transl.* Lane, 1967 (*ex* Codiacrinidae Bather, 1890)] [=Hypocrinacea Arendt, 1970].——Theca small, radials 0 to 5; tegmen low, composed of 5 orals. (U.Sil.-U.Perm.).

Family Codiacrinidae Bather, 1890 [=Embryocrinidae Wanner, 1916; Hypocrinidae Jaekel, 1918] (U.Sil.-U.Perm.).

Subfamily Codiacrininae Bather, 1890 (Lane, 1967) [*nom. transl.* Lane, 1967 (*ex* Codiacrinidae Bather, 1890)] (U.Sil.-U.Perm.) [incl. Cranocrininae Arendt, 1970; Amphipsalidocrininae Arendt, 1970]. Genera: *Codiacrinus* Schultze, 1867 (L.Dev.-M.Dev.).——*Abrachiocrinus* Wanner, 1920 (low.L.Carb.-U.Perm.).——*Amphipsalidocrinus* J. M. Weller, 1930 (L.Miss.-L.Penn.).——*Asymmetrocrinus* Wanner, 1937 (U.Perm.).——*Cranocrinus* Wanner, 1929 (U.Perm.).——*Cydonocrinus* Bather, 1913 (up.L.Carb.-U.Perm.).——*Embryocrinus* Wanner, 1916 (U.Perm.).——*Hydroporocrinus* Arendt, 1970 (L.Perm.).——*Hypocrinus* Beyrich, 1862 (U. Perm.).——*Lecythiocrinus* White, 1879 [=*Menocrinus* S. A. Miller, 1889] (L.Penn.-U.Penn.).——*Paracydonocrinus* Arendt, 1970 (L.Perm.).——*Paralecythiocrinus* Arendt, 1970 (U.Sil.).——*Tenagocrinus* Wanner, 1929 (U.Perm.).

Subfamily Bolbocrininae Wanner, 1929 (Lane, 1967) [*nom. transl.* Lane, 1967 (*ex* section Bolbocrinites Wanner, 1929)] (L.Perm.-U.Perm.). Genera: *Bolbocrinus* Wanner, 1916 (L.Perm.-U.Perm.).——*Nereocrinus* Wanner, 1924 [=*Oceanocrinus* Wanner, 1924] (L.Perm.-U.Perm.).

Subfamily Thetidicrininae Wanner, 1929 (Lane, 1967) [*nom. transl.* Lane, 1967 (*ex* section Thetidicrinites Wanner, 1929)] (low.L.Carb.-U.Perm.). Genera: *Thetidicrinus* Wanner, 1916 (U.Perm.).——*Edapocrinus* Wright, 1935 (low.L.Carb.).——*Prochoidocrinus* Wanner, 1937 (U. Perm.).

Family Sycocrinitidae Lane, 1967 (low.L.Carb.-U.Perm.). Genera: *Sycocrinites* Austin & Austin, 1842 [=*Sycocrinus* Morris, 1843] (low.L.Carb.).——*Allosycocrinus* Wanner, 1924 (U.Perm.).——*Metasycocrinus* Wanner, 1920 (U. Perm.).——*Monobrachiocrinus* Wanner, 1916 (L.Perm.-U.Perm.).——*Parasycocrinus* Marez Oyens, 1940 (U.Perm.).

Family Streblocrinidae Lane, 1967 (M.Dev.-U.Perm.).

Subfamily Streblocrininae Lane, 1967 [incl. Pilidiocrininae Arendt, 1970] (M.Dev.-U.Perm.). Genera: *Streblocrinus* Koenig & Meyer, 1965 (M.Dev.).——*Atremacrinus* Wanner, 1929 (U.Perm.).——*Coenocystis* Girty, 1908 (L. Miss.-U.Perm.).——*Dichostreblocrinus* J. M. Weller, 1930 (L.Miss.-U.Perm.).——*Hemistreptacron* Yakovlev, 1926 (L.Perm.-U.Perm.).——*Pilidiocrinus* Wanner, 1937 (U. Perm.).——*Tytthocrinus* J. M. Weller, 1930 (M.Dev.-L.Penn.).

Subfamily Pentecrininae Lane, 1967 [incl. Acariaiocrininae Arendt, 1970; Lageniocrininae Arendt, 1970] (?U.Dev., L.Miss.-U.Perm.). Genera: *Pentecrinus* Koenig & Niewoehner, 1959 (?U.Dev., L.Miss.).——*Acariaiocrinus* Wanner, 1924 (L.Perm.-U.Perm.).——*Clistocrinus* Kirk, 1937 [=*Clithrocrinus* Kirk, 1937] (L.Miss.).——*Lage-*

niocrinus de Koninck, 1854 (low.L.Carb.-L.Penn.).——*Lampadosocrinus* Strimple & Koenig, 1956 (L.Miss.).——*Neolageniocrinus* Arendt, 1970 (L.Penn.-U.Perm.).

Suborder **DENDROCRININA** Bather, 1899 [*nom. correct.* Moore in Moore, Lalicker & Fischer, 1952 (*pro* suborder Dendrocrinoidea Bather, 1899)] [=suborder Dendrocrinites Jaekel, 1918].——Cup steeply conical, straight-sided, flared outward at rim, arms mostly many-branched, uniserial, nonpinnulate, anal sac large. (L.Ord.-L.Miss.).

Superfamily **DENDROCRINACEA** Wachsmuth & Springer, 1886 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Dendrocrinidae Wachsmuth & Springer, 1886)]. Characters of suborder, with angustary arm facets. (M.Ord.-L.Miss.).

Family Dendrocrinidae Wachsmuth & Springer, 1886 [*nom. transl.* Bather, 1890, *ex* section Dendrocrinites Wachsmuth & Springer, 1886] [=Bactrocrinidae Jaekel, 1918; Esthonocrinidae Jaekel, 1918] (M.Ord.-L.Miss.). Genera: *Dendrocrinus* Hall, 1852 (M.Ord.-U.Sil.).——*Alsopocrinus* Tansey, 1922(1924) (L.Dev.).——*Atractocrinus* Kirk, 1948 M.Dev.-U.Dev.).——*Bactrocrinites* Schnur, 1849 [=*Bactrocrinus* Quenstedt, 1875] (U.Sil.-M.Dev.).——*Esthonocrinus* Jaekel, 1918 (M.Ord.).——*Grenprisia* Moore, 1962 (M.Ord.).——*Parisangulocrinus* Schmidt, 1934 (L.Dev.).

Family Botryocrinidae Wachsmuth & Springer, 1886 [*nom. transl.* Bather, 1899 (*ex* section Botryocrinites Wachsmuth & Springer, 1886)] [=Gothocrinidae Jaekel, 1918; Pandoracrinidae Jaekel, 1918; Rhadinocrinidae Jaekel, 1918] (M.Ord.-M.Dev.). Genera: *Botryocrinus* Angelin, 1878 [=*Sicyocrinus* Angelin, 1878] (U.Sil.-U.Dev.).——*Ancyrocrinus* Hall, 1852 (L.Dev.-M.Dev.).——*Costalocrinus* Jaekel, 1918 (M.Dev.).——*Gastrocrinus* Jaekel, 1895 (L. Dev.).——*Gothocrinus* Bather, 1893 (U.Sil.).——*Imitatocrinus* Schmidt, 1934 (L.Dev.).——*Jahnocrinus* Jaekel, 1918 (M.Dev.).——*Pandoracrinus* Jaekel, 1918 (M.Ord.).——*Parabotryocrinus* Yakovlev, 1941 (U.Dev.).——*Rhadinocrinus* Jaekel, 1895 (L.Dev.-M.Dev.).——*Schmidtocrinus* Haarmann, 1921 (M.Dev.).——*Sigambrocrinus* Schmidt, 1941(1942) (L.Dev.).

Superfamily **MASTIGOCRINACEA** Jaekel, 1918 (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Mastigocrinidae Jaekel, 1918)].——Like Dendrocrinacea but arm facets peneplenary. (L.Ord.-L.Miss.).

Family Aethocrinidae Ubaghs, 1969 (L.Ord.). Genus: *Aethocrinus* Ubaghs, 1969 (L.Ord.).

Family Thenarocrinidae Jaekel, 1918 (U.Sil.). Genus: *Thenarocrinus* Bather, 1890 (U.Sil.).

Family Mastigocrinidae Jaekel, 1918 (M.Ord.-L.Miss.). Genera: *Mastigocrinus* Bather, 1892 (U.Sil.).——*Antihomocrinus* Schmidt, 1934 (U.Sil.-L.Dev.).——*Atelestocrinus* Wachsmuth & Springer, 1886 [=*Atelessocrinus* Wachsmuth & Springer, 1886; *Atelestrocrinus* Bassler & Moodey, 1943] (L.Miss.).——*Bathericrinus* Jaekel, 1918 (U.Sil.-L.Dev.).——*Cradeocrinus* Goldring, 1923 (U.Dev.-L.Miss.).——*Dictenocrinus* Jaekel, 1918 (U.Sil.-L.Dev.).——*Eifelocrinus* Wanner, 1916 [=*Ptilocrinus* Wanner, 1916 (*non* Clark, 1907)] (L.Dev.).——*Follicrinus* Schmidt, 1934 (L.Dev.).——*Goniocrinus* Miller & Gurley, 1890 [=*Goniacrinus* Springer, 1913] (L. Miss.).——*Iteacrinus* Goldring, 1923 (U.Dev.).——*Kalpidocrinus* Goldring, 1954 (M.Dev.).——*Lasiocrinus* Kirk, 1914 (L.Dev.-L.Miss.).——*Nassoviocrinus* Jaekel, 1918 (L.Dev.-U.Dev.).——*Polycrinus* Jaekel, 1918 (M.Ord.).——*Quantoxocrinus* Webby, 1965 (M.Dev.).——*Streptocrinus* Wachsmuth & Springer, 1886 [=*Ophiocrinus* Angelin, 1878 (*non* Salter, 1856)] (U.Sil.).

Superfamily **MEROCRINACEA** S. A. Miller, 1890 (Moore & Lane, n. superfam.) [=*nom. transl.* Moore & Lane, herein (*ex* Merocrinidae S. A. Miller, 1890)].——Like Dendrocrinacea but arm facets plenary; primanal above rim of cup in *Merocrinus* and directly or obliquely beneath *C* radial in other genera. (M.Ord.-U.Ord.).

Family Merocrinidae S. A. Miller, 1890 (M.Ord.-U.Ord.). Genus: *Merocrinus* Walcott, 1884 (M.Ord.-U.Ord.).

Family Cupulocrinidae Moore & Laudon, 1943 (M.Ord.-U.Ord.). Genus: *Cupulocrinus* d'Orbigny, 1849(1850) [=*Scyphocrinus* Hall, 1847 (*non* Roemer, 1849) (obj.)] (M.Ord.-U.Ord.).

Family Ontariocrinidae Jaekel, 1918 (M.Ord.). Genus: *Ontariocrinus* Jaekel, 1918 (M.Ord.).

Family Ottawacrinidae Moore & Laudon, 1943 (M.Ord.). Genus: *Ottawacrinus* Billings, 1887 (M.Ord.).

Family Metabolocrinidae Jaekel, 1918 (M.Ord.-L.Dev.). Genera: *Metabolocrinus* Jaekel, 1902 (M.Ord.).——*Cyliocrinus* Jaekel, 1918 (U.Sil.).——*Pagecrinus* Kirk, 1929 (L.Dev.).

Suborder **POTERIOCRININA** Jaekel, 1918 [*nom. correct.* Moore in Moore, Lalicker & Fischer, 1952 (*pro* suborder Poteriocrinites Jaekel, 1918)] [=Poteriocrinitina Ubaghs, 1953].——Cup conical, bowl-shaped, or very shallow basin-shaped, arms highly pinnulate or tending to become so; anal sac mostly prominent. (L.Dev.-M.Trias.).

Superfamily **POTERIOCRINITACEA** Bassler, 1938 (Moore, n. superfam.) [*nom. transl.* Moore, herein (*ex* Poteriocrinitidae Bassler, 1938, *nom. correct. pro* family Poteriocrinoidea Austin & Austin, 1843)].——Cup conical, longitudinally straight-sided, with 3 anals, arm facets angustary, steeply declivate; slender arms many-branched. (L.Dev.-U.Perm.).

Family Poteriocrinitidae Bassler, 1938 [*nom. correct. pro* family Poteriocrinoidea Austin & Austin, 1843] [=Rhabdocrinidae Wright, 1944] (L.Dev.-U.Perm.). Genera: *Poteriocrinites* Miller, 1821 (L.Dev.-U.Perm.).——*Denariocrinus* Schmidt, 1941(1942) (M.Dev.).——*Propoteriocrinus* Schmidt, 1941 (1942) (L.Dev.).——*Rhabdocrinus* Wright, 1944 (L.Carb.-U.Carb.).——*Springericrinus* Jaekel, 1918 (L.Miss.).

Superfamily **RHENOCRINACEA** Jaekel, 1918 (Moore, n. superfam.) [*nom. transl.* Moore, herein (*ex* Rhenocrinida Jaekel, 1918)].——Like Poteriocrinitacea but arm facets peneplenary. (L.Dev.-M.Penn.).

Family Rhenocrinidae Jaekel, 1918 [=Glossocrinidae Goldring, 1923] (L.Dev.-M.Penn.). Genera: *Rhenocrinus* Jaekel, 1906 (L.Dev.).——*Araeocrinus* Strimple & Watkins, 1969 (M.Penn.).——*Catactocrinus* Goldring, 1923 (U.Dev.).——*Charientocrinus* Goldring, 1923 (M.Dev.-U.Dev.).——*Cydrocrinus* Kirk, 1940 (L.Miss.).——*Glossocrinus* Goldring, 1923 (U.Dev.).——*Hallocrinus* Goldring, 1923 (L.Dev.-L.Carb.).——*Liparocrinus* Goldring, 1923 (U.Dev.).——*Maragnicrinus* Whitfield, 1905 (U.Dev.).

Family Proctothylacocrinidae Kier, 1952 (M.Dev.). Genus: *Proctothylacocrinus* Kier, 1952 (M.Dev.).

Superfamily **SCYTALOCRINACEA** Moore & Laudon, 1943 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Scytalocrinidae Moore & Laudon, 1943)].——

Like Poteriocrinitacea but arm facets plenary. (M.Dev.-U. Perm.).

Family Scytalocrinidae Moore & Laudon, 1943 [=Scytalecrinidae Bather, 1899] (M.Dev.-U.Perm.). Genera: *Scytalocrinus* Wachsmuth & Springer, 1878(1880) [=*Dactylocrinus* Sladen, 1878 (*non* Quenstedt, 1876); *Scytalecrinus* Bather in Lankester, 1900 (obj.)] (U.Dev.-U.Penn.).——*Anemetocrinus* Wright, 1938 (L.Carb.).——*Bollandicrinus* Wright, 1951 (L.Carb.).——*Bridgerocrinus* Laudon & Severson, 1953 (U.Dev.-L.Miss.).——*Corematocrinus* Goldring, 1923 (U.Dev.).——*Gilmocrinus* Laudon, 1933 (L.Miss.).——*Haeretocrinus* Moore & Plummer, 1940 (M.Penn.-U. Penn.).——*Histocrinus* Kirk, 1940 (L.Miss.).——*Hydriocrinus* Trautschold, 1867 (U.Carb.) (M.Penn.-U.Penn.).——*Hypselocrinus* Kirk, 1940 (L.Miss.).——*Linobrachiocrinus* Goldring, 1939 [=*Linocrinus* Goldring, 1938, Aug. (*non* Kirk, 1938, April)] (U.Dev.).——*Logocrinus* Goldring, 1923 (M.Dev.).——*Melbacrinus* Strimple, 1939 (U. Penn.).——*Morrowcrinus* Moore & Plummer, 1938 (L. Penn.).——*Ophiurocrinus* Jaekel, 1918 (U.Carb.).——*Pegocrinus* Kirk, 1940 (U.Carb.).——*Phacelocrinus* Kirk, 1940 (U.Miss.-L.Penn.) (L.Carb.).——*Priniocrinus* Goldring, 1938 (U.Dev.).——*Roemerocrinus* Wanner, 1923 (U. Perm.).——*Sostronocrinus* Strimple & McGinnis, 1969 (L.Miss.).——*Tundracrinus* Yakovlev, 1928 (L.Perm.).

Family Blothrocrinidae Moore & Laudon, 1943 (L.Miss.-L.Perm.) Genera: *Blothrocrinus* Kirk, 1940 (L.Miss.) (L.Carb.).——*Carcinocrinus* Laudon, 1941 (U.Miss.).——*Culmicrinus* Jaekel, 1918 (L.Carb.) (L.Miss.-U.Miss.).——*Elibatocrinus* Moore, 1940 (M.Penn.-U.Penn.).——*Fifeocrinus* Wright, 1951 (L.Carb.).——*Moscovicrinus* Jaekel, 1918 (U.Carb.).——*Nebraskacrinus* Moore, 1939 (L.Perm.).——*Stinocrinus* Kirk, 1941 (L.Miss.).——*Ulrichicrinus* Springer, 1926 (L.Penn.-M.Penn.).——*Woodocrinus* de Koninck, 1854 (U.Carb.).

Family Cercidocrinidae Moore & Laudon, 1943 (L.Miss.). Genera: *Cercidocrinus* Kirk, 1940 (L.Miss.).——*Ascetocrinus* Kirk, 1940 (L.Miss.).——*Coeliocrinus* White, 1863 (L. Miss.).

Family Aphelecrinidae Strimple, 1967 (L.Miss.-U.Miss.). Genera: *Aphelecrinus* Kirk, 1944 (L.Miss.-U.Miss.).——*Cosmetocrinus* Kirk, 1941 (L.Miss.-U.Miss.).——*Paracosmetocrinus* Strimple, 1967 (L.Miss.).——*Rhopocrinus* Kirk, 1942 (U.Miss.).

Family Corythocrinidae Strimple & Watkins, 1969 (L.Miss.). Genus: *Corythocrinus* Kirk, 1946 (L.Miss.).

Family Spaniocrinidae Moore & Laudon, 1943 (L.Miss.-U.Perm.). Genera: *Spaniocrinus* Wanner, 1924 (L.Penn.-U.Perm.).——*Missouricrinus* S. A. Miller, 1891 (L.Miss.).——*Parspaniocrinus* Strimple, 1971 (L.Perm.).——*Stuartwellercrinus* Moore & Plummer, 1938 (U.Penn.-L.Perm.).

Superfamily **CUPRESSOCRINITACEA** Bassler, 1938 (Roemer, 1854) (Moore & Lane, n. superfam.) [*nom. transl.* Moore & Lane, herein (*ex* Cupressocrinitidae Bassler, 1938, *nom. correct. pro* Cupressocrinidae Roemer, 1854)].——Cup truncate conical, straight-sided, flared at rim, no basal concavity or cup anals, arm facets plenary, orals modified into "consolidating apparatus," no anal sac. (L.Dev.-M.Dev.).

Family Cupressocrinitidae Bassler, 1938 [*nom. correct. pro* Cupressocrinidae Roemer, 1854] (L.Dev.-M.Dev.). Genus: *Cupressocrinites* Goldfuss, 1831 [=*Halocrinites* Steininger, 1831; *Cupressocrinus* Agassiz, 1835; *Cypellocrinites* Steininger, 1849; *Cypellocrinus* Bather in Lankester, 1900; *Procupressocrinus* Jaekel, 1918] (L.Dev.-M.Dev.).

Superfamily **MOLLOCRINACEA** Wanner, 1916 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Mollocrinidae Wanner, 1916)].——Cup bowl-shaped with gently convex base and subvertical to incurved sides at rim; arm facets angustary, declivate, 1 or 2 anals in cup, no anal sac. (L.Penn.-U.Perm.).

Family Mollocrinidae Wanner, 1916 (L.Penn.-U.Perm.). Genera: *Mollocrinus* Wanner, 1916 (U.Perm.).——*Hemimollocrinus* Yakovlev, 1930 (L.Perm.).——*Strongylocrinus* Wanner, 1916 (L.Penn.-U.Perm.).

Superfamily **LOPHOCRINACEA** Bather, 1899 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Lophocrinidae Bather, 1899)].——Cup low bowl-shaped with convex base (exceptionally flat or weakly concave), sides flaring outward near rim; arm facets peneplenary, 2 or 3 anals in cup, anal sac tall and prominent. (L.Miss.-U.Perm.).

Family Lophocrinidae Bather, 1899 (L.Carb.). Genus: *Lophocrinus* von Meyer, 1858 [=*Carduocrinus* von Kuenen, 1895] (L.Carb.).

Family Pelecocrinidae Kirk, 1941 (L.Miss.-U.Perm.). Genera: *Pelecocrinus* Kirk, 1941 (L.Miss.).——*Depaocrinus* Wanner, 1937 (U.Perm.).——*Exoriocrinus* Strimple & Moore, 1971 (U.Penn.).——*Forthocrinus* Wright, 1942 (L.Carb.).——*Malaiocrinus* Wanner, 1924 (U.Perm.).

Family Indocrinidae Strimple, 1966 (L.Perm.-U.Perm.). Genera: *Indocrinus* Wanner, 1916 (U.Perm.).——*Metaindocrinus* Strimple, 1966 (U.Perm.).——*Proindocrinus* Yakovlev, 1939 (L.Perm.).

Family Laudonocrinidae Moore & Strimple, n. fam.——Cup bowl-shaped, with flat or faintly convex base and subvertical sides near rim, arm facets peneplenary, interradial notches seen in dorsal and ventral views; 2 or 3 anals in cup; anal sac mushroomlike with horizontal girdling spines at summit; arms endotomous. (U.Miss.-U.Penn.). Genera: *Laudonocrinus* Moore & Plummer, 1940 (M.Penn.-U.Penn.).——*Anchicrinus* Strimple & Watkins, 1969 (L.Penn.-M.Penn.).——*Athlocrinus* Moore & Plummer, 1940 (L.Penn.-U.Penn.).——*Bathronocrinus* Strimple, 1962 (M.Penn.).——*Paianocrinus* Strimple, 1951 (U.Miss.-U.Penn.).——*Schistocrinus* Moore & Plummer, 1940 (U.Penn.).

Family Stellarocrinidae Strimple, 1961 (L.Carb.-L.Perm.). Genera: *Stellarocrinus* Strimple, 1940 (March), (*nom. subst. pro Whiteocrinus* Strimple, 1939, *non* Jaekel, 1918) [=*Apollocrinus* Moore & Plummer, 1940 (May)] (M.Penn.-L.Perm.).——*Brabeocrinus* Strimple & Moore, 1971 (M.Penn.-L.Perm.).——*Brychiocrinus* Moore & Plummer, 1940 (M.Penn.).——*Celonocrinus* Lane & Webster, 1966 (U.Penn.-L.Perm.).——*Heliosocrinus* Strimple, 1951 (U.Miss.-L.Perm.).——*Pedinocrinus* Wright, 1951 (L. Carb.).

Family Pachylocrinidae Kirk, 1942 (L.Miss.-U.Perm.). Genera: *Pachylocrinus* Wachsmuth & Springer, 1879 (Carb., L.Miss.-Perm.).——*Plummericrinus* Moore & Laudon, 1943 (L. Penn.-U.Perm.).

Superfamily **AGASSIZOCRINACEA** S. A. Miller, 1890 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple,

herein (*ex* Agassizocrinidae S. A. Miller, 1890)].——Cup urn- or bowl-shaped with convex to flat base and subvertical to incurved sides near rim, arm facets plenary, 4 to 1 anals in cup, anal sac small and weak. (L.Miss.-U.Perm.).

Family Bursacrinidae Kirk, 1947 (L.Miss.). Genera: *Bursacrinus* Meek & Worthen, 1861 (L.Miss.).——*Lebetocrinus* Kirk, 1940 (L.Miss.).——*Nactocrinus* Kirk, 1947 (L.Miss.).

Family Ampelocrinidae Kirk, 1942 (L.Miss.-U.Perm.). Genera: *Ampelocrinus* Kirk, 1942 (U.Miss.-L.Penn.).——*Armenocrinus* Strimple & Horowitz, 1971 (L.Miss.-U.Miss.).——*Arroyocrinus* Lane & Webster, 1966 (L.Perm.).——*Chlidonocrinus* Strimple & Watkins, 1969 (U.Miss.-U.Penn.).——*Halogetocrinus* Strimple & Moore, 1971 (M.Penn.-U.Penn.).——*Moundocrinus* Strimple, 1939 (U.Penn.).——*Polusocrinus* Strimple, 1951 (U.Penn.-L.Perm.).——*Sphenoscocrinus* Wanner, 1937 (U.Perm.).

Family Sundacrinidae Moore & Laudon, 1943 (L.Carb.-U.Perm.). Genera: *Sundacrinus* Wanner, 1916 (U.Perm.).——*Basleocrinus* Wanner, 1916 (U.Perm.).——*Hemiindocrinus* Yakovlev, 1926 (L.Perm.).——*Hosieocrinus* Wright, 1952 (L.Carb.).——*Laccocrinus* Wanner, 1949 (U.Perm.).——*Parindocrinus* Wanner, 1937 (U.Perm.).——*Tribrachyocrinus* M'Coy, 1847 [=*Tribrachiocrinus* Wachsmuth & Springer, 1886] (Perm.).

Family Anobasicrinidae Strimple, 1961 (U.Miss.-L.Perm.). Genera: *Anobasicrinus* Strimple, 1961 (L.Penn.-M.Penn.).——*Synyphocrinus* Trautschold, 1867 (U.Carb.-U.Perm.).

Family Agassizocrinidae S. A. Miller, 1890 [incl. Paragassizocrininae Strimple & Watkins, 1969] (U.Miss.-L.Perm.). Genera: *Agassizocrinus* Owen & Shumard, 1851 [=*Astylocrinus* Roemer, 1854] (U.Miss.).——*Anartiocrinus* Kirk, 1940 (U.Miss.).——*Epipetschoracrinus* Yakovlev in Yakovlev & Ivanov, 1956 (L.Perm.).——*Paragassizocrinus* Moore & Plummer, 1940 (L.Penn.-U.Penn.).——*Petschoracrinus* Yakovlev, 1928 (L.Perm.).

Family Cricocrinidae Moore & Strimple, n. fam.——Cup flat-based, sides subvertical to incurved near rim, arm facets plenary, 3 anals in cup. (M.Penn.). Genus: *Cricocrinus* Strimple & Watkins, 1969 (M.Penn.).

Family Trimerocrinidae Moore & Laudon, 1943 (U.Perm.). Genus: *Trimerocrinus* Wanner, 1916 (U.Perm.).

Superfamily **CROMYOCRINACEA** Bather, 1890 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Cromyocrinidae Bather, May, 1890)].——Cup bowl-shaped, with or without basal concavity, radials with plenary articular facets, two or three anals in cup. Anal sac not prominent. Arms uniserial or biserial, five to 20 or more, branching confined to primibrachs *1* and secundibrachs *1*. Stem transversely circular. (U.Miss.-L.Perm.).

Family Eupachycrinidae E. A. Miller, Dec., 1890 (U.Miss.-L. Perm.). Genera: *Eupachycrinus* Meek & Worthen, 1865 (U.Miss.).——*Bronaughocrinus* Strimple, 1951 (U.Miss.).——*Ethelocrinus* Kirk, 1937 (U.Penn.).——*Intermediacrinus* Sutton & Winkler, 1940 (U.Miss.).

Family Phanocrinidae Knapp, 1969 (Mar.) [=Phanocrinidae Strimple & Watkins, 1969 (July)] (U.Miss.) (L.Carb.-U.Carb.). Genera: *Phanocrinus* Kirk, 1937 (U.Miss.) (L.Carb.).——*Cryphiocrinus* Kirk, 1929 (U.Miss.).——*Idosocrinus* Wright, 1954 (L.Carb.).——*Pentaramicrinus* Sutton & Winkler, 1940 (U.Miss.) (U.Carb.).

Family Cromyocrinidae Bather, May, 1890 [*nom. transl.* Jaekel, 1918 (*ex* series Cromyocrinites Bather, 1890)] (L.Carb.-L.Perm.). Genera: *Cromyocrinus* Trautschold, 1867 (L. Carb.-L.Perm.).——*Aglaocrinus* Strimple, 1961 [=*Tarachiocrinus* Strimple, 1961 (*pro Ataxiacrinus* Strimple, 1961, *non* Lyon, 1869)] (M.Penn.-L.Perm.).——*Dicromyocrinus* Jaekel, 1918 (L.Penn.-U.Penn.) (U.Carb.).——*Golcocrinus* Strimple & Watkins, 1969 (U.Miss.-M.Penn.).——*Mantikosocrinus* Strimple, 1951 (U.Miss.).——*Metacromyocrinus* Strimple, 1961 (L.Penn.-M.Penn.).——*Moapacrinus* Lane & Webster, 1966 (L.Perm.).——*Mooreocrinus* Wright & Strimple, 1945 (U.Carb.).——*Paracromyocrinus* Strimple, 1966 (L.Penn.-L.Perm.).——*Parethelocrinus* Strimple, 1961 (M.Penn.).——*Parulocrinus* Moore & Plummer, 1940 (U.Penn.-L.Perm.).——*Synarmocrinus* Lane, 1964 (L. Penn.-L.Perm.).——*Terpnocrinus* Strimple & Moore, 1971 M.Penn.).

Family Ulocrinidae Moore & Strimple, 1973 (L.Carb.-Perm.). Genera: *Ulocrinus* Miller & Gurley, 1890 (M.Penn.-Perm.).——*Probletocrinus* Strimple & Moore, 1971 (U.Penn.).——?*Tyriocrinus* Wright, 1945 (L.Carb.).——*Ureocrinus* Wright & Strimple, 1945 (L.Carb.).

Family Cadocrinidae Moore & Laudon, 1943 (U.Perm.). Genus: *Cadocrinus* Wanner, 1924 (U.Perm.).

Superfamily **HYDREIONOCRINACEA** Jaekel, 1918 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Hydreionocrinidae Jaekel, 1918)].——Cup low bowl-shaped, sides flared outward at rim, plenary arm facets, arms biserial, exotomous; 3 anals in cup. (up.L.Carb., U. Miss.).

Family Hydreionocrinidae Jaekel, 1918 (up.L.Carb.). Genera: *Hydreionocrinus* de Koninck, 1858 (up.L.Carb.).——*Derbiocrinus* Wright, 1951 (up.L.Carb.).——*Telikosocrinus* Strimple, 1951 (U.Miss.).

Superfamily **ERISOCRINACEA** Wachsmuth & Springer, 1886 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Erisocrinidae Wachsmuth & Springer, 1886)].——Cup low conical to bowl-shaped, sides flaring outward or curving inward near rim, arm facets plenary, single anal in cup or none visible externally, arms 10 uniserial or biserial, anal sac cylindrical, short and weak. (M. Dev.-L.Perm.).

Family Erisocrinidae Wachsmuth & Springer, 1886 (*nom. transl.* S. A. Miller, 1890) (*ex* section Erisocrinites Wachsmuth & Springer, 1886)] (L. Penn.-L.Perm.). Genera: *Erisocrinus* Meek & Worthen, 1865 [=*Libratocrinus, Pontotocrinus, Parerisocrinus* Knapp, 1969] (L.Penn.-L.Perm.).——*Exaetocrinus* Strimple & Watkins, 1969 (L.Carb.-U.Carb.; U.Penn.-L.Perm.).——*Sinocrinus* Tien, 1926 (U.Carb.).

Family Decadocrinidae Bather, 1890 [=Ramulocrinidae Strimple & Watkins, 1969] (M.Dev.-U.Penn.). Genera: *Decadocrinus* Wachsmuth & Springer, 1879(1880) (M.Dev.-L. Miss.).——*Acylocrinus* Kirk, 1947 (L.Miss.).——*Aulocrinus* Wachsmuth & Springer, 1897 (L.Miss.).——*Eireocrinus* Wright, 1951 (L.Carb.).——*Glaukosocrinus* Strimple, 1951 [=*Gloukosocrinus* Strimple, 1961] (M.Penn.-U.Penn.).——*Ramulocrinus* Laudon, Parks & Spreng, 1952 (L.Miss.-

M.Penn.).——*Trautscholdicrinus* Yakovlev & Ivanov, 1939 (U.Carb.).

Family Graphiocrinidae Wachsmuth & Springer, 1886 [*nom. transl.* Bather, 1899 (*ex* series Graphiocrinites Wachsmuth & Springer, 1886)] (L.Carb.-U.Perm.). Genera: *Graphiocrinus* de Koninck & Lehon, 1854 [=*Scaphiocrinus* Hall, 1858] (L.Carb.).——*Contocrinus* Knapp, 1969 (M.Penn.-U.Penn.).——*Euerisocrinus* Strimple, 1939 (U.Penn).——*Holcocrinus* Kirk, 1945 (L.Carb.).

Family Paradelocrinidae Knapp, 1969 (L.Penn.-U.Perm.). Genera: *Paradelocrinus* Moore & Plummer, 1940 (L.Penn.-U.Penn.).——*Atokacrinus* Knapp, 1969 (M.Penn.).——*Lopadiocrinus* Wanner, 1916 (U.Perm.).——*Neocatacrinus* Knapp, 1969 (U.Penn.).——*Sublobalocrinus* Knapp, 1969 (U.Penn.).

Family Arkacrinidae Knapp, 1969 [*nom. transl.* Moore & Strimple, herein (*ex* Arkacrininae Knapp, 1969)] (L.Penn.). Genus: *Arkacrinus* Knapp, 1969 (L.Penn.).

Family Diphuicrinidae Strimple & Knapp, 1966 [incl. Graffhamicrininae Knapp, 1969] (L.Penn.-L.Perm.). Genera: *Diphuicrinus* Moore & Plummer, 1938 (L.Penn.-M.Penn.).——*Graffhamicrinus* Strimple, 1961 [=*Tholiacrinus* Strimple, 1962] (M.Penn.-L.Perm.).

Family Protencrinidae Knapp, 1969 (M.Penn.) (mid.U.Carb.). Genera: *Protencrinus* Jaekel, 1918 (M.Penn.) (mid.U.Carb.).——*Neoprotencrinus* Knapp, 1969 (M.Penn.).

Family Catacrinidae Knapp, 1969 [*nom. transl.* Moore & Strimple, herein (*ex* Catacrininae Knapp, 1969)] [incl. Arrectocrininae, Palmerocrininae, Knapp, 1969] (M.Penn.-U.Perm.). Genera: *Delocrinus* Miller & Gurley, 1890 [=*Catacrinus* Knapp, 1969; *Asaccocrinus* Wanner, 1916; *Wewokacrinus* Knapp, 1969; *Palmatocrinus* Knapp, 1969; *Cathetocrinus* Knapp, 1969] (M.Penn.-U.Perm.).——*Arrectocrinus* Knapp, 1969 [=*Metarrectocrinus* Knapp, 1969] (U.Penn.-L.Perm.).——*Endelocrinus* Moore & Plummer, 1940 (L.Penn.-L.Perm.).——*Lobalocrinus* Knapp, 1969 (U.Penn.).——*Palmerocrinus* Knapp, 1969 (L.Penn.-U.Penn.).——*Parallelocrinus* Knapp, 1969 (M.Penn.).——*Paraplasocrinus* Moore & Plummer, 1938 (U.Perm.).——*Pyndaxocrinus* Knapp, 1969 (U.Penn.-L.Perm.).——*Subarrectocrinus* Knapp, 1969 (U.Penn.).

Family Stachyocrinidae Moore & Strimple, n. fam.——Crown cylindrical to ovoid. Cup low bowl- or saucer-shaped, with shallow basal concavity, proximal tips of radials reaching basal plane of cup or well above it; primanal in notch between *C* and *D* radial articular facets, not visible from side. Arms ten, uniserial, brachials rectangular in side view. Stem impression circular. (U.Perm.). Genera: *Stachyocrinus* Wanner, 1916 (U.Perm.).——*Parastachyocrinus* Wanner, 1949 (U.Perm.).

Superfamily **APOGRAPHIOCRINACEA** Moore & Laudon, 1943 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Apographiocrinidae Moore & Laudon, 1943)].——Cup bowl-shaped with narrow basal concavity and steep to incurved sides near rim, arm facets peneplenary, primanal on squarely truncate *CD* basal only cup anal, arms 5 or 10, uniserial. (L.Penn.-U.Perm.).

Family Apographiocrinidae Moore & Laudon, 1943 (L.Penn.-U.Perm.). Genera: *Apographiocrinus* Moore & Plummer, 1940 (L.Penn.-L.Perm.).——*Paragraphiocrinus* Wanner, 1937 (U.Perm.).

Family Clathrocrinidae Strimple & Moore, 1971 (U.Penn.). Genus: *Clathrocrinus* Strimple & Moore, 1971 (U.Penn.).

Superfamily **PIRASOCRINACEA** Moore & Laudon, 1943 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Pirasocrinidae Moore & Laudon, 1943)].——Crown pyriform; cup very low bowl-shaped, with mostly deep basal concavity and rounded sides incurved at rim, arm facets peneplenary, interradial notches at rim, 3 anals in cup, anal sac tall, typically mushroomlike with girdle of horizontal spines around summit platform. (L.Miss.-L.Perm.).

Family Pirasocrinidae Moore & Laudon, 1943 [incl. Aatocrininae, Affinocrininae, Exterocrininae, Lasanocrininae, Pirasocrininae, Psilocrininae, Sciadiocrininae, Triceracrininae (all Knapp, 1969)] (U.Miss.-U.Perm.). Genera: *Pirasocrinus* Moore & Plummer, 1940 (M.Penn.).——*Aatocrinus* Moore & Plummer, 1940 (M.Penn.-U.Penn.).——*Affinocrinus* Knapp, 1969 (L.Penn.-M.Penn.).——*Eirmocrinus* Strimple & Watkins, 1969 (M.Penn.).——*Exterocrinus* Knapp, 1969 (L.Penn.).——*Lasanocrinus* Moore & Plummer, 1940 (L.Penn.).——*Metaffinocrinus* Knapp, 1969 (M.Penn.).——*Metaperimestocrinus* Strimple, 1961 (M.Penn.).——*Metutharocrinus* Moore & Strimple, 1973 (L.Penn.).——*Perimestocrinus* Moore & Plummer, 1938 (L.Penn.-U.Penn.).——*Platyfundocrinus* Knapp, 1969 (M.Penn.).——*Plaxocrinus* Moore & Plummer, 1938 (M.Penn.-U.Penn.).——*Polygonocrinus* Strimple, 1961 (M.Penn.).——*Psilocrinus* Knapp, 1969 (M.Penn.).——*Retusocrinus* Knapp, 1969 (M.Penn.).——*Schedexocrinus* Strimple, 1961 (M.Penn.).——*Sciadiocrinus* Moore & Plummer, 1938 (L.Penn.-U.Penn.).——*Separocrinus* Knapp, 1969 (U.Penn.).——*Simocrinus* Knapp, 1969 (U.Penn.).——*Stenopecrinus* Strimple, 1961 (L.Penn.-U.Penn.).——*Triceracrinus* Bramlette, 1943 (L.Perm.-U.Perm.).——*Utharocrinus* Moore & Plummer, 1938 (L.Penn.-U.Penn.).——*Vertigocrinus* Knapp, 1969 (U.Penn.).——*Zetusocrinus* Strimple, 1961 (U.Miss.).

Family Adinocrinidae Strimple, 1961 (L.Miss.). Genus: *Adinocrinus* Kirk, 1938 (L.Miss.).

Superfamily **TEXACRINACEA** Strimple, 1961 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Texacrinidae Strimple, 1961)].——Crown tall and slender, cup bowl-shaped with basal concavity and steep sides near rim, arm facets plenary, 1 to 3 anals in cup, anal sac tall, composed of longitudinal rows of plates, arms long, commonly many (to 40) but 5 or 10 in some. (U.Miss.-L.Perm.).

Family Texacrinidae Strimple, 1961 (U.Penn.-L.Perm.). Genus: *Texacrinus* Moore & Plummer, 1940 (U.Penn.-L.Perm.).

Family Galateacrinidae Knapp, 1969 [*nom. transl.* Moore & Strimple, herein (*ex* Galateacrininae Knapp, 1969)] (M.Penn.-U.Penn.). Genus: *Galateacrinus* Moore, 1940 (M.Penn.-U.Penn.).

Family Sellardsicrinidae Strimple & Watkins, 1969 (M.Penn.). Genus: *Sellardsicrinus* Moore & Plummer, 1940 (M.Penn.).

Family Cymbiocrinidae Strimple & Watkins, 1969 (U.Miss.-U.Penn.). Genera: *Cymbiocrinus* Kirk, 1944 (U.Miss.).——*Acnigmocrinus* Strimple, 1973 (U.Miss.).——*Aesiocrinus* Miller & Gurley, 1890 [=*Pentadelocrinus* Strimple, 1939] (U.Penn.).——*Allosocrinus* Strimple, 1949 (M.Penn.-U.Penn.).——*Lecobasicrinus* Strimple & Watkins, 1969 (L.Penn.-U.Penn.).——*Proallosocrinus* Moore & Strimple, herein (L.Penn.).——*Oklahomacrinus* Moore, 1939 (M.Penn.-U.Penn.).

TABLE 1. *Stratigraphic Distribution of Flexible and Inadunate Crinoid Taxa.*

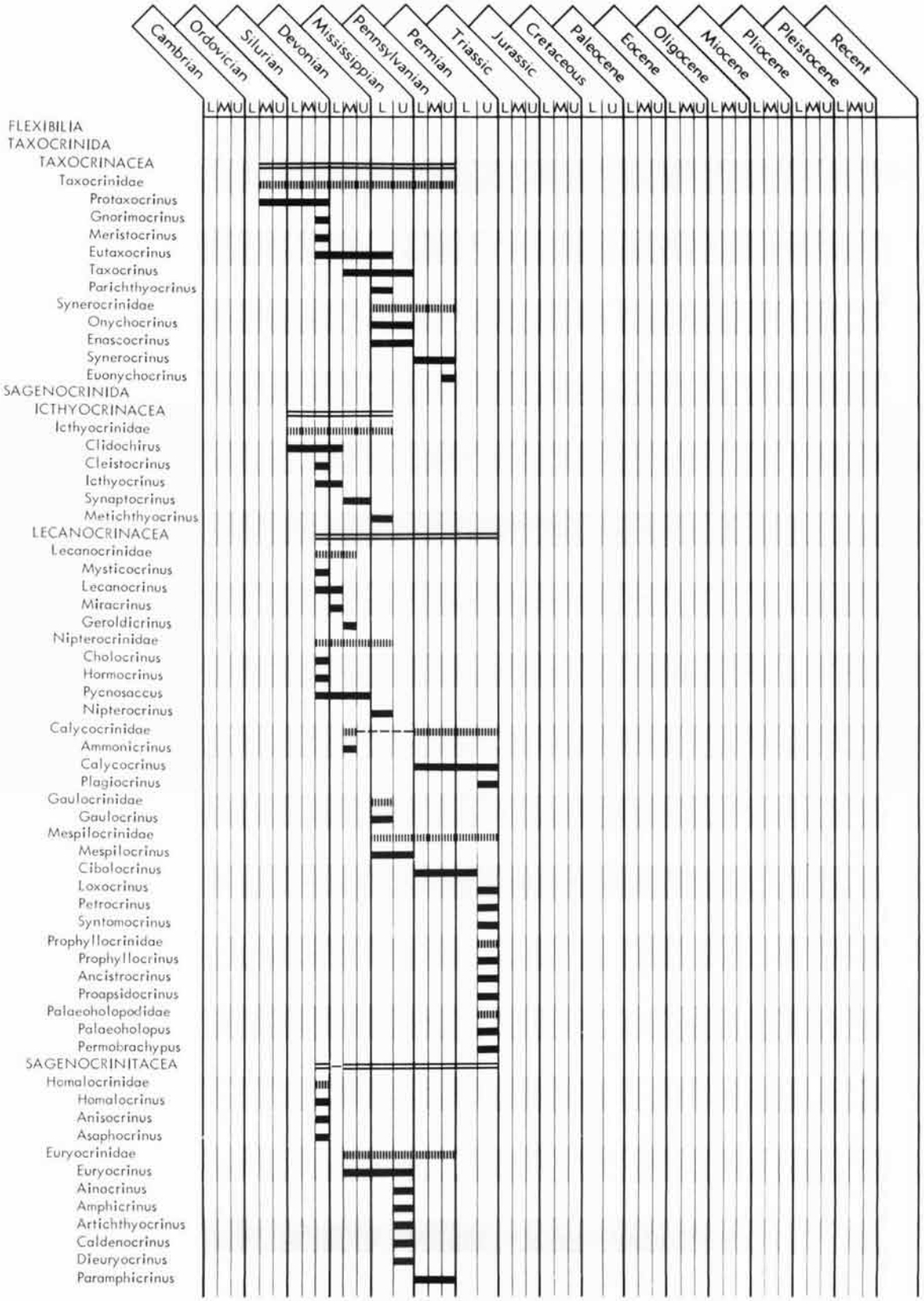


TABLE 1. *(Continued.)*

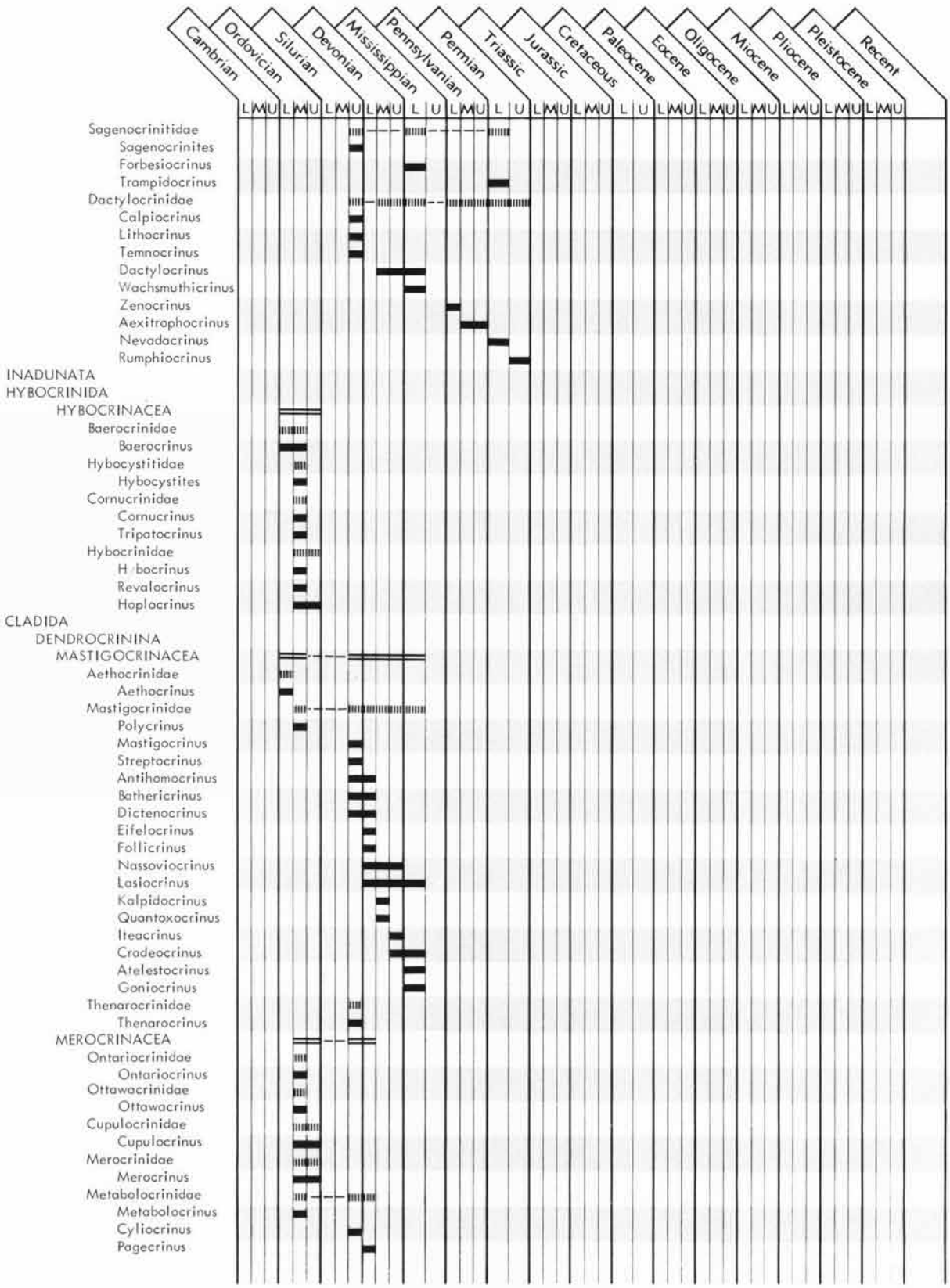
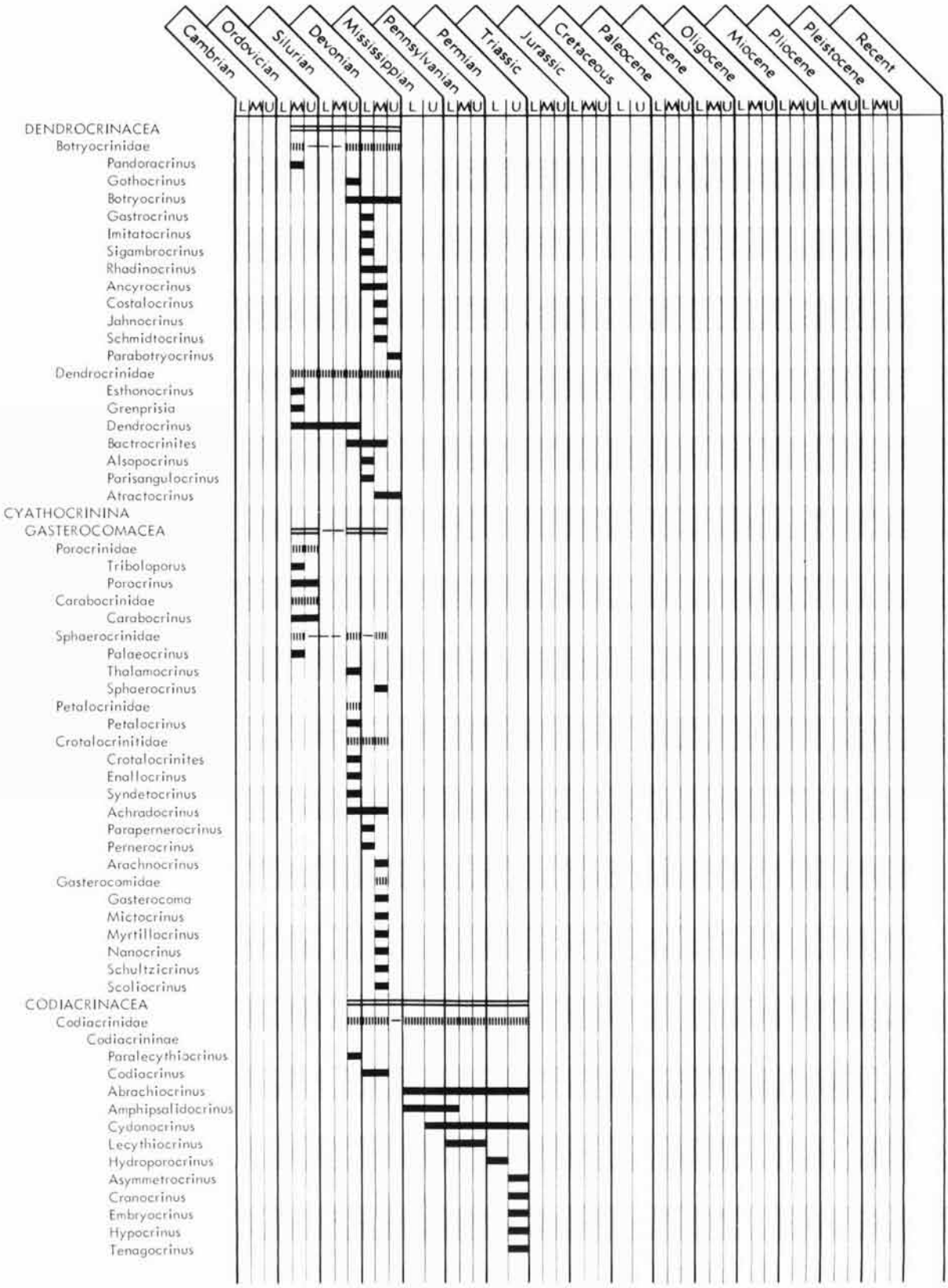


TABLE 1. *(Continued.)*



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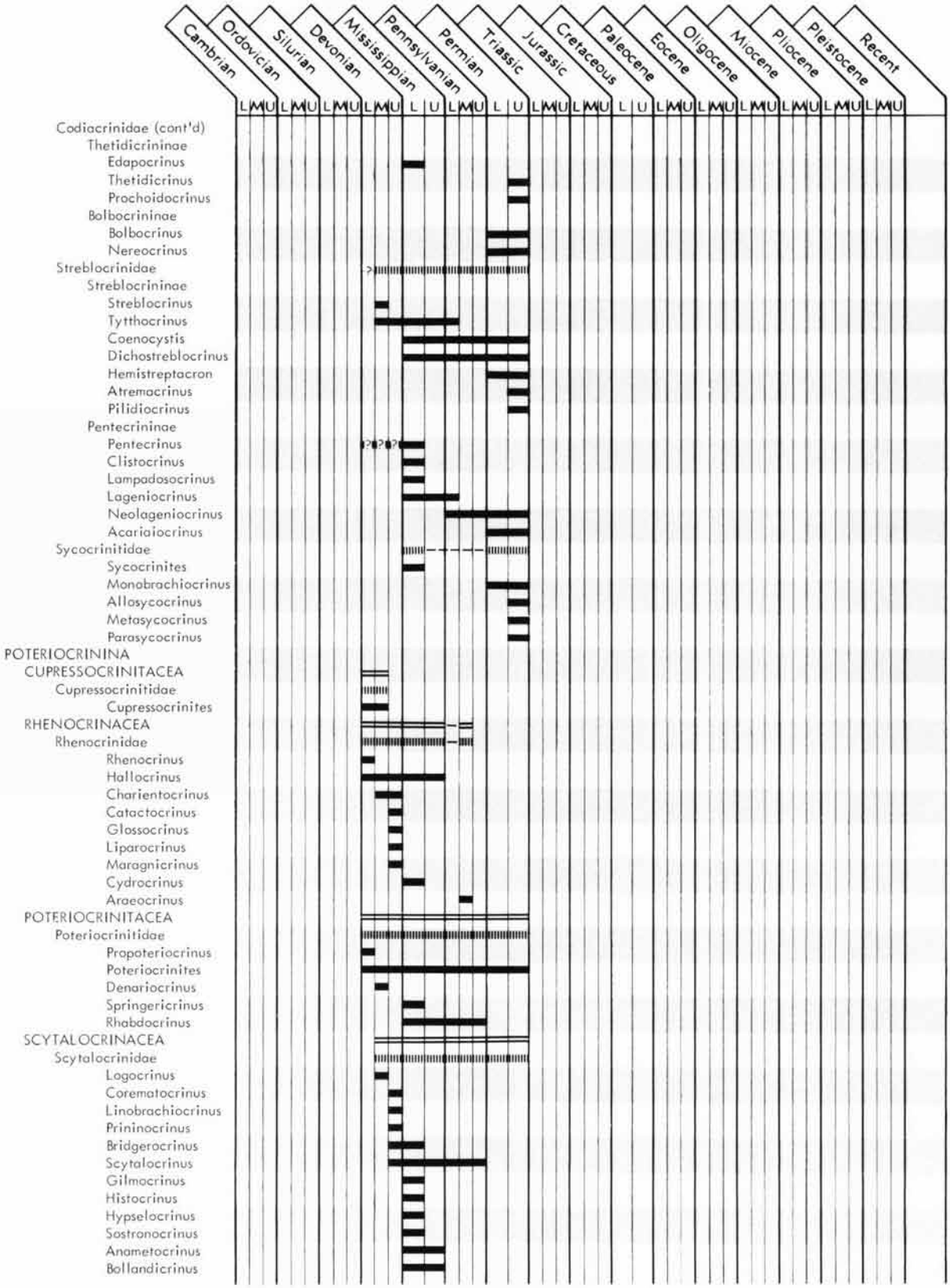


TABLE 1. *(Continued.)*

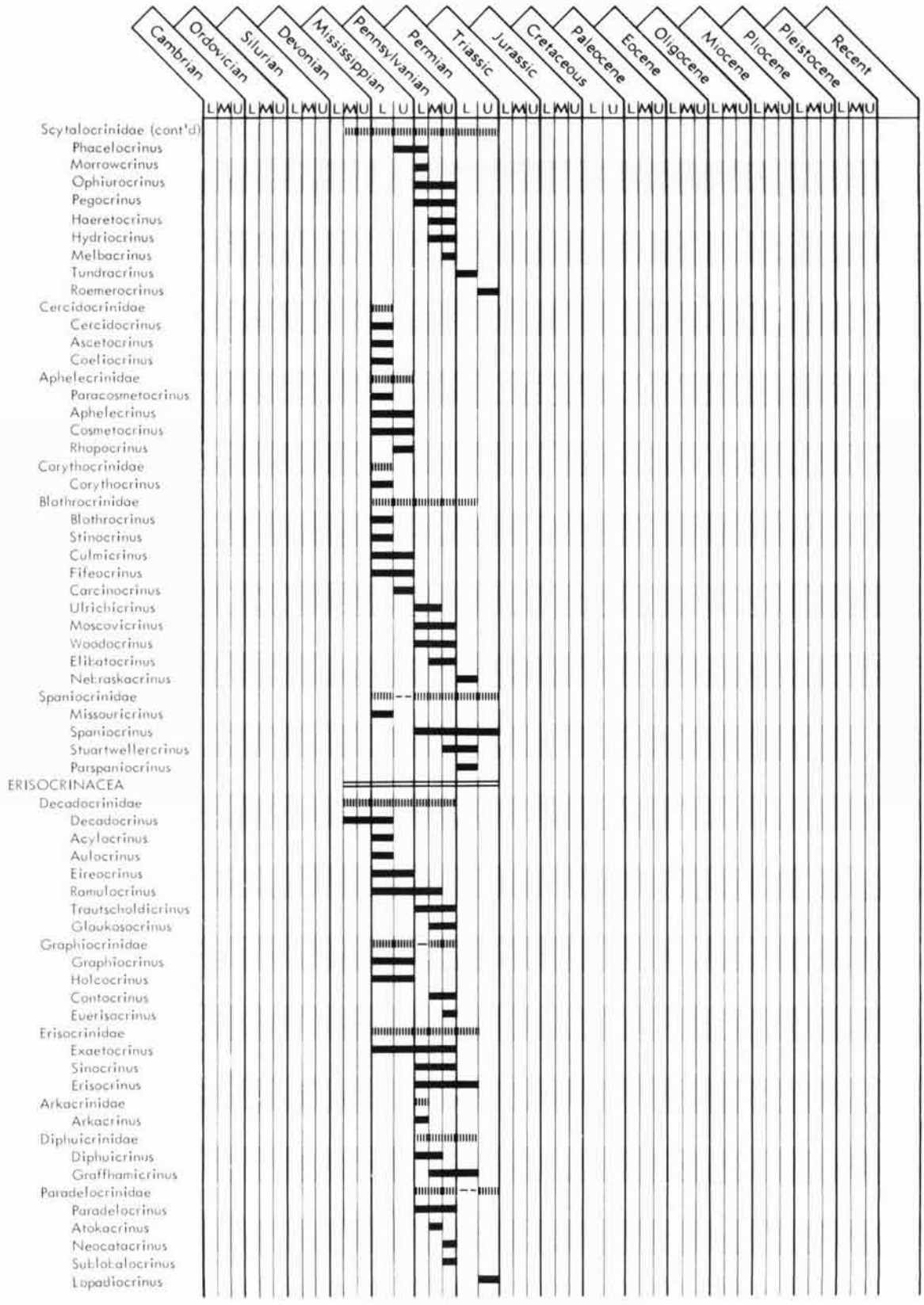


TABLE 1. *(Continued.)*

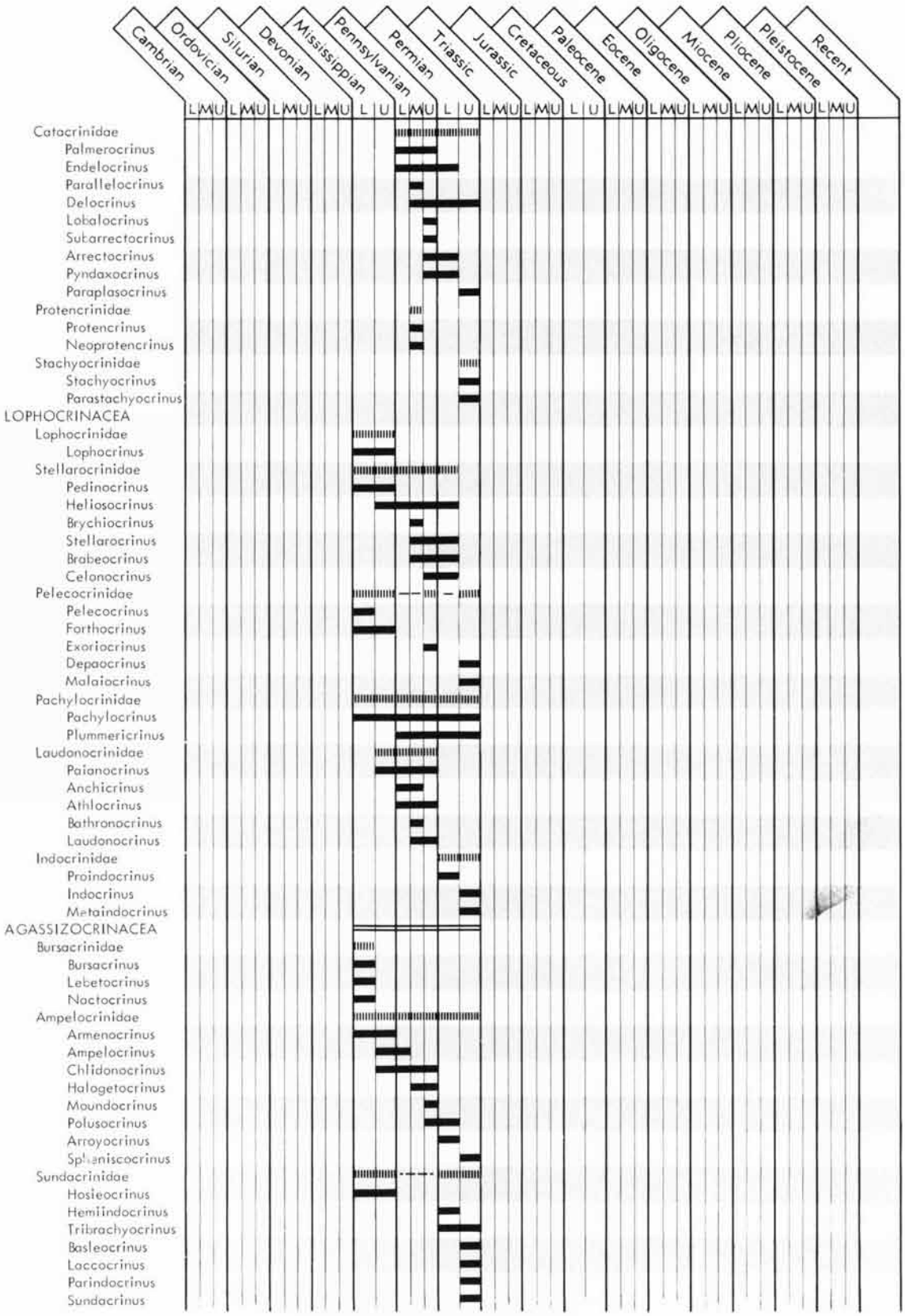


TABLE 1. *(Continued.)*

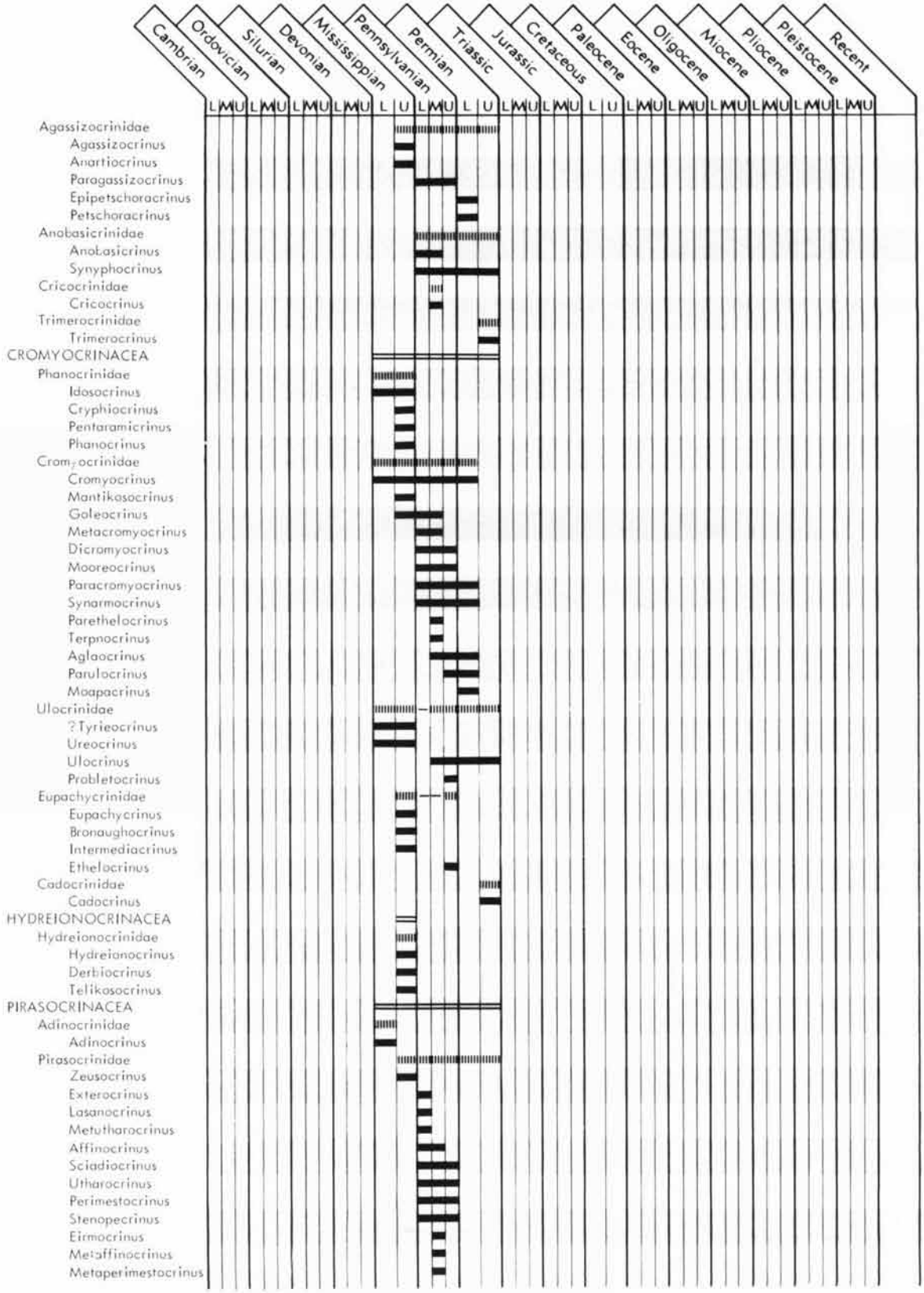
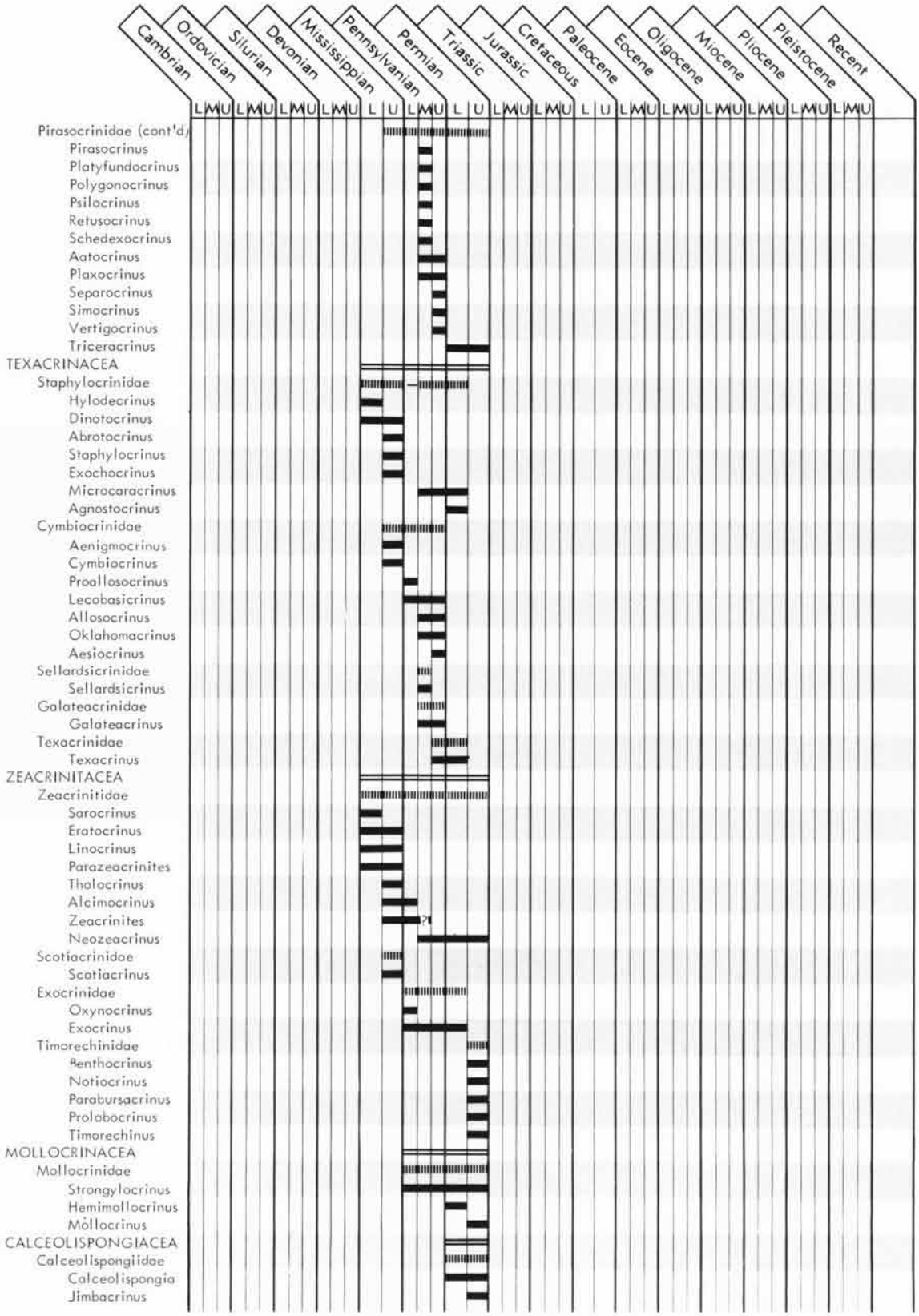


TABLE 1. *(Continued.)*



Family Staphylocrinidae Moore & Strimple, n. fam.——Crown tall, slender; cup bowl-shaped, with basal concavity or exceptionally with fused infrabasal circlet gently convex and visible from side, arm facets plenary, arms 20 to 80 or more, 2 or 3 anals in cup. (L.Miss.-L.Perm.). Genera: *Staphylocrinus* Burdick & Strimple, 1969 (U.Miss.).——*Abrotocrinus* Miller & Gurley, 1890 (U.Miss.).——*Agnostocrinus* Webster & Lane, 1967 (L.Perm.).——*Dinotocrinus* Kirk, 1941 (L.Miss.-U.Miss.).——*Exochocrinus* Burdick & Strimple, 1969 (U.Miss.).——*Hylodecrinus* Kirk, 1941 (L.Miss.).——*Microcaracrinus* Strimple & Watkins, 1969 (M.Penn.-L.Perm.).

Superfamily **ZEACRINITACEA** Bassler & Moodey, 1943 (Moore & Strimple, n. superfam.) [*nom. transl.* Moore & Strimple, herein (*ex* Zeacrinitidae Bassler & Moodey, 1943, *nom. correct. pro* Zeacrinidae Kirk, 1942)]. (U.Miss.-U.Perm.).

Family Zeacrinitidae Bassler & Moodey, 1943 [=Zeacrinidae Kirk, 1942] (L.Miss.-U.Perm.). Genera: *Zeacrinites* Troost in Hall, 1858 [=*Zeacrinus* Hall, 1858; *Xystocrinus* Moore & Plummer, 1938] (U.Miss.-?M.Penn.).——*Alcimocrinus* Kirk, 1938 (U.Miss.-L.Penn.).——*Eratocrinus* Kirk, 1938 (L.Miss.-U.Miss.).——*Linocrinus* Kirk, 1938 (L.Miss.-U.Miss.).——*Neozeacrinus* Wanner, 1937 (M.Penn.-U.Perm.).——*Parazeacrinites* Burdick & Strimple, 1971 (L.Carb.).——*Sarocrinus* Kirk, 1942 (L.Miss.).——*Tholocrinus* Kirk, 1939 (U.Miss.).

Family Exocrinidae Strimple & Watkins, 1969 (L.Penn.-L.Perm.). Genera: *Exocrinus* Strimple, 1949 (L.Penn.-L.Perm.).——*Oxynocrinus* Strimple & Watkins, 1969 (L.Penn.).

Family Timorechinidae Jaekel, 1918 (U.Perm.). Genera: *Timorechinus* Wanner, 1910(1911) [=*Timorocrinus* Wanner, 1912; *Timorocystis* Lambert, 1914] (U.Perm.).——*Benthocrinus* Wanner, 1937 (U.Perm.).——*Notiocrinus* Wanner, 1924 (U.Perm.).——*Parabursacrinus* Wanner, 1924 (U.Perm.).——*Prolobocrinus* Wanner, 1937 (U. Perm.).

Family Scotiacrinidae Moore & Strimple, n. fam.——Like *Zeacrinites* but cup moderately deep bowl-shaped and plates tumid, uniserial arms branching on first primibrachs; arm facets plenary. (up.L.Carb.). Genus: *Scotiacrinus* Wright, 1951 (up.L.Carb.).

Superfamily **CALCEOLISPONGIACEA** Teichert, n. superfam. [*nom. transl.* Teichert, herein (*ex* Calceolispongiidae Teichert, 1954)].——Cup large, base concave, distinguished mainly by prominent spine- or spadelike projections of basals in *Calceolispongia*, arms 5 obliqui-uniserial, spread out laterally. (L.Perm.-U.Perm.).

Family Calceolispongiidae Teichert, 1954 (L.Perm.-U.Perm.). Genera: *Calceolispongia* Etheridge, Jr., 1914 [=*Dinocrinus* Wanner, 1916] [Includes largest, most ponderous crinoid cup known in entire world]. (L.Perm.-U.Perm.).——*Jimbacrinus* Teichert, 1954 (U.Perm.).

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SYSTEMATIC DESCRIPTIONS

The arrangement of taxonomic units adopted in this paper follows that which will be given in the forthcoming Part T of the *Treatise on Invertebrate Paleontology* on Crinoidea.

DESIGNATIONS OF SPECIMENS

Catalogue numbers cited here utilize the index letters BYU (for Brigham Young University), KUMIP (for Kansas University Museum of Invertebrate Paleontology), OU (for Oklahoma University), P (for Plummer Collection), SUI (for State University of Iowa), and USNM (for United States National Museum). BYU specimens are reposited in the Geology Department, Brigham Young University, Provo Utah; KUMIP specimens are reposited in the Museum of Invertebrate Paleontology, The University of Kansas, Lawrence, Kansas, except specimens transferred to The University of Iowa or United States National Museum (Springer Collection); OU specimens are in the Department of Geology Collections, The University of Oklahoma, Norman, Oklahoma; P specimens are in the Natural History Museum, The University of Texas, Austin, Texas; SUI specimens are in the Department of Geology Repository, The University of Iowa, Iowa City, Iowa; USNM specimens are in the Springer Collection of the United States National Museum, Washington, D.C.

Class CRINOIDEA Miller, 1821

Diagnosis.—Echinoderms with skeleton divisible into stem, theca, and arms; stem commonly fixed to sea bottom or foreign object by holdfast; theca enclosing most body parts of dorsal cup or calyx and tegmen, which

may extend into anal sac; arms serving as food-gathering apparatus formed by series of plates termed brachials, joined to dorsal cup at its summit or to theca below tegmen, arms generally branched but may be unbranched (atomous) and with or without lateral branchlets called pinnules or ramules. [Some crinoids stemless and capable of locomotion.]

Occurrence.—Lower Ordovician-Quaternary (Holocene).

Subclass FLEXIBILIA Zittel, 1895

[*nom. correct.* Zittel, 1895, p. 165 (*pro* Articulata Zittel, 1879, p. 345, *non* Miller, 1821, p. 13)] [=suborder Articulosa Jaekel, 1894, p. 118; Articulata Wachsmuth & Springer, 1885, p. 304(82) (*partim*); order Flexibilida Pearse, 1947, p. 10]

Diagnosis.—Dicyclic crinoids (circlets of infrabasals and basals in lower part of cup or calyx next to stem); infrabasals three, comprising two large plates and azygous small one in *C* ray; movable ligamentary junctions of plates; proximal portion of arms generally but not invariably incorporated in calyx without distinct separation from one another, arms tending to be structurally joined to neighbors, commonly with supplemental plates (interradials, interbrachials) between them; arms lacking pinnules; tegmen flexible, formed by orals, ambulacrals, and interambulacrals. Stem invariably circular in section, lacking cirri.

Occurrence.—Middle Ordovician-Upper Permian.

Order SAGENOCRINIDA Springer, 1913

[Sagenocrinida, *nom. correct.* Ubaghs, 1953, p. 755 (*pro* Sagenocrinoidea Springer, 1913, p. 203)]

Diagnosis.—Cup or calyx distinctly or not well differentiated from free arms, plates more firmly joined together than in other Flexibilia; interradials and interbrachials commonly present but may be absent; primanal (when present) narrowly in contact with *CD* basal but widely adjoining *C* and *D* radials, not succeeded by anal plate series bordered by flexible integument.

Occurrence.—Middle Ordovician-Upper Permian.

Superfamily LECANOCRINACEA Springer, 1913 (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (*ex* Lecanocrinidae Springer, 1913, p. 203)]

Type Genus.—*Lecanocrinus* Hall, 1852, p. 199.

Diagnosis.—Crown compactly ovoidal or spheroidal, with closely adjoined incurved short, wide arms. Cup evenly bowl-shaped, summit of large radials sharply set off from wide low brachials in lower part of arms; infrabasals commonly extending well beyond stem impression, uncommonly entirely concealed by stem; primanal obliquely left below *C* radial (equivalent to radianal) or directly above *CD* basal (equivalent to *X* plate) and reaching upward in some species to primibrachs *2* or *3*; mostly no interradials and interbrachials rare. Moderately large stem transversely circular and composed near cup of thin columnals.

Discussion.—This superfamily includes the following families: Lecanocrinidae Springer, 1913; Nipterocrinidae Jaekel, 1918; Mespilocrinidae Jaekel, 1918; Calycocrinidae Moore & Strimple, n. fam.; Gaulocrinidae Moore & Strimple, n. fam.; Prophyllocrinidae Moore & Strimple, n. fam.; and Palaeoholopodidae Wanner, 1916. More than any other flexible crinoid group, the Lecanocrinacea resemble various inadunates.

Occurrence.—Upper Silurian (Gotlandian)-Upper Permian (Basleoan).

Family MESPILOCRINIDAE Jaekel, 1918

Type Genus.—*Mespilocrinus* de Koninck & LeHon, 1854(1853), p. 111.

Diagnosis.—Crown globular, arms in some genera twisted toward right; radianal equivalent lacking, primanal large, broadly resting on *CD* basal. Columnals of proximal, medial, and distal parts of stem dissimilar.

Occurrence.—Lower Mississippian (Osagian)-Upper Permian (Basleoan).

Genus CIBOLOCRINUS Weller, 1909

Type Species.—*Cibolocrinus typus* Weller, 1909, p. 630.

Diagnosis.—Crown rotund, consisting of bowl-shaped cup and wide closely adjoined arms which exhibit no twist, brachials short; three infrabasals, small azygous plate in *C* ray; basals moderately large, with proximal part in basal plane of cup; radials large, with evenly aligned summits, articular facets very short, matching thickness of plates; primanal large, overlying broadly and squarely truncate *CD* basal. Stem large, transversely circular, its attachment to cup generally in vertically sided depression.

Discussion.—The original generic concept of Weller has been emended by Moore & Plummer (1938, p. 225-231) and is accepted as a well-differentiated taxon.

Two species, *Cibolocrinus tumidus* Moore & Plummer (1938, p. 232) and *C. regularis* Moore & Plummer (*ibid.*, p. 235), have been described from the Brentwood Limestone, Bloyd Formation (Morrowan) of Arkansas and Oklahoma. *C. tumidus* is reported to have more bulbous plates and proportionately shorter radials than *C. regularis*. In addition, the small infrabasal of *C. tumidus* is in *C* ray whereas that of *C. regularis* is in *A* ray, which may or may not be of specific importance. Both species have closely spaced small granules.

Occurrence.—Pennsylvanian (Morrowan-Virgilian)-Permian; USA (Texas-Oklahoma-Arkansas-Kansas-Nebraska).

CIBOLOCRINUS TUMIDUS Moore & Plummer, 1938
Plate 1, figures 1a-d

Discussion.—This species is rather common in rocks of Brentwood age in Oklahoma and has been recognized in Arkansas. Because the plates are thin, conditions need to be ideal for the preservation of complete cups. A single hypotype (SUI 33292) is figured for comparative purposes.

Types.—Holotype (KUMIP 45193=USNM 140997), paratypes (KUMIP 45193a=USNM 140998, b=USNM 140999, KUMIP 45201=USNM 140998B) collected by R. C. Moore and C. L. Foster. Figured hypotype SUI 33292 and hypotypes SUI 35489, 33377, 33388, 33393 reposited in Geology Department Repository, The University of Iowa, Iowa City.

Occurrence.—Brentwood interval, Bloyd Formation; Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1]; SUI 33292, Flat Rock Creek, Wagner County, Oklahoma [Loc. 10]; SUI 35489 (4 specimens) east shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16]; SUI 33377, 33388, spillway of Greenleaf Lake, southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a]; SUI 33393, abandoned quarry, Tenkiller Lake, Sequoyah County, Oklahoma [Loc. 25].

CIBOLOCRINUS SPINOSUS Moore & Strimple, new species
Plate 1, figures 2a-c

Description.—Cup very low bowl-shaped with shallow basal concavity accentuated by sharply impressed columnar attachment area. Infrabasals extending beyond large columnar scar; basals (4 preserved) large, protruded in midportion as short, blunt spines just above the basal plane of the cup; radials (3 preserved) protruded as short blunt spines just above midlength; primanal missing but distal facet of *CD* basal shows it to be a large plate; radial articular facets short, typical of the genus. Surface of cup finely granulose.

Discussion.—This monotypic specimen represents the only spinose form of *Cibolocrinus* known, although *C. nodosus* Yakovlev (1934) from the Permian of Sicily has somewhat similar protrusion of the radials. In other respects the species is very much like *C. tumidus.*

Dimensions.—Measurements of holotype (SUI 33066) in millimeters are width of cup, 18.3; height, 7.7; width of infrabasal circlet, 7.6; width of *DE* basal, 7.5; width of *E* radial, 9.5; length 5.6.

Holotype.—SUI 33066 collected by R. C. Moore.

Occurrence.—Brentwood interval, Bloyd Formation at Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1].

CIBOLOCRINUS CIRCULUS Moore & Strimple, new species
Plate 2, figures 1a-d

Description.—Although now represented by a single specimen, this species is distinct when compared to other Morrowan representatives of the genus. The outline of the cup is circular when viewed from above or below and is subspherical when viewed from the side. Infrabasals are gently upflared with some distal tips visible in side view of cup; the small infrabasal is in *C* radius. Basal plates reach well above midheight of the cup and radial plates are unusually long. The medial portion of the infrabasal circlet is sharply impressed for reception of a round stem. The surface of the cup is delicately granulose.

Discussion.—The complete lack of tumidity of cup plates and the resultant circular outline serve to distinguish this species from other Morrowan representatives of the genus.

Holotype.—SUI 33164, collected by R. C. Moore.

Occurrence.—Morrowan, south of Hulbert, Mayes County, Oklahoma. This is probably an old road-cut in the hills south of Hulbert where rocks of Morrowan age have been observed but the road has been re-routed and the junior author has been unable to relocate the exact exposure which might have produced the specimen.

CIBOLOCRINUS BELLUS Moore & Strimple, new species
Plate 1, figures 3a-d, 4a-d; Plate 2, figure 4

Description.—Cup bowl-shaped with a broad, planate base. Infrabasal circlet subhorizontal except for a sharply impressed socket for reception of a round stem, smallest infrabasal in *C* ray. Proximal edges of the basals are curved inward to participate in the flat base, distal ends reach midheight of the cup. Radials are large tumid elements with proximal ends well above the basal plane; articular facets fill the full width of plates and are no longer than the normal thickness of the plate; outer ligament pit rather wide and well defined, furrows confined to sides of pit, transverse ridge marked at right angles by fine denticles, shallow inner troughlike depressions confluent with those of adjacent radials. The primanal is large, extending well above the cup summit and tapering to a point. The cup is covered by minute granules and sporadic small nodes are found on radials, basals and anal.

Discussion.—This species has a wider cup with more tumid basals and radials than either *Cibolocrinus regularis* or *C. tumidus* and in addition, the surface is marked by small granules or pustules. Although prolific in lower strata of the Wapanucka Formation, *C. bellus* appears to be rare in middle and absent in upper beds.

Types.—Holotype (OU 202), paratypes (OU 201, 230, 240, 241, 250) collected by C. L. Rowett; paratypes (SUI 33413 A and B, 33414, 33420 (2 specimens), 33422 (8 specimens)) collected by H. L. Strimple.

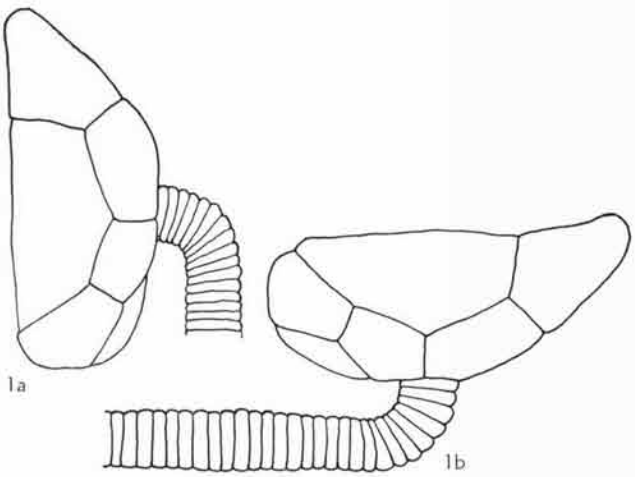

FIG. 2. Interpretations of orientation of dorsal cup and stem of *Calycocrinus* during life; 1a, erect attitude like that of an air ventilator postulated by Yakovlev; 1b, prone attitude on sea bottom suggested by Moore & Strimple.

Occurrence.—Specimen OU 200, 201, 202, 230, SUI 33413 A, B, 33414, lower part of Wapanucka Formation; OU 250, middle part of Wapanucka Formation, Canyon Creek [Loc. 12a and 12b]; OU 240, 241, SUI 33420, 33422, lower part of Wapanucka Formation, Pontotoc County, Oklahoma [Loc. 13].

Family CALYCOCRINIDAE Moore & Strimple, new family

Figure 2

Type Genus.—*Calycocrinus* Wanner, 1916, p. 250.

Diagnosis.—Cup distinctly asymmetrical, with anterior side more steeply sloped than posterior, correlated with inferred strong tilt of cup on stem with posterior side downward; radials also asymmetrical with corners on opposite ends of broadly scalloped articular facets unequal in height; no primanal visible externally, orientation being based on *C*-ray location of azygous small infrabasal. Stem transversely circular.

Discussion.—Yakovlev (1956) interpreted the asymmetry of the dorsal cup of *Calycocrinus* as correlated with orientation of the anteroposterior axis of the cup in a position during life of the crinoid nearly parallel to the main part of the stem rather than approximately at right angle to it as in most crinoids. He also pictured it as upright, like a ventilator placed to catch air currents (Fig. 2,*1a*). We suggest alternatively that both cup and stem lay prone on the sea bottom with arms directed upward (Fig. 2,*1b*). Decision about the mode of life of *Calycocrinus* is not determinable from available evidence.

Occurrence.—Middle Devonian-Upper Permian.

Genus CALYCOCRINUS Wanner, 1916

Type Species.—*Calycocrinus curvatus* Wanner, 1916, p. 261.

Diagnosis.—Characters of family, differing from *Plagiocrinus* and *Ammonicrinus* in more complete and nearly normal radial circlet and circular stem. Crescentic columnals of *Ammonicrinus*, in which crown is concealed by enrollment of stem around it are quite foreign to *Calycocrinus*.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Permian (Basleoan); USA (Okla.); E. Indies (Timor).

CALYCOCRINUS SYMMETRICUS Moore & Strimple, new species

Plate 2, figures 3a-d

Description.—The cup is shallow saucer-shaped, with the anterior side slightly more erect than the posterior side. The infrabasals are upflared but owing to their low angle from horizontal, they are not readily visible in side view of the cup. A large round columnar cicatrix occupies most of the infrabasal circlet. Five basals are relatively large with width and length approximately equal. The radials are considerably wider than long, with exception of those of the right posterior (*C*) and left posterior (*D*) rays. The maximum length of the *C* and *D* radials is next to their common suture. Upper edges of the radials are broadly crescentic. Articular arm

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EXPLANATION OF PLATE 1

Morrowan species of flexible crinoids—*Cibolocrinus*.

FIGURE

1a-d. *Cibolocrinus tumidus* Moore & Plummer. Posterior, anterior, dorsal, and ventral sides of hypotype (SUI 33292) from Flat Rock Creek, Wagoner County, Oklahoma, ×4.7.

2a-c. *Cibolocrinus spinosus* Moore & Strimple, n. sp. Anterior, dorsal, and ventral views of holotype (SUI 33066) from Brentwood interval, Bloyd Formation, Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×3.1.

3a-d, 4a-d. *Cibolocrinus bellus* Moore & Strimple, n. sp.; 3a-d, posterior, anterior, dorsal, and ventral sides of paratype (OU 201) from lower part of Wapanucka Formation, on Canyon Creek, Pontotoc County, Oklahoma, ×2.3; 4a-d, dorsal, posterior, anterior, and ventral sides of holotype (OU 202), from same beds and locality as 3a-d, ×2.3.


1a


1b


1c


1d


4a


2a


2b


2c

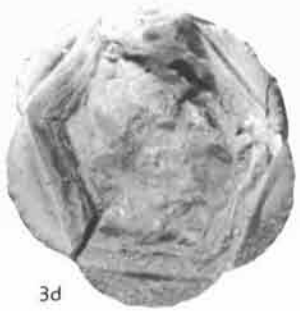

4b


4c

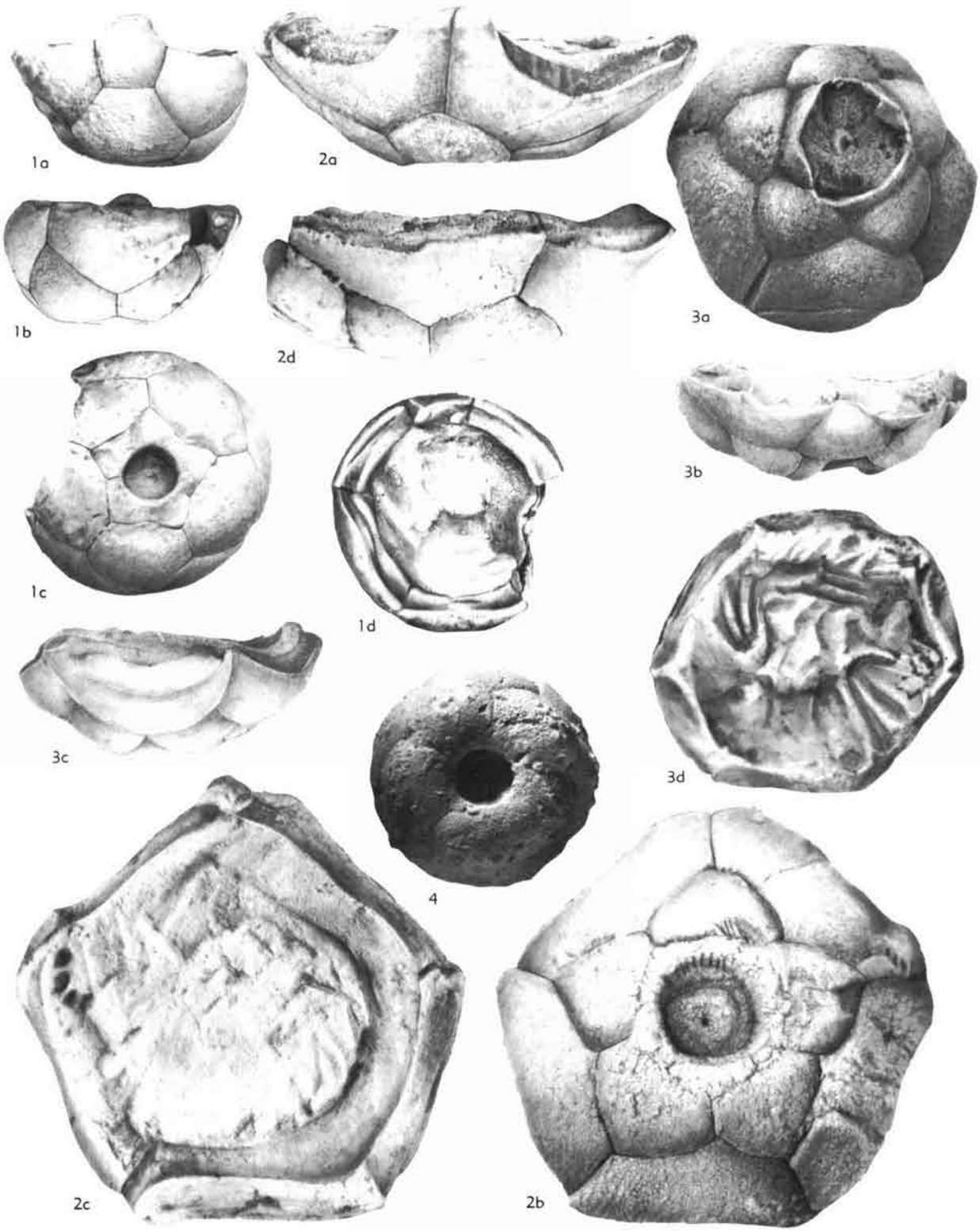

3a


3b


3c


3d


4d


1a
2a
3a
1b
2d
3b
1c
1d
3c
3d
4
2c
2b

facets are directed outward-downward and not longer than normal thickness of the plates. A crescent-shaped basin is formed by confluent muscle furrows passing between adjacent radials.

The outer surface of the cup plates is covered by coarse granules or pustules. Arms, tegmen and column are unknown.

The cup of the holotype is 10 mm wide and 3.5 mm high (minimum height). The posterior side is about 0.1 mm higher than other parts.

Discussion.—This species is more comparable to *Calycocrinus curvatus depressus* Wanner from the Permian of the Island of Timor (East Indies) than to other described forms. The Permian species is highly asymmetrical and the radial articular facets are subhorizontal. These facets are directed outwardly in *C. symmetricus* and the cup is relatively symmetrical as compared to that of *C. curvatus depressus.*

Types.—Holotype (SUI 33170); paratype (SUI 33181), collected by A. L. Bowsher.

Occurrence.—Brentwood interval, Bloyd Formation (Morrowan); Keough Quarry north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1].

CALYCOCRINUS FURNISHI Moore & Strimple, new species
Plate 2, figures 2a-d

Description.—The cup is shallow turbinate with one side more erect than others and therefore inferred to be anterior, the opposite side being gently sloped and longer; 3 unequal infrabasals are mostly confined to the shallow basal concavity, small infrabasal in the *C* ray defined by the adopted orientation; a small round stem impression occupies the center of the basal invagination; the 5 basals are almost pentagonal but actually some have 6 unequal sides, interbasal sutures being short, that in *C* ray position exceptionally so but separating the *C* radial from contact with the azgous infrabasal; widest is the *EA* basal; radials are wider than long and irregularly pentagonal in outline, the *C* and *D* radials being extended at their interradial suture (Pl. 2, fig. 2a) well above the normal summit height of the cup; a comparable arrangement is seen in the *AB* interradial suture (Pl. 2, fig. 2b); the right shoulder of *E* radial is higher than the left shoulder of the *D* radial but no pronounced extension of the former is seen, and the arm articulating facets are not affected; in the mentioned instances, pronounced interruptions of the radial articular facets call for specially shaped primibrachs next above them; the articular facets are short and sloped outward-downward. Arms, stem and tegmen have not been observed.

Width of the dorsal cup of the holotype is 15.6 mm and normal height 4.9 mm.

Discussion.—A remarkable similarity is evident between *Calycocrinus furnishi* and certain species from the Permian of Timor in the East Indies. *C. curvatus turbinatus* Wanner (1921) has a shallow saucer-shaped cup but the infrabasal circlet is more prominent than in *C. furnishi* and more readily visible in side view of the cup. *C. furnishi* has a shallow basal concavity, with only the outermost tips of the infrabasals extending into the basal plane of the cup. *C. symmetricus* is the only other species of the genus presently reported from Pennsylvanian strata. It is readily differentiated in having a more symmetrical cup and a more prominent infrabasal circlet which actually is upflared.

Holotype.—SUI 33171, collected by R. C. Moore.

Occurrence.—Brentwod crinoid horizon, Bloyd Formation (Morrowan); Keough quarry, north of Fort Gibson, Cherokee County, Oklahoma [Loc. 1].

Superfamily SAGENOCRINITACEA Bassler, 1938 (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (*ex* Sagenocrinitidae Bassler, 1938, p. 23, *nom. correct.* Bassler, *pro* Sagenocrinidae Roemer, 1854, p. 228)]

Type Genus.—*Sagenocrinites* Austin & Austin, 1842, p. 110.

Diagnosis.—Crown elongate ovoid or rotund, with lower part of arms not differentiated clearly from radials and lower circlets, plates of cup and proximal brachials

EXPLANATION OF PLATE 2

Morrowan species of flexible crinoids—*Cibolocrinus* and *Calycocrinus.*

FIGURE

1a-d. *Cibolocrinus circulus* Moore & Strimple, n. sp. Posterior, anterior, dorsal, and ventral sides of holotype (SUI 33164) from Morrowan south of Hulbert, Craig County, Oklahoma, ×2.3.

2a-d. *Calycocrinus furnishi* Moore & Strimple, n. sp. Posterior, dorsal, ventral, and anterior sides of holotype (SUI 33171), from Brentwood horizon, Bloyd Formation, at Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×5.

FIGURE

3a-d. *Calycocrinus symmetricus* Moore & Strimple, n. sp. Dorsal, posterior, anterior, and ventral views of holotype (SUI 33170) from Brentwood horizon, Bloyd Formation, at Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×5.

4. *Cibolocrinus bellus* Moore & Strimple, n. sp., dorsal view of paratype (OU 250) from middle part of Wapanucka Formation on Canyon Creek, Pontotoc County, Oklahoma, ×2.3.

of arms rather firmly joined together laterally as well as longitudinally, interradials and interbrachials generally prominent but may be lacking. Branching of arms isotomous or isotomous and heterotomous. Stem transversely circular, mostly large.

Discussion.—This superfamily includes the families Sagenocrinitidae Bassler, 1938; Homalocrinidae Angelin, 1878; Dactylocrinidae Bather, 1899; and Euryocrinidae Moore & Strimple, n. fam.

Occurrence.—Upper Silurian (Gotlandian)-Upper Permian (Basleoan).

Family DACTYLOCRINIDAE Bather, 1899

Type Genus.—Dactylocrinus Quenstedt, 1876, p. 520.

Diagnosis.—Arms not abutting one another, interradials few; no plate equivalent to radianal; arms branching isotomously in lower part of crown but heterotomously (endotomously) in upper part; infrabasals covered by stem.

Occurrence.—Upper Silurian (Gotlandian)-Upper Pennsylvanian (Missourian).

Genus ZENOCRINUS Moore & Strimple, new genus

Type Species.—Zenocrinus zeus Moore & Strimple, new species.

Description.—Small, low crown with wide shallow calyx rounded steeply upward at sides in fixed brachials of proximal parts of arms which branch isotomously on primibrach *2* and secundibrachs *2* (or exceptionally *3*), arms abutting but free above axillary secundibrachs, with strongly heterotomous branching of bi-endotomous type in upper part of crown, each complete ray with 16 slender arm tips bent inward (indicating 80 or more arm tips in perfect crown); infrabasals and most of basal circlet concealed by large proximal columnals; radials exposed all around, laterally abutting except where separated by *CD* basal or (?abnormally) arching over this plate to allow *C* and *D* radials to meet; *CD* interray variable, in holotype of type species with primanal followed by 6 additional anals but in paratype with only 2 plates, lower one very large; other interrays with single large plate touching radials and separating fixed brachials, with or without 1 to 3 small plates above them; single intersecundibrach in each ray. Stem circular in section, composed of very low columnals with peripherally finely crenulate facets, tapering away from calyx and curved strongly toward *A* ray.

Occurrence.—Lower Pennsylvanian (Morrowan); USA (Oklahoma).

ZENOCRINUS ZEUS Moore & Strimple, new species

Plate 3, figures 1a,b

Diagnosis.—Characters of genus.

Description.—Two specimens are available. These consist of a well-preserved, little distorted, nearly complete crown which is chosen as holotype, and an incomplete calyx lacking most arms, but with more of proximal part of stem than found in other specimen, latter with part of attached stem designated as paratype. Aims of this description are to amplify and supplement characters in diagnosis of genus. Boundary between fixed brachials of calyx and free but closely abutting arms in higher part of crown is fairly well defined in holotype, being recognized as placed just above single intersecundibrach of each ray at axillary secundibrachs in each half-ray.

Infrabasal circlet and proximal parts of basals concealed by stem in both specimens, although distal extremities of basals are exposed all around in both holotype and paratype (latter incompletely on anterior side), whereas the *CD* basal is broadly concave distally for contact with primanal, corresponding extremity in this plate in paratype sharply pointed and no plate identifiable as primanal found. Accompanying these differences and apparently determined by them, *C* and *D* radials of holotype have decidedly asymmetrical left and right portions in contrast to symmetry displayed by equivalent plates of paratype, which meet beneath large *CD* interradial, interpreted to represent most of anals above primanal in holotype. Interradials of other rays, which exhibit consistent leftward bent arrangement of upper plates on lower, though such asymmetry is not found in paratype where single large interradial may be followed by a small one symmetrically above it or lacking such plate; intertertibrachs are confined to single plate in each ray of both specimens.

Bifurcation of arms at level of axillary secundibrachs is penisotomous (nearly but not quite evenly istomous), with shorter distal articular facets consistently on side toward axis of ray; next higher bifurcations may depart slightly more from even isotomy or show distinct disparity of distal facets typical of heterotomy. Free arms in upper part of holotype crown closely abut one another and mostly have smooth well-flattened dorsoventral sides equal or nearly equal in width to outward facing surfaces of brachials; interbrachial sutures increasingly flexuous toward summit of crown, patelloid processes and sockets visible at outer edges of some facets.

Dimensions.—Undeformed complete crowns estimated to have width one-third greater than height, these dimensions (based on holotype) being width 30 mm and height 20 mm; height of calyx approximately two-thirds that of crown. Diameter of stem impression 7.0 mm in holotype, 7.2 mm in paratype. Width of *C* radial in these specimens, respectively, 4.0 mm and 5.7 mm, with height measured as 0.9 mm and 1.7 mm, corresponding measurements for the *A* radial are, respectively, 5.8 mm width, and 5.7 mm, height 1.4 mm, and 0.8 mm. Distal articular facets of axillary secundibrachs have average widths of 4.3 mm on outer side and 3.6

mm on inner side, narrow facet 15 percent shorter than wide one. Corresponding facets of axillary tertibrachs average 2.3 mm in width on side away from axis of half-ray, as compared with 1.5 mm on the opposite side, inner facets 33 percent shorter than outer ones. Sides of free arms smooth, straight, and foaming near right angle to outer surface. Height of columnals next to calyx 0.35 mm in holotype and 0.25 mm in paratype; distal heteromorphic part of stem in paratype with average diameter of 4.5 mm has first- and second-order larger columnals with smooth, longitudinally rounded peripheries with height measuring 1.0 and 0.8 mm respectively, separated by third-order columnals 0.3 mm in height. Exposed columnal facets near calyx of holotype show 15 short, narrow crenulae in a quadrant and stellate lumen 0.7 mm in diameter with lobate rays directed radially; similar facets at end of preserved part of stem in paratype has similar short but slightly coarser crenulae, 10 to a quadrant and its lumen has greatest width of 0.9 mm.

Discussion.—Chief morphological differences observed in the holotype and paratype of *Zenocrinus zeus* are found in number and arrangement of plates in the posterior interray and number and distribution of secundibrachs of the various rays. Whereas the posterior interray of the holotype has what is evidently a primanal followed by 5 other anals above the cup rim; the paratype has only 2 plates in the corresponding interray, a very large one below and a smaller one above. Such great dissimilarities are hard to explain. Until additional specimens are found, their significance cannot be assessed. Other interrays of the 2 specimens appear to be nearly the same. The holotype possesses only 2 secundibrachs in all half-rays but the left one of the *D* ray shows 3. Incompleteness of the paratype prevents determination of the number of secundibrachs in the *B* and *E* rays, but other half-rays have 3 secundibrachs, except the left one of the *D* ray which has 2. This is a very curious sort of discrepancy, which also cannot be explained. Insofar as can be determined, all rays of both specimens have a single intertertibrach in each ray and all rays have similar patterns of arm branching. In spite of the differences noted, we firmly judge that the 2 specimens are conspecific and until more information is available, conclude that the species is somewhat unstable. The possibility of sexual dimorphism is highly conjectural but not ruled out.

The peculiarity of a stem composed in its upper part of extremely thin columnals with slightly flexuous keeled edges, curving and tapering away from the crown, provides basis for comparison of *Zenocrinus zeus* with *Paramphicrinus multiramosus* and *P. magnus*. In *Z. zeus* this curvature is toward the *A* ray, whereas it is sideward toward the *DE* interray in *P. multiramosus* and forward-sideward toward the *EA* interray in *P. magnus*. General similarity in structure of the calyx and type of arm branching extends to the 3 mentioned species, but otherwise *Z. zeus* shows little resemblance to the others.

Affinities of the species here described with *Aexitrophocrinus formosus*, another Pennsylvanian crinoid, may be suggested. *A. formosus* shows well-marked isotomy on primibrach *1* and secundibrach *3*, as in the paratype of *Zenocrinus zeus* and the 2 mentioned species of *Paramphicrinus*. *A. formosus* is distinguished and especially characterized by the 4 main arm branches in each ray and diminutive size of its ramulelike minor branches.

No known pre-Pennsylvanian crinoid of the Dactylocrinidae is at all similar to *Zenocrinus zeus* or the other species discussed.

Types.—Holotype (SUI 35487), paratype (SUI 35488) collected by Audd Dailey.

Occurrence.—Lower part of Wapanucka Formation (Morrowan); Canyon Creek, Pontotoc County, Oklahoma [Loc. 12a].

Family EURYOCRINIDAE Moore & Strimple, new family

Type Genus.—Euryocrinus Phillips, 1836, p. 205.

Diagnosis.—Like Dactylocrinidae except that arms are joined laterally together throughout their proximal and medial portions so as to form a large stout calyx.

Occurrence.—Middle Devonian-Upper Pennsylvanian.

Genus PARAMPHICRINUS Strimple & Moore, 1971

[*Paramphicrinus* Strimple & Moore, 1971a, p. 40]

Figures 3, 4

Type Species.—Amphicrinus oklahomaensis Strimple, 1939, p. 364.

Description.—Crown rotund, medium-sized, with stoutly built bowl-shaped calyx forming lower half of crown and closely adjoined parallel free arms upper half, curving inward at summit so that arm tips nearly meet; infrabasal circlet and all except posterior plate of basal circlet covered by stem, subhorizontal in attitude; only distal edges of radials exposed, those of *C* and *D* rays slightly smaller than others and visible parts asymmetrical; no radianal but moderately large primanal on extremity of *CD* basal, followed by 16 to 20 higher anals in double series, interlocking sideward with fixed brachials from primibrach to tertibrach series. Arms broad in proximal portion, branching isotomously on primibrachs *2* and secundibrachs *3* in each ray, thereafter displaying well-marked heterotomy of bi-endotomous type, distal parts of all arms narrow upward, with 80 to 100 arm tips at crown summit, each complete half-ray with 20 arms; interbrachial sutures mostly sinuous; in-

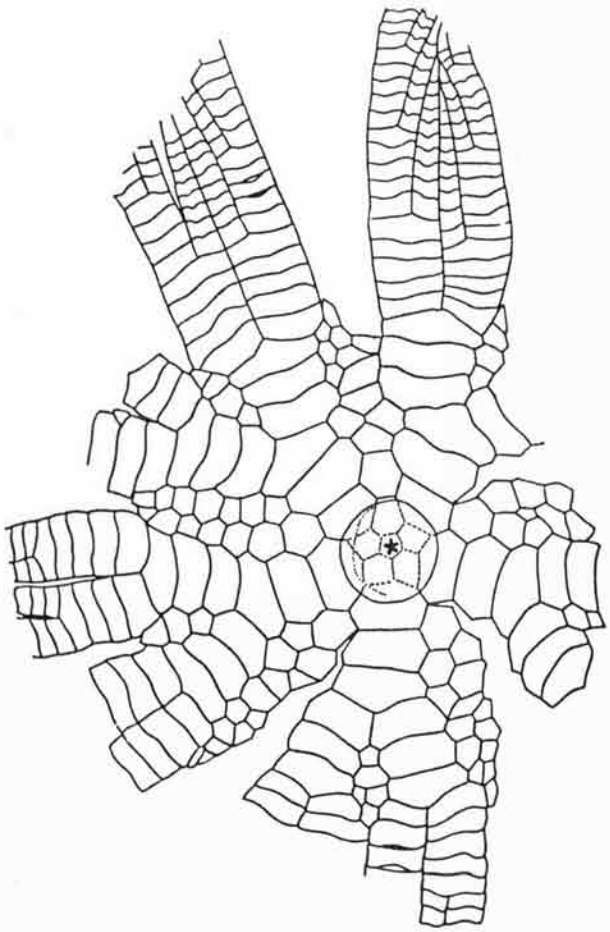


FIG. 3. Camera lucida drawing of holotype (USNM S4031) of *Paramphicrinus oklahomaensis* (Strimple), ×1.5.

terradial polygonal plates 16 to 20 beginning between first primibrachs with large plate, much smaller distal ones suturally joined to tertibrachs; interbrachials beginning between proximal secundibrachs and extending upward nearly to distal tertibrachs; two small areas of three to five intertertibrachs in each ray. Stem large, composed of very low crenulate columnals with quinquelobate axial canal, proximal part tapering gradually and strongly curved toward *DE* interray or *A* ray.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Missourian); USA (Arkansas, Oklahoma, Illinois).

PARAMPHICRINUS MAGNUS Moore & Strimple, new species
Plate 3, figures 2a-d

Description.—Rotund robust crown, thick plates of calyx mostly large, free arms comprising 4 thick rounded main branches on each ray, arranged in pairs which give off ramule-like small branches on sides facing each other, thus exhibiting strongly marked bi-endotomous heterotomy characteristic of genus, arm tips well incurved at summit of crown. Lower part of calyx nearly flat, formed by horizontal infrabasal and basal circlets entirely or almost entirely covered by large stem impression, radials sloping very gently upward, confluent with somewhat steeper proximal fixed brachials, which combine with distal fixed brachials reaching to tertibrachs *2* or *3* to produce wide bowl; size and form of infrabasals not observable externally but clearly seen on inner side of paratype specimen, which reveals pentagonal infrabasal circlet nearly equal in size to pentagonal basals adjoining 4 of its sides, distally truncate posterior basal hexagonal, wider and higher than others; shoulders of all radials obliquely beveled to form rather deep notch at interradial sutures for contact with large proximal interradial plate, edges of *C* and *D* radials on side opposite beveled shoulder truncate for contact with large primanal which separates them.

Rays with hexagonal first primibrach distinctly larger than subjacent radial, with maximum width slightly greater than twice height; axillary primibrach 2 pentagonal in outline with equal distal facets denoting essentially perfect isotomy of left and right main arm branches, each of which bifurcates on secundibrachs *3*, with clearly marked departure from even isotomy by having distal facets nearest axis of ray distinctly narrower than corresponding facet next to outer sides of ray; well-marked heterotomy begins in all main arm branches on tertibrachs *2* to *4*, boundary between calyx and free arms marked at these points. Large primanal distally truncate, followed in holotype by additional even larger plate, its slightly oblique distal facets supporting one more anal; other interrays with double series of large polygonal plates above single proximal one, highest interradials reaching to a level of first tertibrachs; intersecundibrachs comprise 4 or 5 large polygonal plates which extend upward to first or second tertibrachs; intertertibrachs restricted to 1 to 3 elongate small plates.

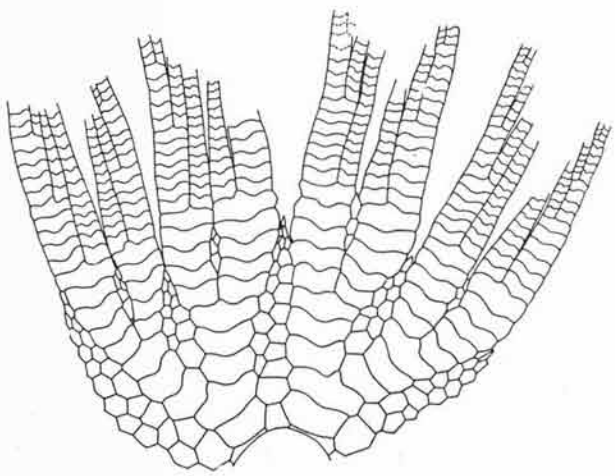


FIG. 4. Camera lucida drawing showing posterior interray and adjacent rays of hypotype (IGS 42P61) of *Paramphicrinus oklahomaensis* (Strimple), ×1.5.

Sutures between successive plates of free-arm brachitaxes gently to rather strongly flexuous; number of arm tips at summit of crown indeterminate but best preserved parts of holotype crown provide basis for estimate that total number may equal or exceed 80. Transversely circular stem very large at attachment to base of calyx, tapering gradually and rather uniformly distally and in curved direction from *CD* interray to *A* ray, attaining nearly a quadrant of arc at a distance of 90 mm measured along outside of curvature (with allowance of 15 mm estimated on basis of taper for lost segment between attached portion of stem and detached loose segment); columnals lowest and with slightly flexuous keeled edges near calyx, becoming appreciably taller and straighter away from calyx.

Dimensions.—Width of flattened holotype crown approximately 60 mm and height 50 mm; estimated width and height of undeformed crown approximately 45 and 40 mm, respectively. Width of undeformed radial circlet enclosing basals, infrabasals, and attached primanal (paratype), measured from articlar facet of *A* radial to distal facet of primanal, 28 mm and from arm facet of *B* radial to notch between *D* and *E* radials, 25 mm; average height of circlet 6 mm; thickness of radials 3.8 mm, *C* radial 10.8 mm; height of *A* radial 6.1 mm, of *C* radial 5.5 mm; diameter of quinquelobate axial canal, well shown by this specimen, 3 mm; other dimensions of components of this circlet can readily be scaled from camera lucida drawings of exterior and interior sides of specimen. Diameter of stem impression (both holotype and paratype) 13 mm; diameter of stem at 22 mm (measured beyond convex structure) 10 mm, and at an estimated 90 mm from calyx, 6 mm; average height of columnals in attached part of stem, 0.4 mm, near proximal extremity of detached stem segment 0.85 mm and at distal extremity of this fragment 1.2 mm; columnal articular facet at proximal end of detached stem segment shows narrow culmina and crenellae extending from periphery to quinquelobate lumen, with approximately 15 of each in a quadrant at the periphery. Width (W) and height (H) of primanal in holotype are 6.2 and 5.0 mm (exposed beyond stem impression); in paratype these dimensions are W 6.7 mm and H 6.2 mm. Average dimensions of primibrach *1* are W 14.0 mm, H 5.8 mm; those of axillary primibrach *2* are W 14.2 mm, H 7.0 mm. Average width of outer distal facet of axillary secundibrach *3* in *E* ray of holotype is 6.9 mm and that of inner facet 5.3 mm, showing the latter as 23 percent shorter; in *C* ray corresponding measurements are 9.0 mm for outer facet and only 5.0 mm for inner facet, indicating the latter to be 45 percent shorter; in tertibrachs *2* to *4*, which are first strongly heterotomous axillaries, distal articular facets on outer sides of half ray average 5.7 mm and those on inner side 2.1 mm, the latter 63 percent shorter.

Discussion.—It is clear that *Paramphicrinus magnus* resembles *P. multiramosus*, type species of the genus, in general morphological features. It differs mainly in having larger, thicker plates in the calyx, stronger differentiation of main arm branches in rays and half-rays as compared with the bi-endotomous small arms, distinctly more unequal distal facets of axillary secundibrachs, relatively shorter interradial areas with fewer plates, and the same for intersecundibrachs. The stem of *P. magnus* is appreciably larger than that of the Upper Pennsylvanian species, although dimensions of the crown are not very dissimilar; doubtless because more is known of the stem belonging to the Morrowan form, its proximal and distal portions seem to be more dissimilar.

Types.—Holotype (SUI 32926) and paratype (SUI 32929) collected by Gary Gillum.

Occurrence.—Thick ?pre-Brentwood shale, Bloyd Formation, on Sweetwater Creek near Strickler, Washington County, Arkansas [Loc. 27].

Subclass CAMERATA Wachsmuth & Springer, 1885

Diagnosis.—Calyx dicyclic or monocyclic, all thecal plates joined rigidly together; mouth and proximal part of food grooves subtegminal; lower part of arms incorporated in calyx; tegmen stout and rigid; posterior interray mostly wider than others and including symmetrically arranged extra (anal) plates which exhibit no tendency to shift upward or to left in course of evolution. Arms uniserial or biserial, invariably pinnulate, brachials typically imperforate. Stem transversely circular or elliptical, not pentagonal or quinquestellate.

Occurrence.—Middle Ordovician-Upper Permian.

Order MONOBATHRIDA Moore & Laudon, 1943

[Monobathrida *nom. correct.* Ubaghs, 1953, p. 738 (*pro* Monobathra Moore & Laudon, 1943, p. 86)]

Diagnosis.—Base of calyx monocyclic, no infrabasal circlet.

Occurrence.—Middle Ordovician-Upper Permian.

Suborder TANAOCRININA Moore, 1952

[Tanaocrinina Moore in Moore, Lalicker & Fischer, 1952, p. 614]

Diagnosis.—Radial circlet interrupted on posterior side by insertion of primanal; base hexagonal.

Occurrence.—Middle Ordovician-Upper Permian.

Superfamily PERIECHOCRINITACEA Austin & Austin, 1843 (Ubaghs, 1953)

[*nom. correct.* Moore & Strimple, herein (*pro* Periechocriniticae Ubaghs, 1953, p. 738; *nom. transl.* Ubaghs, 1953, p. 738, *ex* Periechocrinitidae Austin & Austin, 1843, p. 203)]

Diagnosis.—Calyx subconical to flattened globose with or without shallow basal concavity; three equal basals; primanal beneath three other anal plates; interradials numerous in old genera, few in later ones. Stem transversely round.

Occurrence.—Upper Silurian-Upper Permian.

Family PARAGARICOCRINIDAE Moore & Laudon, 1942

Type Genus.—Paragaricocrinus Yakovlev, 1934, p. 271.

Diagnosis.—Theca low subglobular with depressed base; radial circlet interrupted only by primanal; first primibrach quadrangular, second one axillary, single secundibrach also axillary.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Permian.

Genus MEGALIOCRINUS Moore & Laudon, 1942

Type Species.—Megaliocrinus aplatus Moore & Laudon, 1942, p. 68.

Diagnosis.—Calyx subcircular in dorsal view, base shallowly concave; posterior interray containing primanal followed by three plates, other interrays occupied by single large interbrachial; tegmen high, tapering to blunt summit.

Discussion.—Discovery of a complete theca of *Megaliocrinus aplatus* allows for comparison with the tegmens of related forms. *Paragaricocrinus mediterraneus* Yakovlev (1934), from the Permian of Sicily, has a much lower tegmen. *Wannerocrinus glans* Marez Oyens (1940), from Upper Permian rocks of Timor has a tegmen with more erect sides and a broad, gently rounded summit area.

Occurrence.—Lower Pennsylvanian (Morrowan); USA (Oklahoma).

MEGALIOCRINUS APLATUS Moore & Laudon, 1942

Plate 3, figures 4a,b

Diagnosis.—Characters of genus.

Discussion.—The presently considered metatype (SUI 33124) is a complete theca having an upwardly tapered tegmen terminating in a large, blunt point. The tegmen is considerably taller than the cup height, erect on the posterior side and sloped on the anterior side. Anus is near summit in anterior side.

Megaliocrinus exotericus Strimple (1951, p. 14) is the only other species ascribed to the genus. It differs from *M. aplatus* in having a flat base (other than the centrally impressed stem area) which is occupied by the 3 subequal basals, and in having anal plates of the wide depressed posterior interray that reach the tegmen. The base of *M. aplatus* is broadly concave outside of the sharply depressed columnar attachment area and the posterior interray is obscure at summit of the calyx.

Types.—Holotype (KUMIP 73853=USNM 141190) collected by L. R. Laudon; hypotype (SUI 33124) collected by Claude Bronaugh.

Occurrence.—Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8c].

Suborder GLYPTOCRININA Moore, 1952

[Glyptocrinina Moore in Moore, Lalicker & Fischer, 1952, p. 614]

Diagnosis.—Base of cup pentagonal; primanal above posterior radials, circlet of radials consequently uninterrupted.

Occurrence.—Middle Ordovician-Upper Permian.

EXPLANATION OF PLATE 3

Morrowan species of flexible (*Zenocrinus, Paramphicrinus*), camerate (*Platycrinites, Megaliocrinus*), and inadunate (*Phacelocrinus*) crinoids.

FIGURE

1a,b. *Zenocrinus zeus* Moore & Strimple, n. sp. Oblique view of crown and side view of *D* ray of holotype (SUI 35487) from lower part of Wapanucka Formation on Canyon Creek, Pontotoc County, Oklahoma, ×2.3.

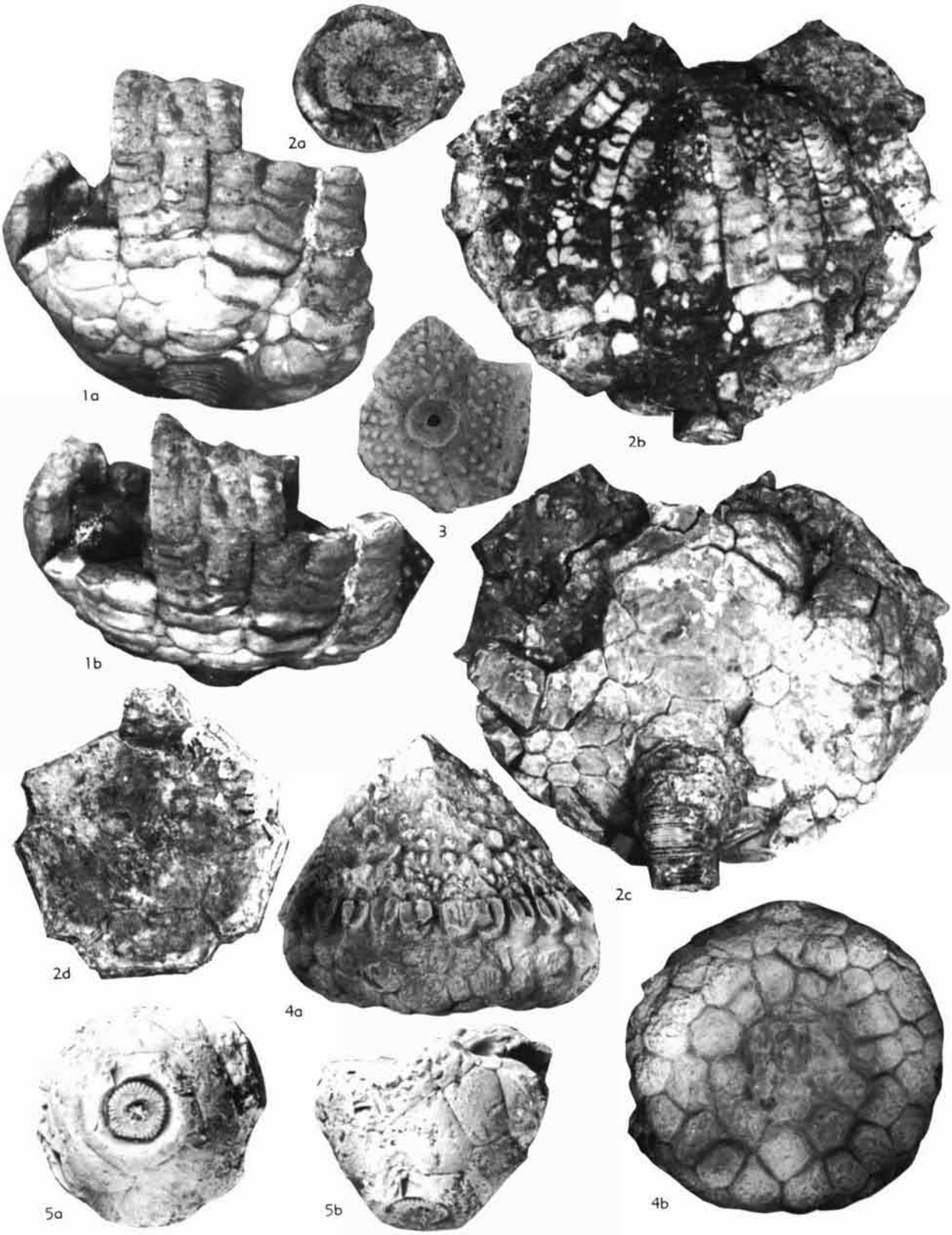
2a-d. *Paramphicrinus magnus* Moore & Strimple, n. sp.; 2a-c, ventral view of proximal portion of cup and column detached from crown, *A*-ray, and *CD*-interray views of holotype (SUI 32926) from ?pre-Brentwood beds of Bloyd Formation on Sweetwater Creek near Strickler, Washington County, Arkansas, ×1.2; 2d, paratype (SUI 32929) from interior, same locality as 2a-c, ×1.8.

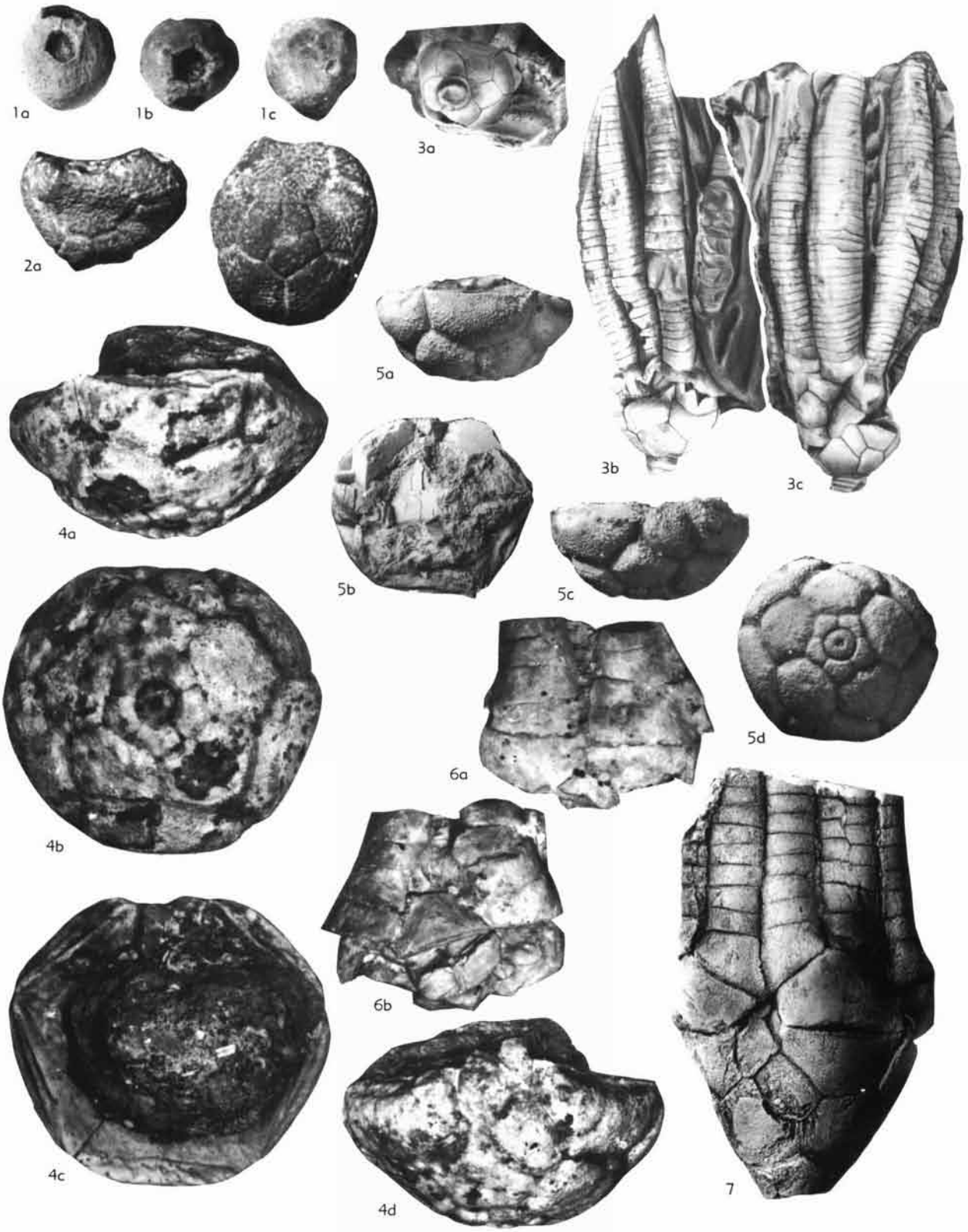
FIGURE

3. *Platycrinites* sp., hypotype (SUI 35427), exterior of basal plates from lower part of Wapanucka Formation, Pontotoc County, Oklahoma, ×1.8.

4a,b. *Megaliocrinus aplatus* Moore & Laudon, hypotype (SUI 33124) calyx from side and base, from Brentwood interval, Bloyd Formation, spillway of Greenleaf Lake, southeast of Braggs, Muskogee County, Oklahoma, ×1.8.

5a,b. *Phacelocrinus brevis* Moore & Strimple, n. sp., dorsal and posterior views of holotype (SUI 33376), from Brentwood interval, Bloyd Formation, spillway of Greenleaf Lake, southeast of Braggs, Muskogee County, Oklahoma, ×3.5.


1a
2a
2b
3
1b
2c
2d
4a
4b
5a
5b


1a
1b
1c
3a
2a
3b
3c
5a
4a
5b
5c
5d
6a
4b
6b
4c
4d
7

Superfamily PLATYCRINITACEA Austin & Austin, 1843 (Ubaghs, 1953)

[*nom. correct.* Moore & Strimple, herein (*pro* Platycriniticae Ubaghs, 1953, p. 742; *nom. transl.* Ubaghs, 1953, p. 742, *ex* Platycrinitidae Austin & Austin, 1843, p. 199)]

Diagnosis.—Calyx formed essentially by basals and radials; brachials, primanal and interradials weakly developed; basals three, unequal or fused into single pentagonal plate. Stem transversely circular or elliptical.

Occurrence.—Upper Silurian-Upper Permian.

Family PLATYCRINITIDAE Bassler, 1938

[=Platycrinidae auctt.]

Type Genus.—*Platycrinites* Miller, 1821, p. 15.

Diagnosis.—Characters of superfamily. Stem elliptical and twisted, except near cup.

Occurrence.—Upper Silurian-Upper Permian.

Genus PLATYCRINITES Miller, 1821

Diagnosis.—Characters of family.

Occurrence.—Middle Devonian-Upper Permian, cosmopolitan.

PLATYCRINITES species

Plate 3, figure 3

Description.—A fragmentary specimen consisting of little more than an infrabasal circlet is presented here for the purpose of documentation. There are 3 sutures in the circlet, which is gently upflared. Small nodes dot the outer surface of the plates and the stem cicatrix is circular and plane. The plates are very thin.

Aside from stem ossicles, the only other reported occurrence of *Platycrinites* in North America above Mississippian strata is *P. remotus* Strimple & Watkins, 1969, p. 219, from Desmoinesian deposits in central Texas.

Figured Specimen.—SUI 35427, collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation, Pontotoc County, Oklahoma [Loc. 13].

Subclass INADUNATA Wachsmuth & Springer, 1885

[*nom. transl.* Moore & Laudon, 1943 (*ex* suborder Inadunata Wachsmuth & Springer, 1885)] [=order Pentacrinoidea Jaekel, 1894 (*partim*)]

Diagnosis.—Crown with free arms above theca, mostly tall subcylindrical or expanding upward; cup conical, bowl- or saucer-shaped to discoid, with convex, flat, or concave base, plates joined by firm sutures; radial articular facets narrow horseshoe-shaped to very wide, mostly with transverse ridge, ligament grooves, and muscle-attachment areas. Anal sac commonly prominent.

Occurrence.—Lower Ordovician-Middle Triassic.

Order CLADIDA Moore & Laudon, 1943

[*nom. correct.* Moore in Moore, Lalicker, & Fischer, 1952, p. 613 (*pro* Cladoidea Moore & Laudon, 1943, p. 32)]

Diagnosis.—Cup with two circlets of plates below radials.

Occurrence.—Lower Ordovician-Middle Triassic.

EXPLANATION OF PLATE 4

Morrowan species of inadunate crinoids—*Lecythiocrinus, Strongylocrinus, Scytalocrinus, Anobasicrinus, Spaniocrinus,* and *Morrowcrinus.*

FIGURE

1a-c. *Lecythiocrinus asymmetricus* Moore & Strimple, n. sp. Posterior, ventral, and dorsal sides of holotype (SUI 33157) from bluffs just south of Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×3.3.

2a,b. *Strongylocrinus ornatus* Moore & Strimple, n. sp. Posterior and dorsal sides of holotype (SUI 35798) from Brentwood horizon, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×2.5.

3a-c. *Scytalocrinus crassibrachiatus* Moore & Strimple, n. sp. Dorsal, anterior, and posterior sides of holotype crown (SUI 33161) from Brentwood interval, Bloyd Formation, southeast of Ft. Gibson, Cherokee County, Oklahoma, ×1.7.

FIGURE

4,5. *Anobasicrinus obscurus* Strimple; 4a-d, hypotype (SUI 32925), from anterior, dorsal, ventral, and posterior sides, from lower part of Wapanucka Formation on Olney road east of Clarita, Coal County, Oklahoma, ×2.3; 5a-d, hypotype (OU 276) from anterior, ventral, posterior, and dorsal sides, from same beds as 4a-d and also east of Clarita, ×1.7.

6a,b. *Spaniocrinus* species, hypotype (SUI 35480) partial crown from opposite sides, lower part of Wapanucka Formation, Pontotoc County, Oklahoma, ×2.7.

7. *Morrowcrinus defendus* (Washburn), posterior side of holotype (BYU 1496), Morrowan beds in Oquirrh Formation, Provo Canyon, Utah County, Utah, ×1.8.

Suborder CYATHOCRININA Bather, 1899

[*nom. correct.* Moore in Moore, Lalicker, & Fischer, 1952, p. 613 (*pro* Cyathocrinoidea Bather, 1899, p. 922)]

Diagnosis.—Cup conical to deep, crateriform, stoutly built tegmen with orals, ambulacrals, and interambulacrals, mouth subtegminal; anal sac lacking or weakly developed; radial articular facets narrow; uniserial arms lacking pinnules.

Occurrence.—Middle Ordovician-Upper Permian.

Superfamily CODIACRINACEA Bather, 1890 (Lane, 1967)

[*nom. transl.* Lane, 1967, p. 10 (*ex* Codiacrinidae Bather, 1890)] [=Hypocrinacea Arendt, 1970]

Diagnosis.—Theca ovoid, lacking radianal and anal sac, infrabasals five to one; anal vent on side of cup next above *CD* basal; uniserial arms round, branched isotomously or rarely atomous.

Discussion.—This superfamily includes the Codiacrinidae Bather, 1890; Sycocrinitidae Lane, 1967; and Streblocrinidae Lane, 1967.

Occurrence.—Upper Silurian-Upper Permian.

Family CODIACRINIDAE Bather, 1890

Type Genus.—*Codiacrinus* Schultze, 1867, p. 143.

Diagnosis.—Very narrow radial articular facets; infrabasals commonly three or fused to one, primanal commonly present but may be absent; round columnals lacking peripheral canals.

Occurrence.—Upper Silurian-Upper Permian.

Subfamily CODIACRININAE Bather, 1890

[*nom. transl.* Lane, 1967, p. 11 (*ex* Codiacrinidae Bather, 1899)] [=Hypocrininae Wanner, 1929; section Hypocrinites Wanner, 1929]

Diagnosis.—Theca lacking primanal and madreporite.

Occurrence.—Upper Silurian-Upper Permian.

Genus LECYTHIOCRINUS White, 1879

[=*Menocrinus* S. A. Miller, 1889]

Type Species.—*Lecythiocrinus olliculaeformis* White, 1879, p. 256.

Diagnosis.—Theca ovoid; infrabasals three; primanal present; anal vent without bordering small accessory plates.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Virgilian), USA (Oklahoma-Illinois-Kansas).

LECYTHIOCRINUS ASYMMETRICUS Moore & Strimple, new species

Plate 4, figure 1a-c

Description.—Cup asymmetrically globose, with constricted summit; infrabasals 3 (smallest in *C* ray) expand rapidly from small columnar attachment area, followed by 5 upflared long basals and these in turn by 5 radials smaller in dimensions, with narrow, horseshoe-shaped articular facets directed outward and slightly elevated. Asymmetry of the basal area is marked by position of the stem attachment area which is not at lowest point of the cup but shifted forward so that basal plane of the cup is formed by the posterior side of the infrabasal circlet, with consequent irregularity in lower plate sizes and shapes. The anal opening or periproct is relatively large and occupies a posterior position between the distal part of the *CD* basal and lower edges of the *C* and *D* radials. The entire surface of the cup is marked by minute closely spaced shallow depressions.

Discussion.—*Lecythiocrinus asymmetricus* has a shorter cup and proportionally larger anal opening than other species of the genus. It is also distinctive in structure of the base of the cup marked by forward displacement of the stem attachment and tilted subplanate posterior part of the base. Two closely associated specimens of the species have been found by Gregory Elias who retained one of them for his private collection.

Dimensions.—Measurements of holotype (SUI 33157) in millimeters are: width of cup, 5.3; height, 5.5; width of infrabasal circlet, about 4.0; width of *DE* basal, 3.3; length, 3.7; width of *E* radial, 2.7; length, 2.5; width of radial articular facet, 0.5; diameter of anal opening, 1.6.

Holotype.—SUI 33157, collected by Gregory Elias.

Occurrence.—Brentwood interval, Bloyd Formation, in bluffs just south of Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1].

Suborder POTERIOCRININA Jaekel, 1918

[*nom. correct.* Moore in Moore, Lalicker & Fischer, 1952, p. 614 (*pro* suborder Poteriocrinites Jaekel, 1918)] [=Poteriocrinitina Ubaghs, 1953]

Diagnosis.—Cup conical, bowl-shaped to nearly discoid, base convex with infrabasals visible from side or flat to concave with infrabasals not visible from side; radial articular facets narrowly horseshoe-shaped or wide, almost or fully equal to summit width of radials; externally visible anals in cup four to one or none visible externally. Tegmen usually lacking identifiable orals, ambulacrals and interambulacrals, mostly extended in tall anal sac. Arms unserial or biserial, typically pinnulate, branching isotomously or in part heterotomously, rarely atomous. Stem quinquestellate, pentagonal, or circular in section, cirri common.

Occurrence.—Upper Silurian (Gotlandian)-Upper Permian (Basleoan).

Superfamily SCYTALOCRINACEA Moore & Laudon, 1943 (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (*ex* Scytalocrinidae Moore & Laudon, 1943, p. 59)]

Type Genus.—*Scytalocrinus* Wachsmuth & Springer, 1879, p. 116.

Diagnosis.—Crown tall, composed of erect uniserial arms and steep-sided cup with infrabasals clearly visible from side and radials with articular facets equal to full width of their summits; anals in cup three. Anal sac tall, with or without balloonlike distal expansion. Arms stout, pinnulate, branching isotomously on first primibrach. Stem circular in section.

Discussion.—As currently defined the Scytalocrinacea contain the Scytalocrinidae Moore & Laudon, 1943; Blothrocrinidae Moore & Laudon, 1943; Cercidocrinidae Moore & Laudon, 1943; Aphelecrinidae Strimple, 1967; Corythocrinidae Strimple & Watkins, 1969; and Spaniocrinidae Moore & Laudon, 1943.

Occurrence.—Middle Devonian-Upper Permian.

Family SCYTALOCRINIDAE Moore & Laudon, 1943

[Scytalocrinidae Moore & Laudon, 1943, p. 59] [=Scytalecrinidae Bather, 1899]

Type Genus.—*Scytalocrinus* Wachsmuth & Springer, 1879, p. 116.

Diagnosis.—Arms mostly ten but may be nine owing to occurrence of atomous anterior arm. Anal sac tall cylindrical, composed of small polygonal plates, not expanded distally.

Occurrence.—Middle Devonian-Upper Permian.

Genus SCYTALOCRINUS Wachsmuth & Springer, 1879

[=*Dactylocrinus* Sladen, 1878 (*non* Quenstedt, 1876); *Scytalecrinus* Bather, 1899]

Type Species.—*Scaphiocrinus robustus* Hall, 1861, p. 315.

Diagnosis.—Characters of family, cup wider at summit than in several other genera and with tendency to slight longitudinal curvature of dorsal cup sides.

Discussion.—As discussed by Strimple & Watkins (1969, p. 197, 198) Pennsylvanian representatives formerly assigned to *Scytalocrinus* are atypical of the genus. Comparison with *Hypselocrinus* Kirk (1940) and other genera assigned to the family also discloses differences in characters. *Scytalocrinus sansabensis* Moore & Plummer (1938), typically of Atokan age, is reported herein from Morrowan rocks of northeastern Oklahoma.

Occurrence.—Middle Devonian-Upper Pennsylvanian; USA, Britain, Belgium, USSR.

SCYTALOCRINUS CRASSIBRACHIATUS Moore & Strimple, new species

Plate 4, figures 3a-c

Description.—This species is based on 2 complete crowns preserved in hard limestone, most of the cup and arms being covered by matrix. Removal of the matrix from the holotype was very difficult, but has been accomplished with only slight breakage near the base of the arms. All structural features are clearly determinable.

The crown has a pyriform outline and the total height is about 10 times that of the dorsal cup. The most noteworthy features of the specimens are very thick round arms composed of very short uniserially arranged brachials. The arms are thickest at midheight, being slightly smaller near the cup and tapering noticeably toward the tips.

The cup is turbinate or truncate conical bowl-shaped, with height less than one-half of greatest width. The 5 infrabasals slope gently upward from the stem impression and are visible in side view of the cup. The distal extremities of the basals reach to about midheight of the cup. The radials are wider than long and form the more steeply sloping upper part of the cup. The sutures between radials and primibrachs gape very slightly. The posterior interray of the cup is slightly flattened but not depressed. Three plates of the anal series occur in normal position, the primanal (radianal) touching the *BC* basal, secundanal resting against the narrowly truncate distal extremity of the *CD* basal, and tertanal obliquely at right above primanal. The first primibrach is axillary in all rays, with height nearly equal to width. It supports 2 massive unbranched arms which are crowded closely together in their lower parts but nevertheless are well rounded in section. The arms are composed of segments about 1 mm in thickness, their lower and upper surfaces being almost but not quite parallel and therefore faintly cuneiform. No pinnules are visible along sides of the crown, but at the top are numerous cross sections of small pinnules. Doubtless each secundibrach is pinnule-bearing. The stem is round transversely, few columnals attached at the base of the cup showing alternate thin narrow segments and wider thicker ones, giving the stem an annulated appearance. The lumen is very small and round. The surface of the cup and arms seems to be smooth except for very fine granules.

Dimensions.—Measurements of the holotype in millimeters are as follows: height of crown, about 55; height of dorsal cup, 4.5; width of cup, 8; diameter of proximal part of stem, 3.5; diameter of arms at midheight, 5.3.

Discussion.—The crinoid here described differs markedly from other known Pennsylvanian crinoids, especially in the nature of its arms. The form and structure of the cup and arms are essentially identical to those of *Scytalocrinus robustus*, the type species of *Scytalocrinus*. The arms of *S. robustus*, as in most other species referred to this genus, are relatively much more slender and pinnules more prominently grouped than is seen in the crinoid here described. It is distinguished from *S. robustus* and other species by its very thick arms and very short even brachials.

The nature of the cup and arms corresponds fairly well to those of *Pegocrinus bijugus* (Trautschold), which is characterized by a bowl-shaped cup and 10

extremely massive rounded arms composed of relatively short brachials. Kirk (1940, p. 331) introduced the genus *Pegocrinus* to include this single species from the Moscovian of Russian which previously had been named *Poteriocrinus bijugus* (Trautschold, 1867, p. 14; Jaekel, 1879, p. 64) or *Poteriocrinus (Scytalocrinus) bijugus* Wachsmuth & Springer (1880, p. 118). Chief distinction between the Russian crinoid and *Scytalocrinus crassibrachiatus* is seen in the nature of the primibrachs, for 2 or 3 of these are found in each ray of *P. bijugus* and only one in *Scytalocrinus crassibrachiatus*. The arms of *P. bijugus* are very uniform in thickness throughout their length, although the length of their brachials varies somewhat; in *S. crassibrachiatus* the arms taper and the length of the brachials is fairly constant. Examples of Trautschold's species, which are available for direct comparison, indicate no basis for judgment that the Morrowan crinoid belongs to *Pegocrinus*.

Types.—Holotype (SUI 33161) collected by C. L. Foster, paratype (SUI 33162) collected by H. L. Strimple.

Occurrence.—Brentwood interval, Bloyd Formation, from road cut on old Hwy. 10, southeast of Ft. Gibson, Oklahoma [Loc. 2], and abandoned quarry near Ft. Gibson Lake, Cherokee County, Oklahoma [Loc. 16].

SCYTALOCRINUS SANSABENSIS Moore & Plummer, 1940

Plate 5, figure 1a-d

Discussion.—This species has been adequately described and figured by Moore & Plummer (1940, p. 131, pl. 5, fig. 6, pl. 14, fig. 10) and has been further discussed by Strimple & Watkins (1969, p. 198). It occurs typically in the Lemons Bluff Member, Marble Falls Formation (Atokan) near San Saba, Texas. The small hypotype from the Morrowan of Oklahoma is thought to be conspecific, differing only in having a finely granulose surface.

Hypotype.—SUI 35410 collected by H. L. Strimple.

Occurrence.—Brentwood interval, Bloyd Formation, at base of Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8].

Genus PHACELOCRINUS Kirk, 1940

Type Species.—*Poteriocrinus wetherbyi* S. A. Miller, 1879, p. 36.

Diagnosis.—High steep-sided cup, prominent infrabasals, three anal plates in normal (primitive) arrangemen, ten uniserial arms, first branching on primibrach *2* or fused primibrachs *1* and *2*. Stem pentagonal.

Discussion.—By middle Chesteran time, *Phacelocrinus* had developed fused primibrachs *1* and *2* in all rays and stabilized the crown in having ten elongated arms. *Hydriocrinus* Trautschold (1867) of Late Carboniferous age retained a pentagonal stem but developed a confluent distal articulating surface on primanal and secundanal for tilting the anal tube and an addition of arms may occur in the distal portion of the crown.

Occurrence.—Mississippian (Lower Carboniferous)-Pennsylvanian (Upper Carboniferous); USA, Ireland.

PHACELOCRINUS ROSEI (Moore & Plummer, 1938) Moore & Strimple, new combination

Discussion.—*Hydriocrinus? rosei* was described by Moore & Plummer (1938, p. 239) on the basis of a monotypic specimen found at the base of a slope which contained outcrops of both Morrowan and Chesteran rocks just north of Keough quarry near Ft. Gibson; however, Strimple (1961, p. 306) reported another specimen from the Brentwood interval exposed at Greenleaf Lake spillway and established a Morrowan age. Both specimens have anal plates in normal arrangement which distinguishes the species from typical *Hydriocrinus*, which has a specialized arrangement with distal surfaces of primanal and secundanal confluent and bearing articulating facets. The species is identified as *Phacelocrinus rosei* (Moore & Plummer) Moore & Strimple, new combination.

Types.—Holotype (KUMIP 45197), collected by R. Rose; hypotype (OU 3619) collected by Jack Hood.

Occurrence.—Holotype, Bloyd Formation, just north of Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1]; hypotype, Brentwood interval, Bloyd Formation, Greenleaf Lake spillway, Muskogee County, Oklahoma [Loc. 8b].

PHACELOCRINUS BREVIS Moore & Strimple, new species

Plate 3, figures 5a,b

Description.—Cup low, truncate cone-shaped with infrabasals extending evenly from a rim encircling the impressed stem attachment. Infrabasals upflared, short; basals moderately short; radials wider than long, articular facets filling summit width of plates; 3 anal plates in normal (primitive) arrangement, primanal somewhat larger than others, proximal end of primanal short.

Discussion.—The specimen described as *Hydriocrinus? rosei* Moore & Plummer (1938) has a primitive arrangement of anal plates in the *CD* interray, a feature shared with Chesteran *Phacelocrinus*, whereas *Hydriocrinus* has an advanced arrangement of these plates with primanal and secundanal forming an almost confluent subhorizontal plane. *P. rosei* has a taller, more evenly expanded dorsal cup and more elongate infrabasals than *P. brevis*.

Dimensions.—Measurements of holotype (SUI 33376) in millimeters are: width of cup, 10.9; height, 4.8; width of infrabasal circlet, 5.4; width of *DE* basal, 5.2; length, 3.7; width of *E* radial, 5.5; length, 3.8; diameter of proximal column, 3.8.

Holotype.—SUI 33376, collected by Jack Hood.

Occurrence.—Brentwood interval, Bloyd Formation,

in dense limestone from well up in the Greenleaf Lake spillway, southeast of Braggs, Muskogee County, Oklahoma [Loc. 8c].

Genus MORROWCRINUS Moore & Plummer, 1938

Plate 4, figure 7

Type Species.—*Morrowcrinus fosteri* Moore & Plummer, 1938, p. 245.

Description.—Cup conical, evenly expanded, height approximately equal to width, infrabasals five, clearly visible from side, surface of cup frosted in appearance; three anal plates in cup in normal (primitive) arrangement; round stem. The most distinctive character of *Morrowcrinus* is seen in the arms which are 10, branching on large primibrach *1* and composed of wide uniserial secundibrachs. The arms are closely in contact all around. The anal sac apparently is large.

Discussion.—Moore & Plummer (1938, p. 243, 244) emphasized that the supernumerary plate (designated as a superbasal) in *C* ray of the holotype (monotype) of the type species did not affect differentiation of the genus from other known taxa. No further representatives of the genus have been reported from the mid-continent region but a form described from Morrowan rocks of Utah as *Hypselocrinus defendus* Washburn (1968) is here designated as *Morrowcrinus defendus* (Washburn) Moore & Strimple, new combination, and the holotype (BYU 1496) illustrated (Pl. 4, fig. 7). Other than for the extra basal plate in the holotype of *M. fosteri* the two forms are almost identical. *Morrowcrinus* probably gave rise to *Stuartwellercrinus* Moore & Plummer (1938), typically of Permian age.

Occurrence.—Pennsylvanian (Morrowan); USA (Oklahoma, Utah).

Family SPANIOCRINIDAE Moore & Laudon, 1943

Type Genus.—*Spaniocrinus* Wanner, 1924, p. 292.

Diagnosis.—Cup slightly or broadly truncate conical, with three to five infrabasals well visible in side view, radial articular facets equal in width to summit of these plates; three to one, with primanal in line with radials or located in notch at distal extremity of *CD* interradial suture. Anal sac unknown. Arms five or ten, with isotomous branching on first primibrach, composed of massive uniserially arranged brachials. Stem transversely round.

Occurrence.—Lower Mississippian (Osagian)-Upper Permian (Basleoan).

Genus SPANIOCRINUS Wanner, 1924

Type Species.—*Spaniocrinus validus* Wanner, 1924, p. 292.

Diagnosis.—Cup broadly truncate at base; five infrabasals; primanal not visible externally, located in *CD* interradial notch.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Permian (Basleoan), USA (Texas-Oklahoma), USSR (Transcaucasia), Indonesia (Island of Timor).

SPANIOCRINUS species

Plate 4, figures 6a,b

Description.—A single specimen consisting of 3 radial plates and adjoining lower portions of the arms is the only material at hand. The arms are unbranched, uniserial and robust which has led to assignment of this fossil to *Spaniocrinus*. The genus has previously been reported from rocks of Permian age in Texas, the Island of Timor, Indonesia, and Transcaucasia, USSR. This is the first to be recorded from the Pennsylvanian and from the United States.

Figured Specimen.—SUI 35480, collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation, Morrowan, Pontotoc County, Oklahoma [Loc. 13].

Superfamily MOLLOCRINACEA Wanner, 1916 (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (*ex* Mollocrinidae Wanner, 1916, p. 67)]

Type Genus.—*Mollocrinus* Wanner, 1916, p. 67.

Diagnosis.—Cup deep bowl-shaped to globose, base convex; infrabasals three to five, generally visible from side; radial articular facets narrow horseshoe-shaped, sloping outward-downward; anals in cup two or one. Anal sac lacking. Arms uniserial, branching isotomously.

Discussion.—Only a single family, the Mollocrinidae, is assigned to this superfamily.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Permian (Basleoan).

Family MOLLOCRINIDAE Wanner, 1916

[Mollocrinidae Wanner, 1916, p. 67]

Diagnosis.—Cup globose, three infrabasals visible from side. Arms unknown.

Occurrence.—Lower Pennsylvanian-Upper Permian.

Genus STRONGYLOCRINUS Wanner, 1916

[*Strongylocrinus* Wanner, 1916, p. 72]

Type Species.—*Strongylocrinus molengraffi* Wanner, 1916, p. 72.

Diagnosis.—Cup spheroidal; three infrabasals readily visible in side view of cup; five large basals with that of *CD* interray larger than others and truncated for contact with primanal; five radials somewhat smaller than

basals, with narrow articular facets. Stem round. Anal sac and arms unknown.

Discussion.—*Strongylocrinus uralicus* Yakovlev (1937) has a fully developed primanal (radianal) as well as secundanal. The genus has not been reported previously from rocks other than Permian in age and only three *bona fide* species, including the type and two others reported here from Lower Pennsylvanian (Morrowan) rocks are now known.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Permian (Basleoan); USA (Oklahoma), Indonesia (Island of Timor), ?USSR (Ural Mountains).

STRONGYLOCRINUS HANSONI Moore & Strimple, new species
Plate 5, figures 4a-d

Diagnosis.—Characters of the genus, surface of plates smooth, sutures between them not impressed, *CD* basal considerably larger than others.

Description.—Infrabasals unequal in size, the smallest located in the *C* ray; *CD* basal very appreciably wider and longer than others and distinguished by a slightly crescentic wide distal facet; radial articular facets indistinct, small, horseshoe-shaped, and directed outward. Cup plates are unornamented and lack tumidity.

Discussion.—*Strongylocrinus hansoni* has proportionally larger radials than are found in *S. molengraffii*, type species of the genus. The largest paratype (SUI 35831) of *S. hansoni* has a cup width of 16.8 mm and height of 10 mm.

Dimensions.—Measurements of the holotype in millimeters, width (W) and height (H), are as follows: dorsal cup, W-9.3, H-5.7; infrabasal circlet, W-5.0, H-0.9; *DE* basal, W-4.7, H-4.6; *CD* basal, W-5.0, H-4.6; *A* radial, W-4.8, H-3.2.

Types.—Holotype (SUI 33169), collected by Albert Hanson, paratypes (SUI 35798, 35831) collected by Allen Graffham, paratypes (SUI 35832, 35833) collected by Christina Strimple.

Occurrence.—Bloyd Formation, near Muskogee, Muskogee County, Oklahoma [Loc. 17]; Brentwood interval, Bloyd Formation, near Gore, Muskogee County, Oklahoma [Loc. 40].

STRONGYLOCRINUS ORNATUS Moore & Strimple, new species
Plate 4, figures 2a,b

Diagnosis.—Characters of the genus, surface of cup coarsely granulose, sutures between plates impressed.

Discussion.—*Strongylocrinus ornatus* is readily separable from *S. molengraffi* and *S. hansoni* in having a highly ornate surface. *S. molengraffi* is further distinguished in having tumid cup plates. *S. hansoni* lacks tumidity of the cup plates, has an almost spherical shape, and displays unimpressed sutures.

Dimensions.—Measurements in millimeters of the holotype (SUI 35798) designated as A and paratype (SUI 35831) indicated as B are width (W) and height or length (H) as follows dorsal cup (anteroposterior), A-W-11.7, H-7.4; B-W-15.6, H-9.7; infrabasal circlet, A-W-4.8, H-4.9, B-W-8.4, H-7.0; *DE* basal, A-W-5.0, H-4.9, B-W-7.3, H-7.0; *CD* basal, A-W-5.7, H-5.0, B-W-9.7, H-6.3; *A* radial, A-W-5.9, H-3.9, B-W-7.8, H-5.8; radial articular facet, A-W-2.0, B-W-2.0.

Types.—Holotype (SUI 35798) and paratype (SUI 35831) collected by Allen A. Graffham.

Occurrence.—Brentwood interval, Bloyd Formation, Morrowan, spillway at Greenleaf Lake, Muskogee County, Oklahoma [Loc. 8a].

Superfamily LOPHOCRINACEA Bather, 1899 (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (*ex* Lophocrinidae Bather, 1899)]

Type Genus.—*Lophocrinus* von Meyer, 1858, p. 59.

Diagnosis.—Cup low bowl-shaped with convex base (exceptionally flat or weakly concave), sides flaring outward near rim, arm facets peneplenary, two or three anals in cup; and sac tall and prominent.

EXPLANATION OF PLATE 5

Morrowan species of inadunate crinoids—*Scytalocrinus*, *Cromyocrinus*, and *Paragassizocrinus*.

FIGURE

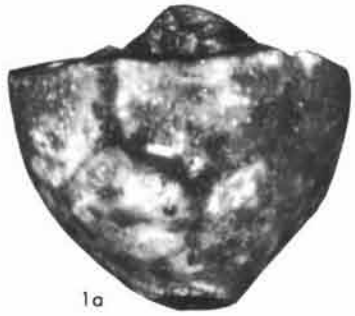
1a-d. *Scytalocrinus sansabensis* Moore & Plummer, 1940. Anterior, dorsal, ventral, and posterior views of hypotype (SUI 35410) from Brentwood interval, Bloyd Formation, at base of Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×5.2.

2a-d. *Cromyocrinus grandis* Mather, 1915. Ventral, dorsal, posterior and anterior views of juvenile hypotype (SUI 33166) from Brentwood interval, Bloyd Formation, at Keough quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×4.5.

FIGURE

3. *Paragassizocrinus kendrickensis* Strimple & Knapp, 1966. Anterior view of hypotype (Ky. State Geol. Survey), from Kendrick Shale Member, Breathitt Formation, Pike County, Kentucky, ×1.3.

4a-d. *Strongylocrinus hansoni* Moore & Strimple, new species. Dorsal, posterior, anterior, and ventral views of holotype (SUI 33169) from Bloyd Formation near Muskogee, Muskogee County, Oklahoma, ×4.5.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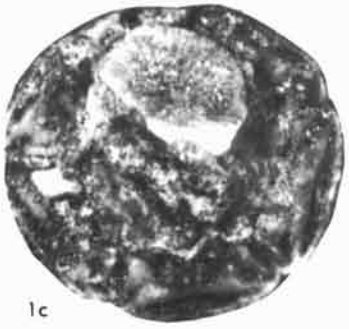
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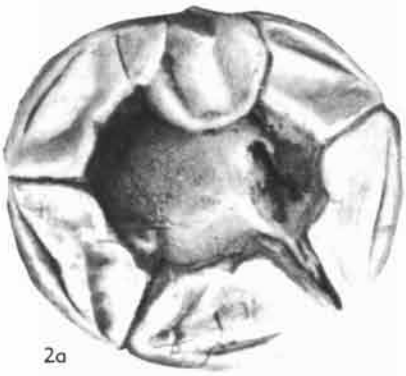
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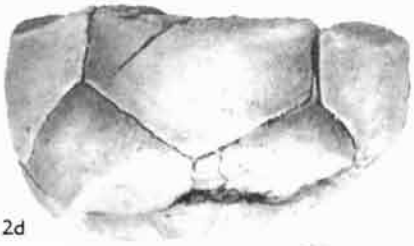
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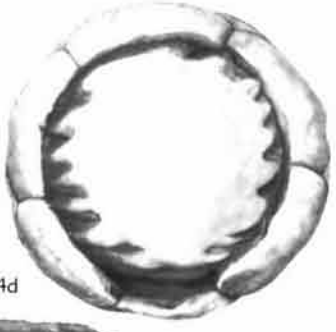
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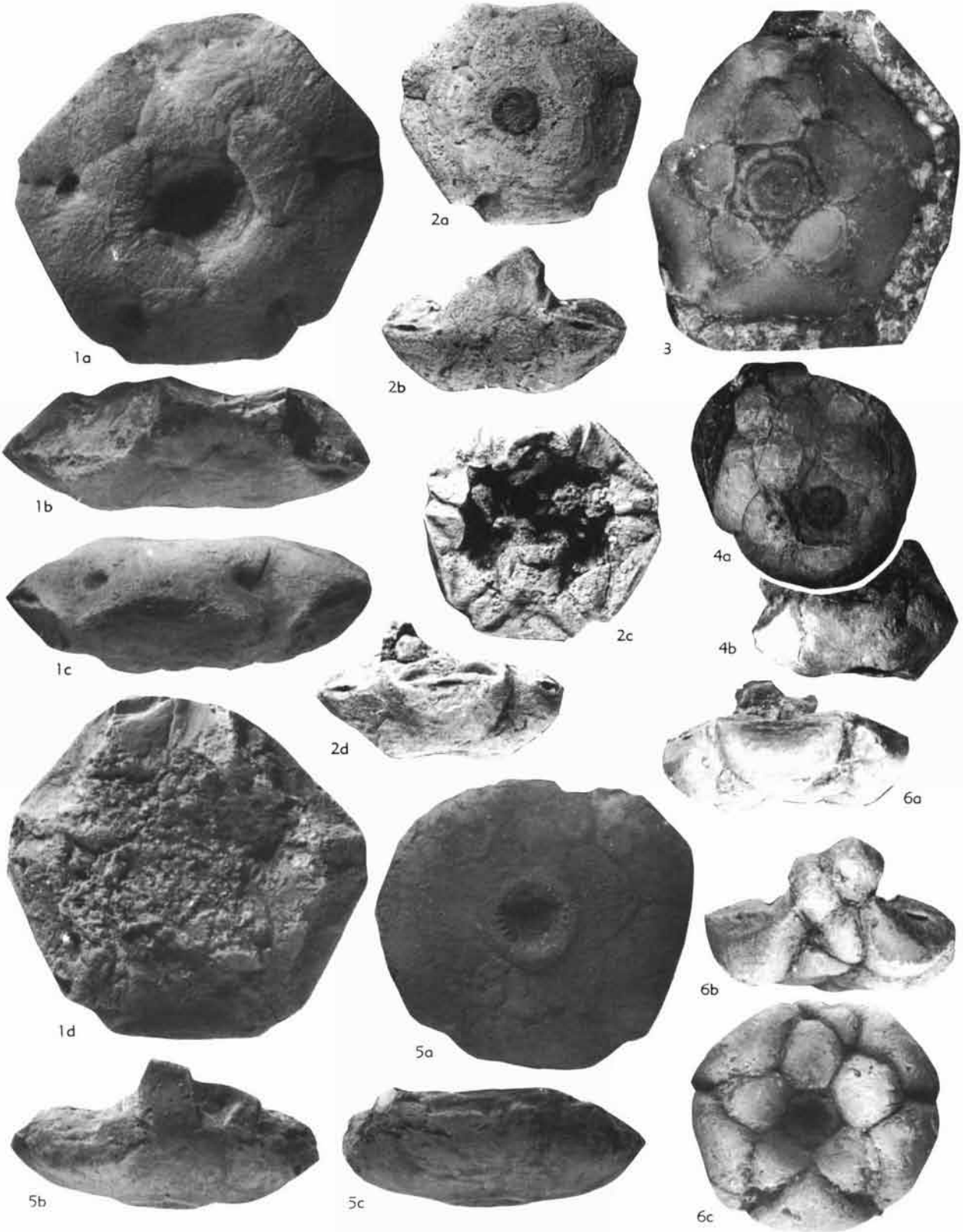
4a


4c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3
1b
2c
4a
4b
1c
2d
6a
1d
5a
6b
5b
5c
6c

Discussion.—Included families are: Lophocrinidae Bather, 1899; Pelecocrinidae Kirk, 1941; Indocrinidae Strimple, 1966; Laudonocrinidae Moore & Strimple, n. fam.; Stellarocrinidae Strimple, 1961; and Pachylocrinidae Kirk, 1942.

Occurrence.—Upper Silurian-Upper Permian.

Family LAUDONOCRINIDAE Moore & Strimple, new family

Type Genus.—*Laudonocrinus* Moore & Plummer, 1940, p. 174.

Diagnosis.—Cup bowl-shaped, with flat or faintly convex base and subvertical sides near rim, arm facets peneplenary, interradial notches distinct in dorsal and ventral views, two or three anals in cup; anal sac mushroom-shaped, with summit platform girdled by horizontally directed spines, uniserial arms endotomous.

Occurrence.—Lower Pennsylvanian-Lower Permian.

Genus ANCHICRINUS Strimple & Watkins, 1969

[*Anchicrinus* Strimple & Watkins, 1969, p. 206]

Type Species.—*Anchicrinus toddi* Strimple & Watkins, 1969, p. 207.

Diagnosis.—Base of cup planate or very gently concave; sutures between plates somewhat impressed and pits at plate angles; wide basals extend into side walls of cup; large slightly bulbous arms branch twice or more isotomously. Primaxils articulated with radials, other axillary brachials at higher levels in crown. The anal sac is mushroomlike, with wide spine-bordered platform at top.

Discussion.—*Anchicrinus* seemingly is related to *Laudonocrinus* Moore & Plummer (1940), *Athlocrinus* Moore & Plummer (1940), and *Metaperimestocrinus* Strimple (1961), all of which possess essentially flat-bottomed cups. *Laudonocrinus* and *Metaperimestocrinus* typically have proportionally higher cups and the latter genus has a larger platform at summit of the anal sac. Young specimens of *Anchicrinus rugosus* (Strimple, 1961), which is atypical of the genus, may exhibit a shallow basal concavity but mature individuals have a sharply impressed basal invagination. Species presently assigned to *Anchicrinus* include the following:

Species of Anchicrinus

Anchicrinus planulatus		
Moore & Strimple, n. sp.	Morrowan, Okla.	*Anchicrinus*
Anchicrinus toddi		
Strimple & Watkins, 1969	Desmoinesian, Tex.	Type species
Anchicrinus minutus		
Moore & Strimple, n. sp.	Morrowan, Okla.	*Anchicrinus*
Athlocrinus? sp.		
Knapp, 1969	Atokan, Mo.	*Anchicrinus planulatus*
Stenopecrinus rugosus		
Strimple, 1961	Morrowan, Okla.	*Anchicrinus*

Occurrence.—Lower Pennsylvanian (Morrowan)-Middle Pennsylvanian (Desmoinesian); USA (Oklahoma, Texas, Missouri).

ANCHICRINUS PLANULATUS Moore & Strimple, new species

Plate 6, figures 1a-d, 2a-d, 3, 4a,b

Diagnosis.—Characters of the genus, outward-upward slope of radials gentle.

Discussion.—The cup is shallow saucer-shaped rather than bowl-shaped as in *Anchicrinus toddi*, the type species. The arms and anal sac of *A. planulatus* are unknown.

Small pronounced depressions at corners of the cup plates, seen in both *Anchicrinus planulatus* and *A. toddi*, is a character shared with a specimen (Univ. Missouri 14829) designated by Knapp (1969, pl. 62, fig. 6-8) as *Athlocrinus?* sp. but considered here as a hypotype of *A. planulatus*.

EXPLANATION OF PLATE 6

Morrowan species of inadunate crinoids—*Anchicrinus*, *Affinocrinus*, *Athlocrinus*.

FIGURE

1-4. *Anchicrinus planulatus* Moore & Strimple, new species, from Brentwood interval, Bloyd Formation; 1a-d, dorsal, posterior, anterior, and ventral views of holotype (SUI 33284) from abandoned quarry on east shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma, ×4.6; 2a-d, dorsal, posterior, ventral, and anterior views of paratype (SUI 32777) from Greenleaf Lake spillway, southeast of Braggs, Muskogee County, Oklahoma, ×4.6; 3, dorsal view of paratype (SUI 32941) from Bloyd Mountain, Washington County, Arkansas, ×1.9; 4a,b, dorsal and anterior view of paratype (SUI 35428) from Evansville Mountain, Washington County, Arkansas, ×1.5.

5a-c. *Athlocrinus dejustus* Moore & Strimple, new species, from lower part of Wapanucka Formation, SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, dorsal, posterior, and anterior views of holotype (SUI 32933), ×4.6.

6a-c. *Affinocrinus normalis* Moore & Strimple, new species, from lower part of Wapanucka Formation, in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, anterior, posterior, and dorsal side of holotype (SUI 33126), ×3.

Part of the infrabasal circlet (about two-thirds) of the holotype (SUI 33284) of *Anchicrinus planulatus* has collapsed inward but the remaining third demonstrates its subhorizontal attitude. Paratype (SUI 32941) has undisturbed infrabasals which are subhorizontal (distal tips slightly upflared).

Dimensions.—Measurements of the holotype (SUI 33284) indicated as A and of a paratype (SUI 32941) indicated as B are given in millimeters; width (W) and height or length (H) are as follows: dorsal cup, A, W-13.0, H-3.0; B, W-24.8, H-3.2; infrabasal circlet (average), A, W-3.1; B, W-8.9; basal plate, A, W-4.0, H-2.9; B, W-6.2, H-5.6; radial plate, A, W-6.6, H-4.0; B, W-12.8, H-7.2; stem attachment scar, A, W-1.5; B, W-5.5.

Types.—Holotype (SUI 33284) and paratype (SUI 32777) collected by H. L. Strimple; paratype (SUI 32941) collected by W. M. Furnish; paratype (SUI 35428) collected by Walter Manger.

Occurrence.—Holotype (SUI 33284), Brentwood interval, Bloyd Formation, abandoned quarry on east shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16]; paratype (SUI 32777), same formation, Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8b]; paratype (SUI 32941), Brentwood Limestone, Bloyd Formation at type locality of Bloyd Formation, Bloyd Mountain, Washington County, Arkansas; paratype (SUI 35428), 1 foot below top of Brentwood Limestone, Bloyd Formation, Evansville Mountain, Washington County, Arkansas.

ANCHICRINUS RUGOSUS (Strimple, 1961) Moore & Strimple, new combination

[=*Stenopecrinus rugosus* Strimple, 1961, p. 42]

Plate 7, figures 1a-d, 2a-d, 3a-d, 4a,b, 5a-d

Description.—Cup low, flat-bottomed saucer-shaped base lacking concavity other than depression of stem attachment cicatrix; infrabasals subhorizontal; basals moderately large, distal ends visible in side view of cup; radials large, articular facets strongly sloped outward-downward, proximal ends barely reaching basal plane of cup or distinctly above it; small but prominent pits at all plate angles and distributed along many interplate sutures; cup anals 3, in normal (primitive) arrangement; proximal columnal circular, its attachment to cup marked by sharp crenulations, lumen small, round. Anal sac mushroom-shaped, terminal platform bordered by longer slender, laterally directed spines. Arms uniserial, branching isotomously on spine-bearing first primibrach, higher axillaries also spinose or bulbous, brachials between axials short and wide, with rectilinear interbrachial facets.

Discussion.—*Anchicrinus toddi* Strimple & Watkins (1969), from the Millsap Lake Formation (Desmoinesian) of Texas, has steeper curvature of the cup sides than *A. rugosus*. *A. planulatus* has a broader cup and less numerous and less conspicuous pits at plate angles.

Anchicrinus rugosus is an ornate species well represented in and restricted to the Brentwood interval of the Bloyd Formation in northeastern Oklahoma and lower part of the Wapanucka Formation in southeastern Oklahoma.

Types.—Metatypes include rather numerous specimens: OU 4166, collected by Allen Graffham, reposited in Paleontological Collections, The University of Oklahoma, Norman, Oklahoma; others (SUI 33318, 33167, 33168, 33301, 33302, 35438), collected by Melba & Harrell Strimple, and (SUI 33340), collected by R. C. Moore.

Occurrence.—Brentwood interval, Bloyd Formation at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a]; and lower part of the Wapanucka Formation, Canyon Creek, Pontotoc County, Oklahoma [Loc. 12a], and in the same county [Loc. 13].

Genus ATHLOCRINUS Moore & Plummer, 1940

Type Species.—*Athlocrinus placidus* Moore & Plummer, 1940, p. 170.

Diagnosis.—Cup extremely shallow saucer-shaped, base wide and almost perfectly flat except for indentation of round stem; sides of cup flare gently upward to subvertical at summit plane; posterior interray typically broad; sutures not impressed. Distal portions of basals visible in side view of cup, proximal parts horizontal, in basal plane; proximal tips of radials extend to basal plane; typically three anal plates in cup.

EXPLANATION OF PLATE 7

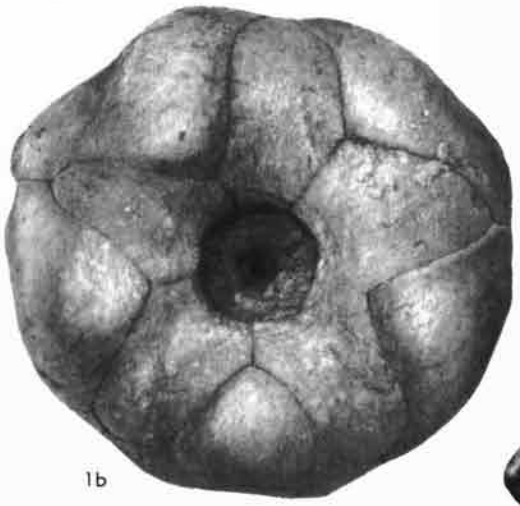
Morrowan species of inadunate crinoids—*Anchicrinus*.

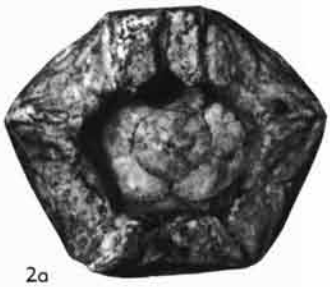
FIGURE

1-5. *Anchicrinus rugosus* (Strimple), 1961, from Brentwood interval, Bloyd Formation, Muskogee County, or lower part of Wapanucka Formation, Pontotoc County, both Oklahoma; 1a-d, dorsal, posterior, anterior, and ventral views of metatype (SUI 33302) from Bloyd Formation, ×4.6; 2a-d, dorsal, ventral, anterior, and posterior views of metatype (SUI 33340) from Bloyd Formation, ×4.6; 3a-d, dorsal, posterior, ventral, and anterior views of metatype (SUI 33318) from Wapanucka Formation, ×4.6; 4a,b, posterior and dorsal views of metatype from Bloyd Formation, ×4.6; 5a-d, dorsal, anterior, posterior, and ventral views of metatype (SUI 33301) from Bloyd Formation, ×4.6.

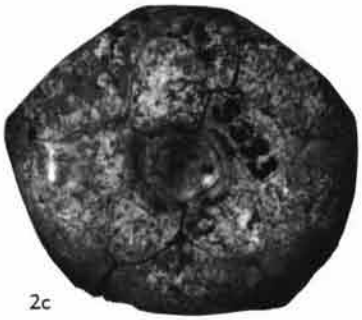

1a
1b
1c
1d
2a
2b
2c
2d
3a
3b
3c
3d
4a
4b
5a
5b
5c
5a


1a

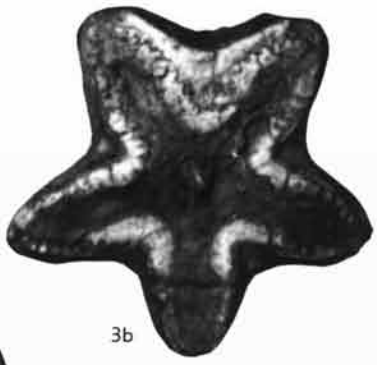

1b

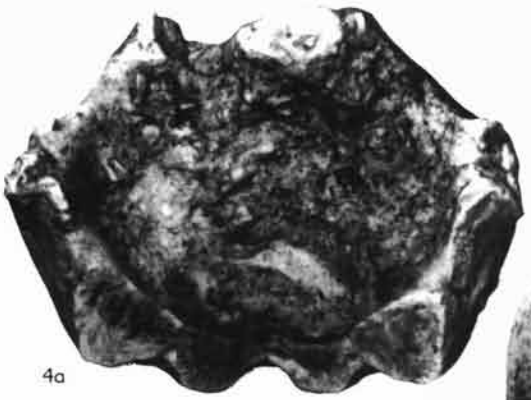

2a


2b


2c


3a


3b


4a


4b


4c


5a


5b


5c

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Virgilian); USA (Oklahoma, Kansas, Texas, Nebraska, ?Missouri).

ATHLOCRINUS DEJUSTUS Moore & Strimple, new species
Plate 6, figures 5a-c

Description.—Cup with broad planate base save for rim around columnar cicatrix which causes a slightly upflared appearance to the infrabasal circlet. Cup outline circular when viewed from above or below; sutures mildly impressed, cup plates smooth; radial articular facets directed slightly outward-downward. Anal plates 3, in normal arrangement.

Discussion.—The cup of *Athlocrinus* is much shallower than typical *Laudonocrinus* Moore & Plummer (1940) and the sides are more evenly rounded than in *Bathronocrinus* Strimple (1962). The infrabasal circlet is somewhat more prominent than typical of *Athlocrinus* but apparently this is through formation of a collar about the area impressed for reception of the proximal columnals. The genus is not reported elsewhere in the Morrowan. Some resemblance of *Athlocrinus dejustus* to *Anchicrinus planulatus* Moore & Strimple, n. sp., is noted, but distal ends of the basals are sharply flexed into round depressions which extend into interradial troughs. Interradial sutures of *Athlocrinus dejustus* are not impressed, but essentially flush with the cup surface, as typical of the genus.

Dimensions.—Measurements of the holotype (SUI 32933) in millimeters are: width of cup, 11.0; height, 3.5; width of infrabasal circlet, 3.6; width of *DE* basal, 3.0; length, 2.2; width of *E* radial, 5.4; length, 3.4.

Holotype.—SUI 32933, collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation; Pontotoc County, Oklahoma [Loc. 13].

Family STELLAROCRINIDAE Strimple, 1961

[Stellarocrinidae Strimple, 1961, p. 108]

Type Genus.—*Stellarocrinus* Strimple, 1940, p. 1.

Diagnosis.—Crown typically explanate, with well-separated arms outspread laterally. Cup patelliform, with wide shallow basal concavity; commonly with pits at plate angles and sharp ridges across interplate sutures; radial articular facets peneplenary and strongly declivate, lacking prominent transverse ridge and ligament fossae; anal plates in cup three or uncommonly a single one (primanal) resting on squarely truncate *CD* basal. Anal sac tall, slender, and spinose, with vent at summit. Arms strongly obliqui-uniserial, incipiently biserial, or full biserial, branching isotomously on primibrachs *2* in geologically older forms but on primibrachs *1* in others, pinnulate. Stem transversely quinquestellate or pentagonal in older representatives, otherwise circular, cirri lacking.

Occurrence.—Upper Mississippian-(Chesteran)-Lower Permian (Wolfcampian).

Genus HELIOSOCRINUS Strimple, 1951

Type Species.—*Heliosocrinus aftonensis* Strimple, 1951, p. 676.

Diagnosis.—Crown expanded, obliqui-uniserial arms not abutting. Cup low, with shallowly concave base, raised ridges crossing interplate sutures, with flattened long spine developed in midposition of basal plates; radial articular facets peneplenary; 3 normally arranged anal plates in *CD* interray. Arms in all rays branch on first primibrach and twice or more above primaxils, short spines on all axillary brachials. Stem quinquelobate in outline.

EXPLANATION OF PLATE 8

Morrowan species of inadunate crinoids.—*Affinocrinus, Heliosocrinus, Dicromyocrinus.*

FIGURE

1a,b. *Affinocrinus progressus* Moore & Strimple, new species, posterior and dorsal views of paratype (SUI 33180) from Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway, southeast of Braggs, Muskogee County, Oklahoma, ×4.6, ×5.

2a-c. *Affinocrinus normalis* Moore & Strimple, new species, ventral, posterior, and dorsal views of paratype (SUI 36244) from lower part of Wapanucka Formation, in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×2.

3a,b. *Heliosocrinus* species, facetal views of columnals (hypotype SUI 32930), from Brentwood interval, Bloyd Formation, from Greenleaf Lake spillway southeast of Flat Rock Creek, Wagoner County, Oklahoma, ×6.

4a-c. *Heliosocrinus neotosus* Moore & Strimple, new species, ventral, dorsal, and posterior views of slightly incomplete cup (holotype, SUI 33127) from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×6.

5a-c. *Dicromyocrinus medius* Moore & Strimple, new species, dorsal, ventral, and posterior views of paratype (SUI 33130) from middle part of Wapanucka Formation on Canyon Creek southeast of Fittstown in SE ¼ sec. 35, T. 13 N., R. 33 W., Pontotoc County, Oklahoma, ×2.3.

Discussion.—*Heliosocrinus* is distinguished from the geologically younger *Stellarocrinus* Strimple (1940) in having the three anal plates in normal (primitive) arrangement and in possessing a highly quinquestellate or quinquelobate column. The anal plates of *Stellarocrinus* are advanced, with the primanal in direct posterior position, and the stem is round. The earliest reported representatives of *Stellarocrinus* are Middle Pennsylvanian (Desmoinesian) in age, whereas *Heliosocrinus* is Late Mississippian (Chesteran) and Early Pennsylvanian in age. A species is recorded herein as *Heliosocrinus neotosus* Moore & Strimple, new species, from the lower part of the Wapanucka Formation (Morrowan). A poorly preserved cup and columnal from a Brentwood crinoid fauna in the Bloyd Formation are recorded as *Heliosocrinus* sp.

Occurrence.—Upper Mississippian (middle Chesteran)-Lower Pennsylvanian (Morrowan); USA (Oklahoma).

HELIOSOCRINUS NEOTOSUS Moore & Strimple, new species
Plate 8, figures 4a-c

Description.—Cup low, bowl-shaped, with shallow basal concavity. Infrabasals 5, forming a regular pentagon almost entirely covered by a very large quinquelobate columnar scar; basals convex angular, the *CD* basal having a truncate distal tip for reception of secundanal and the *BC* basal wider than normal and having an extra facet for reception of primanal (radianal); lower portions of basals in the basal plane of the cup; radials 5 wide regular pentagonal elements with peneplenary articular facets normal to the basal plane of the cup; 3 anal plates in the cup, secundanal resting on the *CD* basal, adjoined low at right by the primanal (radianal), which supports tertanal above. Arms, tegmen, and anal sac are unknown.

Dimensions.—Measurements of the holotype in millimeters are: height of dorsal cup, 3.9; width, 14.5; width of infrabasal circlet, 5.9; diameter of stem cicatrix, 5.0.

Discussion.—*Heliosocrinus aftonensis* Strimple (1951), type species of the genus, has long basal spines. *H. neotosus* has short spines. Several Morrowan crinoids (e.g., *Utharocrinus* Moore & Plummer, 1938) developed long basal spines comparable to those of *H. aftonensis* and presumably for similar reasons, whatever they may be. Most Morrowan forms with projecting cup plates (e.g., *Lasanocrinus* Moore & Plummer, 1940, and *Metutharocrinus* Moore & Strimple, new genus) have moderate projections of the basals or radials, as in *H. neotosus*.

Holotype.—SUI 33127, collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation in SE ¼, sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma [Loc. 13].

HELIOSOCRINUS species
Plate 8, figures 3a,b

A single crinoid ossicle and a partial cup from northeastern Oklahoma are ascribed to *Heliosocrinus* sp.

Hypotypes.—SUI 32930 (columnal) collected by H. L. Strimple, and SUI 32924 (partial cup) collected by A. L. Bowsher.

Occurrence.—SUI 32930 Brentwood interval, Bloyd Formation, Flat Rock Creek north of Wagoner, Wagoner County, Oklahoma [Loc. 10]; SUI 32924, Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a].

Family PACHYLOCRINIDAE Kirk, 1942

Type Genus.—*Pachylocrinus* Wachsmuth & Springer, 1879, p. 115.

Diagnosis.—Cup low bowl-shaped, with flaring sides and shallowly concave, nearly flat broad base; outline with interradial notches in dorsal or ventral views; three anals in cup. Arms uniserial, branching twice or more. Stem round.

Occurrence.—Lower Mississippian-Upper Permian.

Genus PLUMMERICRINUS Moore & Laudon, 1943

[*Plummericrinus* Moore & Laudon, 1943, p. 56]

Type Species.—*Pachylocrinus mcguirei* Moore, 1939, p. 205, Brownville Limestone, Virgilian, Osage County, Oklahoma.

Diagnosis.—Plates of cup moderately tumid and sutures between them impressed; base concave; radial articular facets sloping outward-downward. Anal sac looped downward from its summit below arm tips. Arms stout, uniserial, upspread outward.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Virgilian), USA (Oklahoma-Illinois).

PLUMMERICRINUS EXPANSUS Moore & Strimple, new species
Plate 9, figures 3a-d

Description.—The cup truncate cone-shaped, with lowermost extremities of the basal plates curved inward so as to produce a broad gentle slope with outer parts of the infrabasals, the stem attachment being located in a small steep-sided depression. Sutures between the cup plates are mildly impressed and small deep pits are formed at plate angles in the upper part of the cup. The anterior side of the cup is somewhat flattened, producing an asymmetry in which the shortest width of the cup is from front to back. The outer surface of the cup is smooth, plates lacking any sort of ornament. The basals are somewhat bulbous, with their distal portions in the

basal plane of the cup. The radial plates project outward-upward at a low angle and small interradial notches are seen between them. The posterior interray is rather broad and does not interrupt the normal round outline of the cup when viewed from above or below. Three anals occur in this interray in normal (primitive) arrangement, with tertanal considerably larger than others. The arms and tegmen are unknown.

Dimensions.—Measurements in millimeters of the holotype of *Plummericrinus expansus* are given in width (W) and height or length (H) as follows: dorsal cup, W-14.0, H-6.0; ratio of H/W, 0.48; basal cavity, H-1.4; infrabasal circlet, H-4.0; *D* basal, W-4.5, H-6.0; *B* radial, W-7.0, H-4.4.

Discussion.—This species is remarkably similar to *Plummericrinus mcguirei* (Moore), differing in that plates of the latter are relatively wider and notches at summit of interradial sutures are more pronounced. The relatively high cup of *P. expansus* serves to distinguish it from other described species.

Holotype.—SUI 33128, collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation, at knoll in sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma [Loc. 13].

Superfamily AGASSIZOCRINACEA S. A. Miller, 1890 (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (*ex* Agassizocrinidae S. A. Miller, 1890, p. 214)]

Diagnosis.—Crown tall; dorsal cup semiovoid, with infrabasal circlet clearly visible from side above rounded convex base; radial articular facets equal to full summit width of these plates; one to four anal plates in posterior interray. Anal sac low, cylindrical. Arms uniserial or uncommonly biserial, branching isotomously on primibrachs *2* or *1*, without bifurcations higher. Stem round in section.

Discussion.—Includes Agassizocrinidae S. A. Miller, 1890; Bursacrinidae Kirk, 1947; Ampelocrinidae Kirk, 1942; Cricocrinidae Moore & Strimple, n. fam.; Trimerocrinidae Moore & Laudon, 1943; Sundacrinidae Moore & Laudon, 1943; and Anobasicrinidae Strimple, 1961.

Occurrence.—Mississippian-Permian.

Family AGASSIZOCRINIDAE S. A. Miller, 1890

Type Genus.—*Agassizocrinus* Owen & Shumard, 1851, p. 93.

Diagnosis.—Cup with five separate basals or large plates of this circlet fused solidly and stemless in adult growth stage, plates thick, radial articular facets short, matching thickness of these plates. Arms uniserial.

Occurrence.—Mississippian-Pennsylvanian.

Genus PARAGASSIZOCRINUS Moore & Plummer, 1940

Type Species.—*Agassizocrinus tarri* Strimple, 1938, p. 10.

Diagnosis.—Crown slender and tall. Cup narrowly semiovoid, with large solidly fused infrabasals in adult growth stage, convexly rounded below; no radianal, only primanal in cup. Arms uniserial, branching isotomously on first primibrach. Stemless.

Discussion.—Differs from *Agassizocrinus*, which it resembles superficially, in having 2 primibrachs in each ray instead of only 1 and in lacking more than a primanal in the cup. In general, 3 distinct forms occur in Morrowan species of *Paragassizocrinus*, characterized respectively by 1) sharply delineated edges at summit of the infrabasal circlet, 2) rounded edges and apices of this fused circlet, and 3) a series of projections and depressions on the distal suture faces. These severally include 1) *P. deltoideus* Strimple (1960), *P. disculus* Strimple (1960), *P. calyculoides* (Lane, 1964); 2) *P. caliculus* (Moore & Plummer, 1938), *P. asymmetricus* Strimple (1960), and 3) *P. turris* Strimple (1960).

Another character for differentiation of these species is length of the individual upper infrabasal facets which reflects proximal thickness of the basal plates. *Paragassizocrinus deltoideus* and *P. caliculus* have very long facets surrounding a small central depression. All other Morrowan species have relatively short infrabasal distal facets and a large depressed central area in the fused half-egg at base of the dorsal cup. Some questions concerning *P. magnus* are encountered because this feature is not illustrated for the holotype and the descriptive text is not clear. A hypotype (SUI 33358) shows a strong sursumate (outward-upward) slope of the facets and large interbasal projections.

More detailed study is needed before the genus is fully understood. Even though the forms are stalkless, and therefore presumably free to move at will, they are not as widespread as many associated stalked forms. Also very many specimens found in restricted areas suggest a preferred environment such as close association with a nearby calcareous build-up on the shallow sea floor. For example, large number of specimens have been found associated with a reeflike locally thickened limestone in the lower part of the Wapanucka Formation in Pontotoc County, Oklahoma [Loc. 13], type locality of *Paragassizocrinus deltoideus, P. asymmetricus,* and *P. turris*. Yet at nearby Locality 12, in a crinoidal shale facies of lower Wapanucka beds essentially none of these crinoids occur. No large populations of *P. disculus* have been found but the species has wide distribution from the top of the lower into the middle part of the Wapanucka Formation. *P. disculus* is thought to be ancestral to *P. atoka* Strimple & Blythe (1960) from a black shale about 15 feet above the base of Atokan

beds in Cherokee County, Oklahoma. Information concerning some of these crinoids is summarized in the following table.

Presently Known Species of Paragassizocrinus

SPECIES	CATALOGUE NO.	NO. SPECIMENS	OCCURRENCE
P. caliculus?	SUI 33381	1	*Gaitherites* Zone at top of Brentwood Limestone, Bloyd Formation; Gaither Mountain south of Harrison, Arkansas
P. caliculus	SUI 33360	3	Brentwood Limestone Member, Bloyd Formation; Keough Quarry north of Ft. Gibson, Cherokee County, Oklahoma
P. caliculus	SUI 33401	15	Bloyd Formation, east flank of Kessler Mountain, south of Fayetteville, Washington County, Arkansas
P. caliculus	SUI 35484	1	House-of-Hess Member, upper Hale Formation; House-of-Hess, south of Fayetteville, Washington County, Arkansas
P. magnus	SUI 33358	1	Kessler Limestone, Bloyd Formation, 2 miles SE of Morrow, Washington County, Arkansas
P. disculus	SUI 33416	3	Top of lower part of Wapanucka Formation, Reservoir near Wapanucka, Johnson County, Oklahoma
	OU 22, 23, 26	3	
P. disculus	SUI 33310	1	Wapanucka Formation, Limestone Gap, north of Atoka, Atoka County, Oklahoma
P. disculus	OU 195	1	Lower beds in upper part of Wapanucka Formation, NE ¼ sec. 30, T. 1 N., R. 8 E., Coal County, Oklahoma.
P. disculus	OU 166	1	Top of lower part of Wapanucka Formation, abandoned quarry east of Clarita, Coal County, Oklahoma
P. deltoideus	SUI 35485	5	Lower part of Wapanucka Formation, Knoll, SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma
P. deltoideus	SUI 35403	1	Middle part of Wapanucka Formation, Burr Valley Ranch west of Clarita, Coal County, Oklahoma

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Virgilian); USA (Kansas, Oklahoma, Texas, Iowa, Missouri, Illinois, Kentucky, Utah, and Nevada).

PARAGASSIZOCRINUS KENDRICKENSIS Strimple & Knapp, 1966

Plate 5, figure 3

Discussion.—A nearly complete crown is figured here in order to demonstrate the relation of cup height to length of arms. The arms are a little more than 3 times as long as the cup is high, and are slender, uniserial, branching once on axillary primibrach 2.

Figured Hypotype.—Reposited Kentucky State Geol. Survey, collected by Shel Bergman.

Occurrence.—Kendrick Shale, Breathitt Formation (Morrowan), divide between Hurricane Creek and left fork of Grapevine Creek, Lick Creek Quadrangle, 27′30″-29.5′ North, 82′22″ West, Pike County, Kentucky.

Family AMPELOCRINIDAE Kirk, 1942

Type Genus.—Ampelocrinus Kirk, 1942, p. 23.

Diagnosis.—Crown tall and slender. Cup bowl-shaped, with convex base in which infrabasals are visible from side; radial articular facets filling entire summit of

EXPLANATION OF PLATE 9

Morrowan species of inadunate crinoids—*Cromyocrinus*, *Proallosocrinus*, *Plummericrinus*, and *Lasanocrinus*.

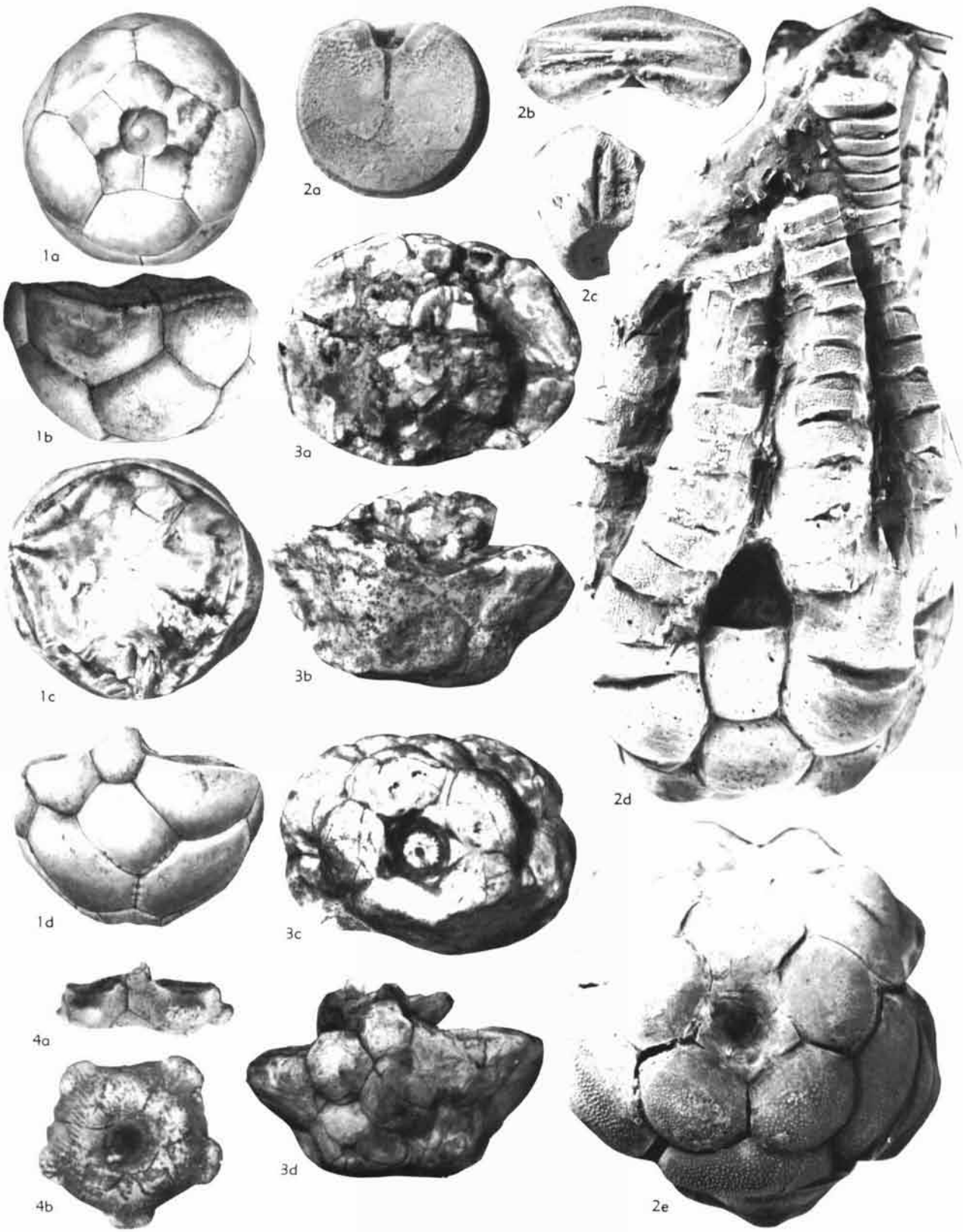
FIGURE

1a-d. *Cromyocrinus grandis* Mather, from Brentwood horizon, Bloyd Formation, at Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma; dorsal, anterior, ventral, and posterior views of juvenile hypotype (SUI 33165), ×2.8.

2a-e. *Proallosocrinus glenisteri* Moore & Strimple, new genus, new species, from Gene Autry Formation, in sec. 34, T. 3 S., R. 4 E., Carter County, Oklahoma; 2a, articular surface of secundibrach (paratype SUI 45432), ×4.5; 2b,c, summit and edge views of radial (paratype SUI 35431), ×1.9; 2d,e, posterior and dorsal views of holotype crown (SUI 33404), ×1.9.

3a-d. *Plummericrinus expansus* Moore & Strimple, new species, lower part of Wapanucka Formation in sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma; ventral, anterior, dorsal, and posterior views of holotype (SUI 33128), ×3.8.

4a,b. *Lasanocrinus nodatus* Moore & Strimple, new species, from Brentwood interval, Bloyd Formation, in abandoned quarry on east shore of Ft. Gibson Lake, Cherokee County, Oklahoma; posterior and dorsal views of paratype (SUI 35412), ×3.1.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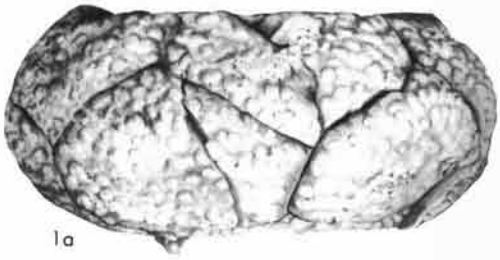
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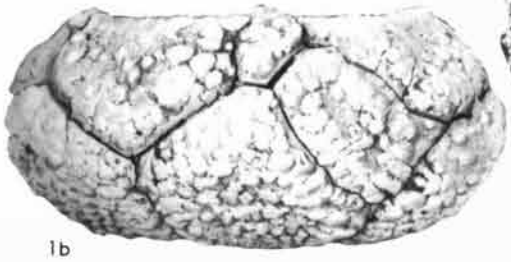
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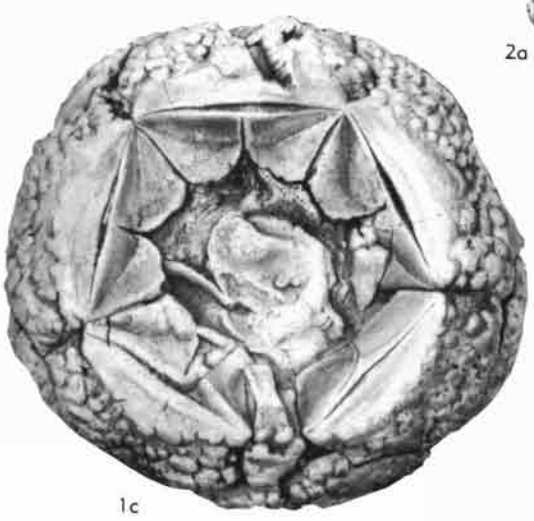
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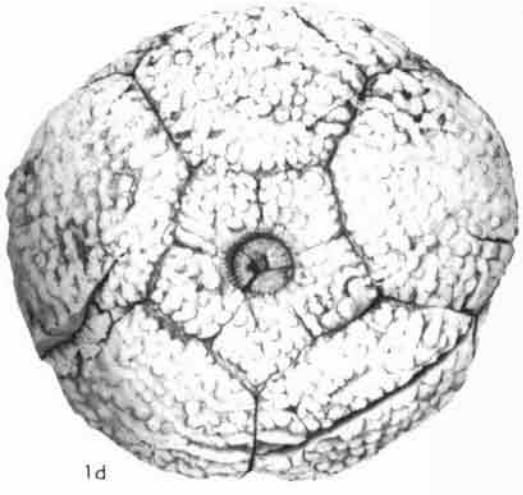
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2a


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2c


3


4a


4b

these plates, commonly sloped outward-upward, only primanal in cup (inferred to be radianal as indicated by oblique contact with *CD* basal). Anal sac elongate, narrowly cylindrical, composed of longitudinal rows of rugose plates. Arms slender, round, uniserial, pinnulate. Stem pentagonal with cirri.

Occurrence.—Lower Mississippian (Osagian)-Upper Pennsylvanian (Missourian).

Genus AMPELOCRINUS Kirk, 1942

Diagnosis.—Characters of family, arms branching isotomously on primibrachs 2 and isotomously or heterotomously at two or three higher levels.

Occurrence.—Lower Mississippian (Osagian)-Upper Pennsylvanian (Missourian); USA (Indiana, Illinois, Iowa, Missouri, Kansas, Oklahoma, Arkansas, Texas).

AMPELOCRINUS CONVEXUS (Strimple, 1940) Moore & Strimple, new combination

Description.—A species described as *Delocrinus convexus* Strimple (1940, p. 7, pl. 1, fig. 13, 14) remains an enigma, especially since no other than the holotype specimens have been found. The presence of a single anal plate and a large round stem led Strimple (*ibid.*, p. 7) to ascribe this crinoid to *Delocrinus* with the notation "This species is obviously not a true *Delocrinus*." The planate base is more primitive than found in any cymbiocrinid and more advanced than in ampelocrinids. Divergence from normal forms is shown by shortening of the interbasal sutures (entirely eliminated in one ray). The prominent infrabasals suggest affinity with *Ampelocrinus* and are supported by presence of axillary primibrachs 2. The species is referred to here as *Ampelocrinus convexus* (Strimple).

Holotype.—USNM S4337.

Occurrence.—Lower part of Wapanucka Formation, Canyon Creek, Pontotoc County, Oklahoma [Loc. 12a].

Family ANOBASICRINIDAE Strimple, 1961

[Anobasicrinidae Strimple, 1961, p. 114]

Type Genus.—*Anobasicrinus* Strimple, 1961, p. 114.

Diagnosis.—Crown moderately tall, expanding upward. Cup low truncate bowl-shaped with faintly convex or concave base but mainly flat; radial articular facets peneplenary, leaving small interradial notches; anal plates in cup three. Anal sac with distal balloon-like expansion. Arms uniserial, typically with strongly cuneate brachials, branching isotomously on first primibrachs and at irregular higher levels. Stem transversely circular.

Occurrence.—Lower Pennsylvanian (Morrowan)-Lower Permian (Wolfcampian).

Genus ANOBASICRINUS Strimple, 1961

Type Species.—*Anobasicrinus bulbosus* Strimple, 1961, p. 114.

Diagnosis.—Crown long, expanded upward, arms uniserial, branching more than once, not abutting; cup low, broadly truncate conical, infrabasals forming low slightly upflared disc; radial articular facets not filling distal width of radials; three anal plates in cup. Anal sac balloon-shaped, with plates projected as short spines.

Occurrence.—Lower Pennsylvanian (Morrowan)-Middle Pennsylvanian (Desmoinesian); USA (Oklahoma, Texas, Illinois).

ANOBASICRINUS OBSCURUS Strimple, 1961

Plate 4, figures 4a-d, 5a-d

Discussion.—Two cups of this species are in the presently studied collections. In one (hypotype SUI 32925) the primanal overlies the *CD* basal with a diagonal suture between them, but in the other (hypotype OU 276) the arrangement of anal plates is normal (primitive), as found in the holotype. The infrabasals are readily visible in side view of the cup but extend upward only a short distance.

Types.—Holotype (OU 4167) collected by Allen Graffham; hypotype (OU 276) collected by C. L. Rowett; hypotype (SUI 32925) collected by Amel Priest.

EXPLANATION OF PLATE 10

Morrowan species of inadunate crinoids—*Metacromyocrinus*, *Paracromyocrinus*.

FIGURE

1a-d. *Metacromyocrinus papulosus* (Moore & Plummer), 1938, anterior, posterior, ventral, and dorsal views of metatype (SUI 33155) from Brentwood interval, Bloyd Formation, at Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×1.2.

2-4. *Paracromyocrinus oklahomensis* (Moore & Plummer), 1938; 2a-c, hypotype (SUI 35422) segment of arm (pluribrachial) showing oblique interior, side, and exterior, from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×3; 3, hypotype (SUI 35424) pluribrachial from oblique interior, same beds and locality as 2a-c, ×3; 4a,b, hypotype (SUI 35423) pluribrachial from midlength of crown viewed from interior showing pinnule facets and ambulacral groove, and side view showing ridges and grooves which interact with adjacent arms, same beds and locality as 2a-c, ×3.

Occurrence.—Holotype (OU 4167) lower part of Wapanucka Formation, Canyon Creek, Pontotoc County, Oklahoma [Loc. 12a]; hypotype (OU 276), east of Clarita, Coal County, Oklahoma [Loc. 30]; hypotype (SUI 32925), Olney road, east of Clarita, Coal County, Oklahoma [Loc. 15].

Superfamily CROMYOCRINACEA Bather, 1890 (Moore & Strimple, new superfamily)

[Cromyocrinacea Bather, May, 1890, p. 385 (*nom. transl.* Moore & Strimple, herein, *ex* Cromyocrinidae Bather, 1890, *nom. transl.* Jaekel, 1918, p. 65, *ex* series Cromyocrinites Bather, 1890)]

Diagnosis.—Cup bowl-shaped, with or without basal concavity, radials with plenary articular facets, two or three anals in cup. Anal sac not prominent. Arms uniserial or biserial, five to 20 or more, branching confined to primibrachs *1* and secundibrachs *1*. Stem transversely circular.

Discussion.—This superfamily, prevailingly characterized by medium-sized to large cups with convex or flat base, includes some with shallow to deep basal concavity, because all have seemingly diagnostic features in common. Included are the Eupachycrinidae, Phanocrinidae, Cromyocrinidae, Ulocrinidae, and Cadocrinidae.

Occurrence.—Upper Mississippian-Lower Permian.

Family CROMYOCRINIDAE Jaekel, 1918

Diagnosis.—Cup more or less globose, including forms with upflared infrabasals, which are visible from side; one to three anal plates in cup; arms uniserial or biserial, unbranched (*Cromyocrinus*) or branched on primibrachs *1* in all rays, some younger forms branching also on secundibrachs *1* in some rays. Anal tube circular in section, small and short. Stem round transversely.

Occurrence.—Mississippian (Lower Carboniferous)-Permian.

Genus CROMYOCRINUS Trautschold, 1867

Type Species.—*Cromyocrinus simplex* Trautschold, 1867, p. 19.

Diagnosis.—Cup subglobular with convex base (upflared infrabasals) to almost planate in gerontic specimens; three anal plates in cup. Short anal sac. Five uniserial arms composed of short, wide brachials, pinnulate.

Occurrence.—Mississippian (Lower Carboniferous)-Permian; USA (Oklahoma, Arkansas), USSR.

CROMYOCRINUS GRANDIS Mather, 1915

Plate 5, figure 2a-d; Plate 9, figures 1a-d

Description.—Cup very large, subglobular, with large gently upflared infrabasals and constricted upper part of radials, 3 anal plates with quadrangular primanal largest.

Discussion.—Moore & Plummer (1938, p. 255) reported a poorly preserved specimen probably belonging to this species from Morrowan beds on Braggs Mountain, southeast of Ft. Gibson, Muskogee County, Oklahoma. Also, large smooth individual plates which probably belong to the species have been observed by one of us (Strimple), associated with *Brannerоceras branneri* in a railroad cut near Union Mission, southeast of Choteau, Mayes County, Oklahoma [Loc. 9].

A large nearly complete cup (OU 7125) is reported here from Buckhorn Mountain, Cherokee County, Oklahoma. The holotype came from the Brentwood Member, Bloyd Formation (Morrowan), 2 miles northwest of Brentwood (S ½ sec. 23, T. 14 N., R. 30 W.), Washington County, Arkansas [Loc. 41]. Measurements of the hypotype (OU 7125) in millimeters are: height of cup, 35; width, 58; width of infrabasal circlet, 28.5.

Two young specimens (SUI 33165, SUI 33166) are recorded here from Keough Quarry north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1] and from south of Hulbert, Cherokee County, Oklahoma [Loc. 35].

EXPLANATION OF PLATE 11

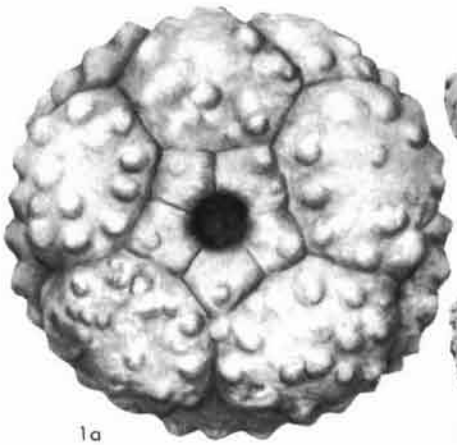
Morrowan species of inadunate crinoids—*Dicromyocrinus, Paracromyocrinus, Metacromyocrinus.*

FIGURE

1,4. *Dicromyocrinus subaplatus* Moore & Strimple, new species; 1a-d, dorsal, posterior, ventral, and anterior views of paratype (SUI 33174) from Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma; 4a,b, anterior and posterior views of holotype (SUI 33177) from Brentwood interval, Bloyd Formation, at Keough Quarry north of Ft. Gibson, Cherokee County, Oklahoma, ×4.6.

2a-d. *Paracromyocrinus oklahomensis* (Moore & Plummer), 1938, posterior, anterior, dorsal, and ventral views of hypotype (OU 231) from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., southeast of Fittstown, Pontotoc County, Oklahoma, ×4.6.

3a-c. *Metacromyocrinus gillumi* Strimple, 1966; dorsal, *BC*- and *DE*-interray views of juvenile crown (metatype SUI 33066) from ?pre-Brentwood shale, Bloyd Formation, on Sweetwater Creek near Strickler, Washington County, Arkansas, ×1.5.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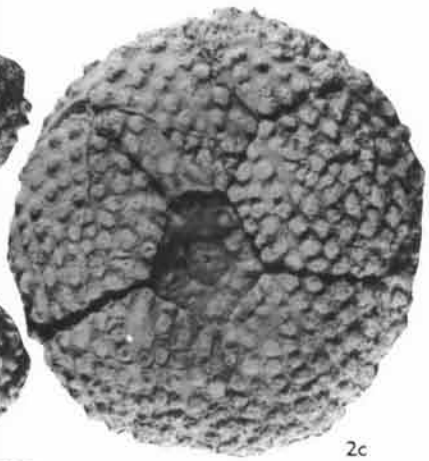
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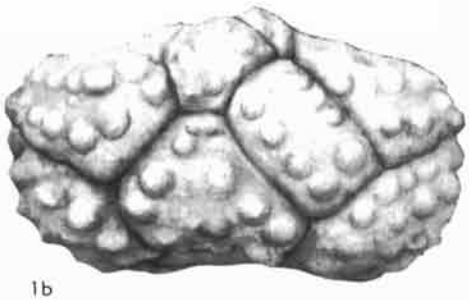
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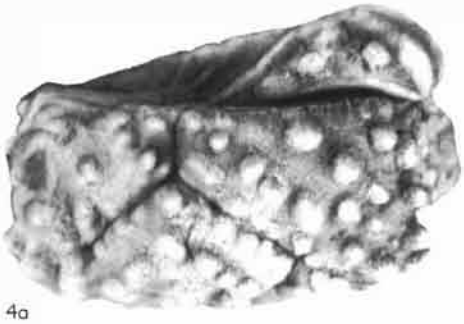
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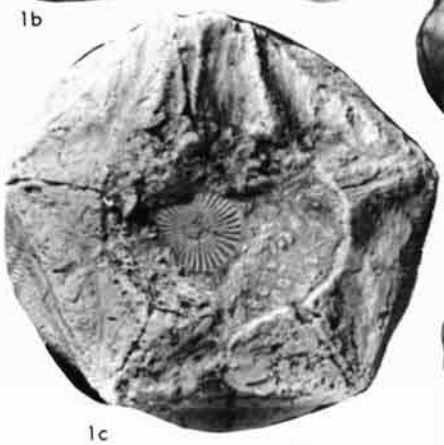
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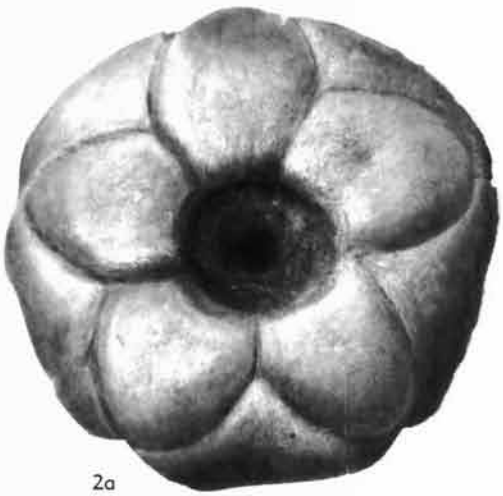
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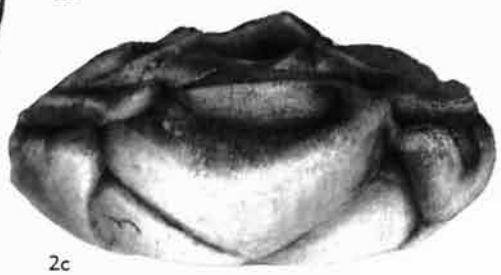
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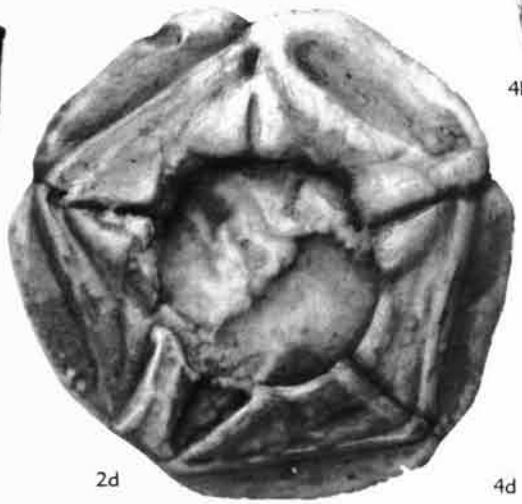
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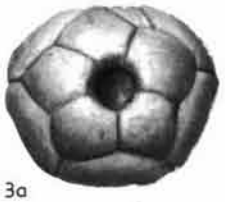
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4a


4b


4c


4d

Measurements of hypotype (SUI 33165) in millimeters are: width of cup, 17.8; height, 12.4; width of infrabasal circlet, 10.0. The basal view of specimen SUI 33165 illustrates a pronounced protrusion of the right posterior side. In unabraded areas a faint vermicular surface ornamentation is present.

Hypotypes.—OU 7125, SUI 33165, 33166.

Occurrence.—OU 7125, Morrow Formation, interval 43.7 to 32.7 feet below Cookson Member (Sutherland & Henry Loc. 39-4), on Buckhorn Mountain, Cherokee County, Oklahoma [Loc. 36]; SUI 33165, 33166; Brentwood interval, Bloyd Formation, Keough Quarry north of Ft. Gibson, Cherokee County [Loc. 1] and 2 miles south of Hulbert, Cherokee County, Oklahoma [Loc. 35].

Genus METACROMYOCRINUS Strimple, 1961

Type Species.—Metacromyocrinus holdenvillensis Strimple, 1961, p. 69.

Diagnosis.—Cup globose, with convex base, infrabasals large, moderately upflared but indistinct in side view, three anal plates in older species, two in younger ones; arms ten, biserial, stout, branching on primibrachs *1*; surface of cup marked by stout nodes, stem round in section.

Occurrence.—Lower Pennsylvanian (Morrowan)-Middle Pennsylvanian (Desmoinesian); USA (Oklahoma).

METACROMYOCRINUS PAPULOSUS (Moore & Plummer, 1938) Moore & Strimple, new combination

Plate 10, figures 1a-d

Discussion.—This species proposed as *Ethelocrinus papulosus* was based on 2 radial plates and 1 basal plate. The generic assignment depended mainly on the tuberculose surface of the plates. Assignment now by us is based on a complete dorsal cup and classified as *Metacromyocrinus papulosus* (Moore & Plummer, 1938), new combination.

As reconstructed by Moore & Plummer (1938, fig. 5) the cup was indicated to be large and subhemispherical in outline. Closely packed irregularly shaped short ridges and contiguous furrows produce a rough distinctive surface. The infrabasal circlet is moderately large and subplanate, the stem attachment area small and slightly impressed. Two anal plates are seen in the posterior interray, the primanal being large, elongate, and quadrangular, the secundanal about one-fourth as large and not extending appreciably above the cup summit. The radial articular facets have been thoroughly described by Moore & Plummer (1938, p. 259, 260). The anal sac and arms are unknown.

Types.—Holotype, a radial plate (KUMIP 45198) and paratypes, a radial and basal plate (KUMIP 45198a,b) collected by C. L. Foster, metatype (SUI 33155) collected by B. Richard Shields.

Occurrence.—Brentwood interval, Bloyd Formation, at Keough Quarry, north of Ft. Gibson, Muskogee County, Oklahoma [Loc. 1].

METACROMYOCRINUS GILLUMI Strimple, 1966

Plate 11, figures 3a-c

Discussion.—A juvenile crown (metatype SUI 33066) in remarkably fine preservation is illustrated here. The cup is slightly more spherical than larger specimens and the infrabasals more prominent in side view. Overall length of the crown is 20.5 mm; height of cup, 12.8 mm; width of cup, 20.5 mm; width of infrabasal circlet, 9.7 mm. The entire surface of the crown is covered by small nodes.

Types.—Holotype (SUI 12279) collected by Gary Gillum, paratype SUI 12280, collected by J. H. Quinn, paratype (SUI 12281) collected by H. L. Strimple, metatype (SUI 33066) collected by John Taylor.

EXPLANATION OF PLATE 12

Morrowan species of inadunate crinoids—*Affinocrinus*, *Perimestocrinus*, and *Dicromyocrinus*.

FIGURE

1,2. *Affinocrinus progressus* Moore & Strimple, new species; 1a-d, dorsal, anterior, ventral, and posterior views of paratype (SUI 33275) from Brentwood horizon, Bloyd Formation, at abandoned quarry on east shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma, ×4.6; 2a-d, dorsal, posterior, anterior, and ventral views of holotype (SUI 33173) from abandoned quarry on east side of Grand River, SE ¼ sec. 22, T. 17 N., R. 19 E., Wagoner County, Oklahoma, ×4.6.

3a-d. *Perimestocrinus teneris* Moore & Plummer, 1938, dorsal, posterior, ventral, anterior views of hypotype (SUI 33190) from Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×4.6.

4a-d. *Dicromyocrinus optimus* Moore & Strimple, new species, dorsal, posterior, ventral, anterior views of hypotype (OU 252) from middle part of Wapanucka Formation, Canyon Creek, Pontotoc County, Oklahoma, ×2.3.

5. *Dicromyocrinus medius* Moore & Strimple, new species, anterior view of paratype (SUI 33130) from same beds and locality as 4a-d, ×2.3.

Occurrence.—All types were found in a thick pre-Brentwood? shale, Bloyd Formation, on Sweetwater Creek near Strickler, Washington County, Arkansas [Loc. 27].

Genus GOLEOCRINUS Strimple & Watkins, 1969

Type Species.—*Goleocrinus masonensis* Strimple & Watkins, 1969, p. 168.

Description.—Cup medium bowl-shaped with broad base containing a small concavity; five infrabasals are downflared except for their distal tips which are flexed outward subhorizontally and visible from the side; five large basals lie proximally in the basal plane of the cup and distally curve upward to form much of the cup walls. The basals and radials are tumid, the radials slightly wider than high and displaying a flattened subhorizontal forefacet next to the normal articulating area. Three anal plates are in normal (primitive) arrangement but the large primanal (radianal) is dominant and may take an advanced position. The surface of plates is essentially smooth. The stem attachment scar is circular. Arms are narrow, uniserial, moderate in length, and branch once on primibrachs *1*.

Discussion.—A crinoid from Morrowan deposits near Provo, Utah, loaned to us for study, originally named *Phanocrinus vadosus* by Washburn (1968, p. 126), now is identified as a species of *Goleocrinus* and so recorded here. It was found in the Bridal Veil Falls Member of the Oquirrh Formation in Provo Canyon.

An undescribed species of *Goleocrinus* is known to us from the Imo Formation (uppermost Chesteran) of Arkansas.

No specimens of the genus have been observed in the Morrowan of Arkansas, Oklahoma, or Texas.

Occurrence.—Upper Mississippian (upper Chesteran)-Middle Pennsylvanian (Atokan); USA (Texas-Utah-Arkansas).

GOLEOCRINUS VADOSUS (Washburn), 1968, Moore & Strimple, new combination

[*Phanocrinus vadosus* Washburn, 1968, p. 126]

Figure 5,1a-c

Description.—Characters of the genus, cup notably taller than that of *Goleocrinus masonensis* Strimple & Watkins (1969, p. 168) and interplate sutures somewhat more impressed; the slender recti-uniserial arms are composed of brachials with length equal or nearly equal to width, pinnules stout (Fig. 5,*1c*).

Discussion.—A form described as *Phanocrinus vadosus* Washburn (1968, p. 126) is here designated as *Goleocrinus vadosus* (Washburn) Moore & Strimple, new combination (see Figure 5,*1a-c*). Washburn (1968, p. 127) recognized that this species probably does not belong to *Phanocrinus*. The base of the holotype (BYU 1487) has collapsed inward and the paratypes are poorly preserved in their lower parts. Examination of the type specimens has led us to conclude that the distal tips of the infrabasals joined the proximal edges of the basals in a nearly horizontal attitude. The proximal edges of the radials are curved slightly inward so as to contribute to a basal concavity.

The cup of *Goleocrinus vadosus* is only slightly less tall than wide, whereas height of the cup is barely half the width in *G. masonensis*, type species of the genus.

Holotype.—BYU 1487.

Occurrence.—Bridal Veil Falls Member, Oquirrh Formation, in Provo Canyon, near Provo, Utah.

Genus DICROMYOCRINUS Jaekel, 1918

Type Species.—*Cromyocrinus ornatus* Trautschold, 1879, p. 121.

Diagnosis.—Cup low bowl-shaped with erect longitudinally rounded sides and planate base, surface of plates rugose, infrabasals not visible from side, radial articular facets plenary and planate; three or two anal

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EXPLANATION OF PLATE 13

Morrowan species of inadunate crinoids—*Dicromyocrinus*.

FIGURE

1a-d. *Dicromyocrinus medius* Moore & Strimple, new species, dorsal, posterior, ventral, and anterior views of paratype (OU 255) from middle part of Wapanucka Formation on Canyon Creek southeast of Fittstown, SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×1.7.

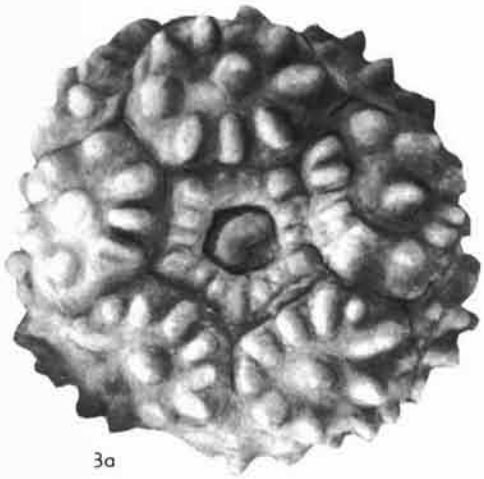
2,4. *Dicromyocrinus optimus* Strimple, 1951; 2a-d, dorsal, ventral, posterior, and anterior views of hypotype (OU 261) from lower part of Wapanucka Formation 2 miles east of Clarita, Coal County, Oklahoma, ×3; 4a-d, anterior, posterior, dorsal, and ventral views of hypotype (SUI 33163) from Brentwood interval, Bloyd Formation at base of Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×3.

3a,b. *Dicromyocrinus subaplatus* Moore & Strimple, new species, dorsal and ventral views of holotype (SUI 33177) from Brentwood interval, Bloyd Formation, at Keough Quarry north of Ft. Gibson, Cherokee County, Oklahoma, ×4.6.


1a


1b


2a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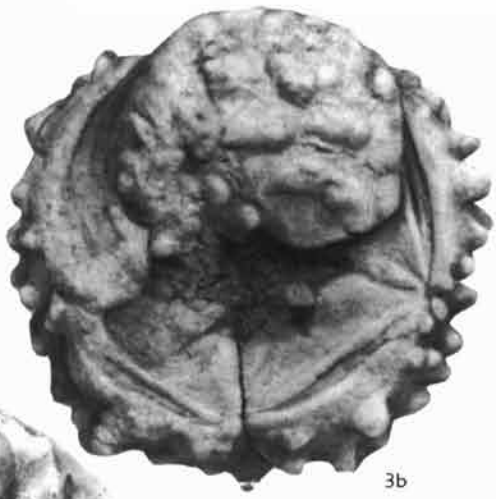
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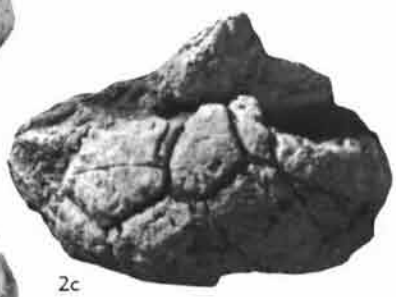
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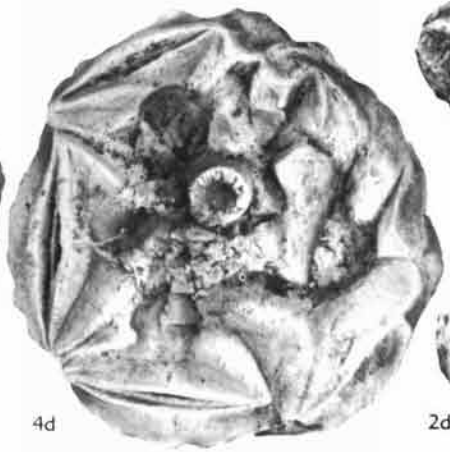
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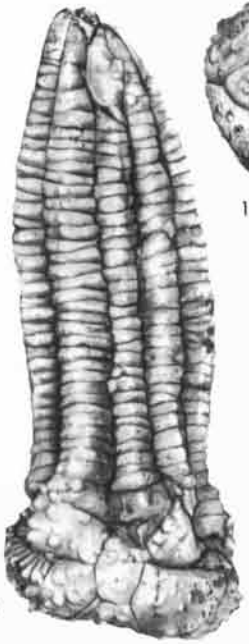
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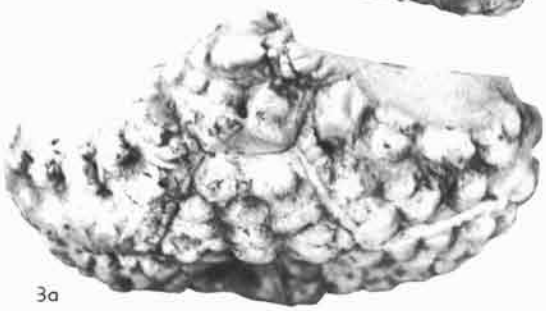
1d


2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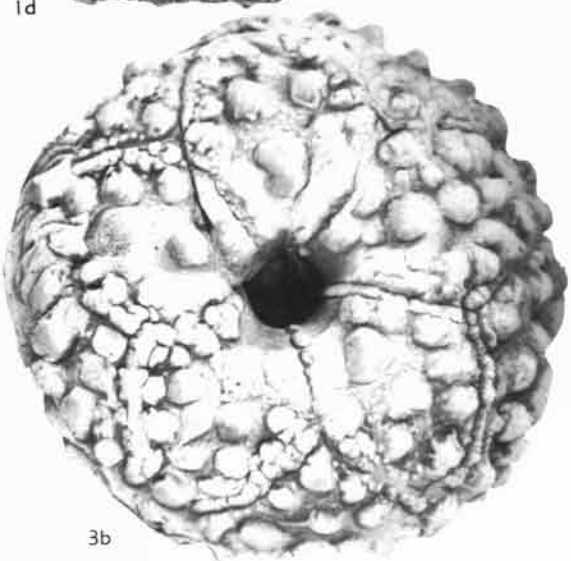
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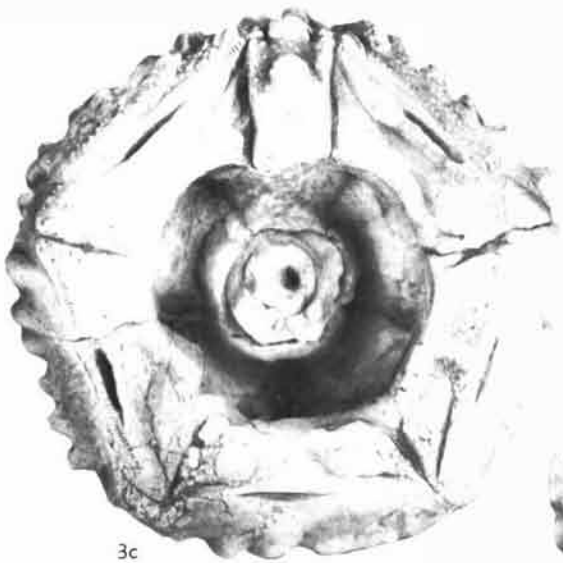

3c


3d


4

plates in cup. Arms obliqui-uniserial bifurcating isotomously on primibrachs *1* in all rays. Stem round transversely, cirri lacking.

Occurrence.—Lower Pennsylvanian (Morrowan)-Middle Pennsylvanian (Desmoinesian); USA (Oklahoma-Arkansas-Texas-Montana), USSR (near Moscow), Brazil.

DICROMYOCRINUS OPTIMUS Strimple, 1951

Plate 12, figures 4a-d; Plate 13, figures 2a-d, 4a-d

Description.—Cup medium bowl-shaped with almost vertical sides except for curvature at base and constriction toward summit, base evenly planate or faintly concave; interplate sutures impressed, entire surface of cup covered by closely packed rounded nodes; infrabasal circlet of medium size; proximal ends of basals curved to form part of cup base and extending distally to about midheight of cup; radials not reaching basal plane; 3 or 2 anal plates in normal (primitive) arrangement, primanal being largest (exception in OU 310, tertanal in some specimens squeezed out of cup). Anal sac and arms unknown.

Discussion.—The broad, nearly flat base of *Dicromyocrinus optimus*, 3 anal plates in cup, and closely spaced small nodes covering the surface serve to distinguish this species from related forms. It is represented in our collections by 17 specimens from both the Bloyd and Wapanucka Formations. The largest specimen (OU 310), which is from Wapanucka beds, has a width of 22.9 mm and height of 12.0 mm.

Types.—Holotype (SUI 33163), collected by Claude Bronaugh; metatypes (SUI 32257, 33320) collected by A. L. Bowsher and H. L. Strimple; hypotypes (SUI 33115, 33309, 33409) collected by R. C. Moore and H. L. Strimple; hypotypes (OU 251, 252, 261, 310) collected by C. Rowett.

Occurrence.—Holotype (SUI 33163) and metatypes (SUI 33115, 33163, 33320, 32257) are from the Brentwood interval, Bloyd Formation, at base of Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a]; hypotype (SUI 33309), Brentwood interval, Bloyd Formation, Keough Quarry, north of Ft. Gibson, Muskogee County, Oklahoma [Loc. 1]; hypotype (OU 261) lower middle part of Wapanucka Formation, 2 miles east of Clarita, Coal County, Oklahoma [Loc. 15]; hypotype (OU 251, 252), middle part of Wapanucka Formation on Canyon Creek, Pontotoc County, Oklahoma [Loc. 12b]; hypotype (OU 310), top of lower Wapanucka beds in abandoned quarry east of Clarita, Coal County, Oklahoma [Loc. 32]; hypotype (SUI 33409), middle part of Wapanucka Formation at Burr Valley Ranch, Coal County, Oklahoma [Loc. 14].

DICROMYOCRINUS MEDIUS Moore & Strimple, new species

Plate 8, figures 5a-c; Plate 12, figure 5; Plate 13, figures 1a-d

Description.—Cup low bowl-shaped with broad subplanate base and erect sides curved at summit and base; sutures slightly impressed and surface marked by widely spaced rounded nodes; infrabasal circlet moderately large, gently convex but not visible in side view of cup; basals large, proximal ends slightly curved so that infrabasals are not visible from side even though gently upflared, distal tips of basals reaching midheight of cup; radials with slight forefacet at summit, extending below midheight of cup but well above basal plane; 3 anal plates in advanced arrangement with large primanal (radianal), medium-sized secundanal above *CD* basal, and tertanal barely notching the cup. Anal sac and arms unknown. Columnar cicatrix circular.

Discussion.—The infrabasal circlet is slightly larger than found in associated *Dicromyocrinus optimus*. *Cromyocrinus grandis* Mather (1915) has a smooth cup with upflared infrabasals readily visible in side view.

Dimensions.—Measurements of holotype (OU 254) in millimeters are: width of cup, 18.9; height, 10.0; width of infrabasal circlet, 8.2; width of *DE* basal, 9.9; length, 8.9; width of *E* radial, 9.4; length, 6.0.

Types.—Holotype (OU 254) and paratype (OU 255) collected by C. L. Rowett, paratype (SUI 33130) collected by H. L. Strimple.

EXPLANATION OF PLATE 14

Morrowan species of inadunate crinoids—*Diphuicrinus*, *Paracromyocrinus*.

FIGURE

1a-d. *Diphuicrinus faustus* Moore & Strimple, new species; 1a, posterior side of holotype crown (OU 262) from middle part of Wapanucka Formation, 2 miles east of Clarita, Coal County, Oklahoma, ×1.7; 1b-d, posterior, dorsal, and *AB*-interray views of paratype (OU 4597) from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×1.5.

2. *Paracromyocrinus oklahomensis* (Moore & Plummer), 1938, external view of arm fragment (SUI 35423) showing biserial arrangement of brachials, from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×3.

3a-d,4. *Diphuicrinus mammifer* Moore & Strimple, new species; 3a-d, posterior, dorsal, ventral, and anterior views of paratype (SUI 11902) from same beds and locality as 1b-d, ×2.3; 4, posterior view of paratype (SUI 33177) from same beds and locality as 1b-d, ×4.6.

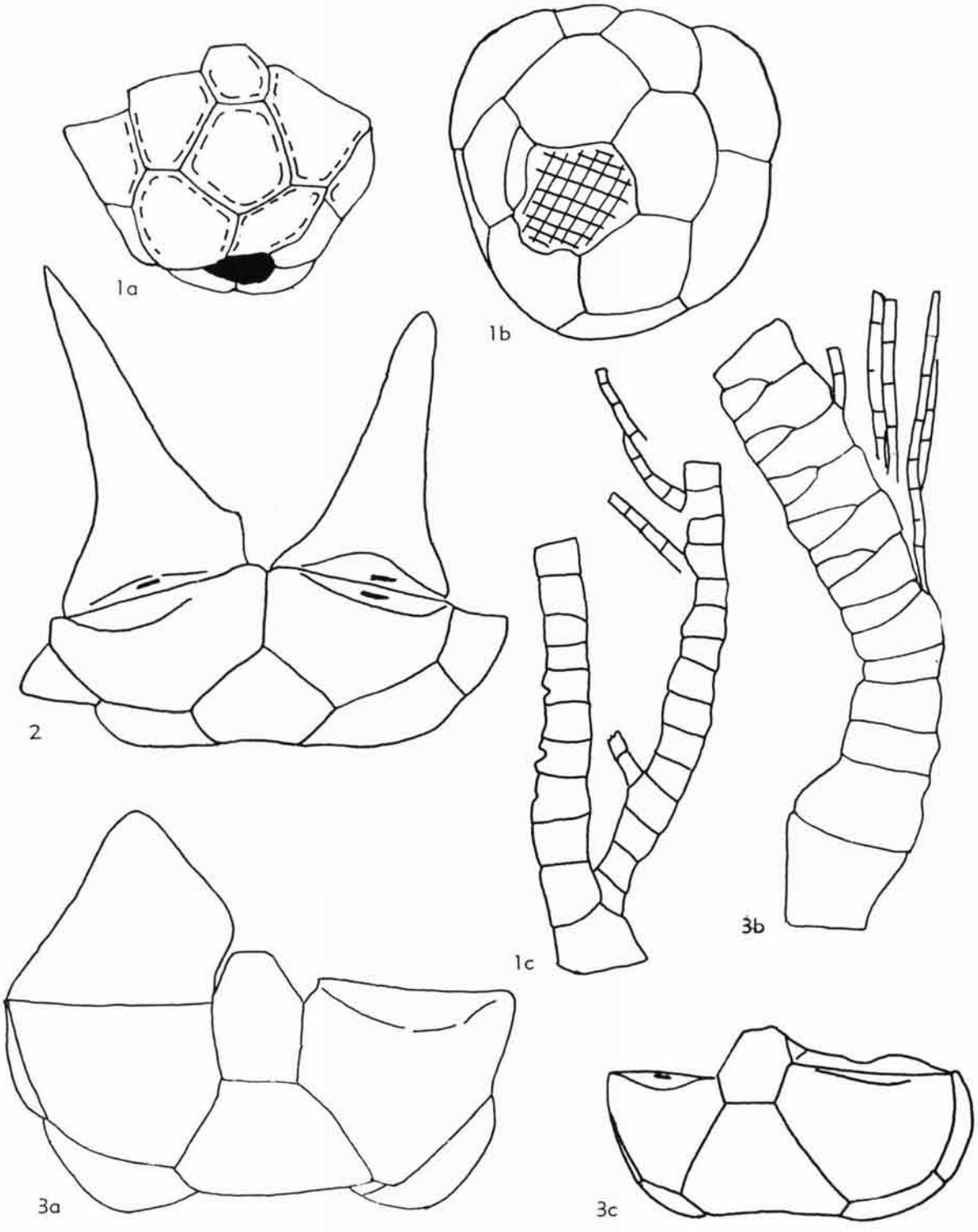


FIG. 5. *Goleocrinus, Stenopecrinus,* and *Palmerocrinus* from Morrowan beds of Utah and Oklahoma.

1a-c. *Goleocrinus vadosus* (Washburn), camera lucida drawings (×4.5), of posterior and dorsal sides and B-ray arm of holotype (BYU 1492) from Bridal Veil Member, Oquirrh Formation, Provo Canyon, near Provo, Utah.

2. *Stenopecrinus* sp., from same beds and locality as Fig. 1, camera lucida drawing of *AB* side of specimen (BYU 1491) showing long spine-bearing primibrachs, ×4.5.

3a-c. *Palmerocrinus profundus* Moore & Strimple, new species; posterior side of cup and side view of a single arm of hypotype (BYU 1493) from Bridal Veil Member, Oquirrh Formation in Provo Canyon near Provo, Utah, posterior side of paratype (SUI 35415) from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, camera lucida drawings, ×4.5.

Occurrence.—Middle part of Wapanucka Formation on Canyon Creek, Pontotoc County, Oklahoma [Loc. 12b].

DICROMYOCRINUS SUBAPLATUS Moore & Strimple, new species

Plate 11, figures 1a-d, 4a,b; Plate 13, figures 3a,b

Description.—Cup small to medium-sized, bowl-shaped, base planate to mildly concave; infrabasal disc subhorizontal to mildly downflared, sides of cup vertical except for slight curvature at bottom and top. Each infrabasal is marked by 3 elongate nodes, the largest in midportion; basals are large, with proximal ends forming gently sloped sides of shallow basal concavity (when present) and distal portion curving upward to reach midheight of cup or above, elongate nodes at right angles to sutures mark edges of the plates and radiate from one or two central pustules; radials are wider than long, with proximal extremities well above basal plane, pustules are rounded, more or less parallel to sutures but are more randomly placed than on basals, articular facets are subhorizontal, ligament pit distinct, narrow and bordered to the fore by a narrow outer ligament furrow, transverse ridge distinct and inner articular facets almost smooth; 3 anal plates in normal (primitive) arrangement, primanal largest, essentially quadrangular but with a small facet above for contact with tertanal, marked by 6 tubercles about the perimeter. Arms unknown.

Discussion.—This species is closely related to the rather prolific *Dicromyocrinus optimus* Strimple (1951) from which it differs in having a slight basal invagination and larger more sparse surface tubercles. *Paracromyocrinus oklahomensis* (Moore & Plummer, 1938), which is also related, has a pronounced basal concavity, more pronounced and irregular surface ornamentation and sides of the cup more rounded proximally and distally.

Dimensions.—Measurements of holotype (SUI 33177) in millimeters are: width of cup, 13.8; height, 6.0; width of infrabasal circlet, 4.5; width of *DE* basal, 5.3; length, 4.6; width of *E* radial, 6.4; length, 4.5.

Types.—Holotype (SUI 33177) (Pl. 23, 3a,b; Pl. 11, fig. 4a,b) collected by Albert Hanson; paratype (SUI 33174) (Pl. 11, fig. 1a-d), (SUI 33321), collected by R. C. Moore and A. L. Bowsher.

Occurrence.—Brentwood interval, Bloyd Formation; holotype (SUI 33177) from Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1]; paratypes (SUI 33174, 33321), Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a].

Genus PARACROMYOCRINUS Strimple, 1966

[*Paracromyocrinus* Strimple, 1966, p. 4]

Type Species.—*Parulocrinus vetulus* Lane, 1964, p. 681.

Diagnosis.—Cup normally more than twice as wide as high, broad base, erect rounded sides, basal plates curving into basal concavity; two anal plates; 10 broad and thick biserial arms.

Discussion.—The genus normally has an ornate surface, although not in the type species.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Missourian); USA (Oklahoma-Texas-Kansas-Nevada).

PARACROMYOCRINUS OKLAHOMENSIS (Moore & Plummer), 1938

Plate 10, figures 2a-c, 3, 4a,b; Plate 11, figures 2a-d; Plate 14, figure 2

Description.—Cup a flattened bowl with nearly vertical sides rounded above and below, and greatest diameter at about midheight; interplate sutures in V-shaped depressions; base concave, infrabasal disc flat or slightly concave; proximal portions of large basals form sloping sides of basal concavity, distal part curving into a vertical plane and rising somewhat above midheight of cup, strongly convex longitudinally; radials about twice as wide as long, distal part curving inward, articular facets nearly plane and subhorizontal, transverse ridges forming together a strongly marked pentagon with straight sides except where interrupted by *CD* interray; typically 2 anal plates in cup, but many specimens have 3. Arms 10, very robust, equibiserial. Anal sac unknown. Stem round in outline. Entire surface of cups bears large tubercles with spaces between them strongly granulose.

Discussion.—This species was originally described as *Ethelocrinus oklahomensis* Moore & Plummer (1938, p. 256). Assignment to *Ethelocrinus* Kirk, 1937, was on the basis of surface tubercles and the presence of a basal concavity. Two dorsal cups and disarticulated plates provided the type material, the holotype (OU 3279) collected by C. E. Decker from "North of Muskogee" and paratype (KUMIP 45281) collected by R. Rose with no locality data). Various disarticulated plates designated as paratypes were catalogued as KUMIP 41914a-f (radials), 41914g-k (basals) and 419141 (infrabasal disc). Strimple (1940, p. 9) described a set of arms (USNM S 4336) found with a disarticulated cup in the lower part of the Wapanucka Formation on Canyon Creek, Pontotoc County, Oklahoma, and designated as *Ethelocrinus oklahomensis*. The arms are equibiserial, massive and widen as well as project outward appreciably at midheight. Their length is not as great as one might expect to be associated with a moderately large cup. The thickened projecting midsection of the arms is well articulated and such pluribrachials are found occasionally in both the Bloyd and Wapanucka Formations. So far as known at the time (1940), *E. oklahomensis* possessed 2 anal plates in the cup.

Moore & Plummer (1940, p. 379) described a form from lower beds of the Marble Falls Formation (Mor-

rowan) of Texas as *Ethelocrinus texasensis* and discussed the similarity to *E. oklahomensis* save for the presence of 3 anal plates in all 3 type specimens.

Strimple (1961, p. 68) proposed a genus *Metacromyocrinus* based on forms with a highly ornate surface, 2 anal plates in the cup and 10 biserial arms. Although the type species, *M. holdenvillensis*, of Desmoinesian age, had a bulbous cup and a mildly upflared, large infrabasal circlet, the species *E. oklahomensis* was assigned by Strimple to *Metacromyocrinus* on the basis of its rugose cup surface, 2 anal plates, and 10 biserial arms.

Strimple (1963, p. 270) identified 9 specimens recovered from the Bloyd Formation at Greenleaf Lake, Oklahoma, as *Metacromyocrinus oklahomensis* and noted that 6 of these possessed 3 anal plates. Because two-thirds showed the same characters as *Ethelocrinus texasensis*, Strimple (*ibid.*, p. 271) suggested suppression of *E. texasensis* as a synonym of *M. oklahomensis*. Actually *E. texasensis* is slightly older than *M. oklahomensis* and a form described by Strimple & Watkins (1969, p. 163) from the Marble Falls Formation as *Dicromyocrinus* sp. cf. *D. texasensis* (Moore & Plummer) has 10 uniserial arms. *Dicromyocrinus* Jaekel (1918) described from Moscovian deposits in the vicinity of Moscow, USSR, is judged to correspond in age to upper Atokan or lower Desmoinesian beds of central USA. *Dicromyocrinus* has cuneate brachials and 3 anal plates in an ornate cup. The base of the cup of *D. ornatus* (Trautschold), type species of *Dicromyocrinus*, is usually planate, with subhorizontal infrabasals in the basal plane of the cup, which is a more primitive condition than the basal concavity found in the older *E. texasensis*.

With the establishment of *Paracromyocrinus* Strimple (1966, p. 4) for forms with 2 or 3 cup anal plates, a basal concavity (but with subhorizontal infrabasal circlet), and 10 biserial arms, *E. oklahomensis* was reassigned to *Paracromyocrinus*.

The cup plates of this species are relatively thin and apparently do not hold together well after death of the animal. Among hundreds of specimens observed up to the present time, only 17 dorsal cups are included. A specimen (hypotype OU 232) from the Wapanucka Formation is larger than the original types and has more erect cup walls. The largest observed specimen (hypotype SUI 33370) is from the Woolsey Member, Bloyd Formation, with a maximum width of 45.4 mm and height of 18 mm; it retains the characteristic longitudinal curvature of the cup walls and has 3 anal plates in the cup.

The arms of *Paracromyocrinus oklahomensis* develop a peculiar expansion and protrusion of brachials at midheight which is unique among crinoids (Pl. 10, fig. 2b, c, 4b). The arms are unusually thick even without such specialized development. These features, together with the concave base of the cup indicate that *P. oklahomensis* represents a uniquely differentiated lineage among cromyocrinids and eupachycrinids. It seems to have reached an end in Morrowan time.

Dimensions.—Measurements of hypotype (OU 231) in millimeters are: height of cup, 18.3; width, 47.0; diameter of infrabasal circlet, 12.9; depth of basal concavity, 7.8; length of basal, 12.3; width, 23.6; length of radial, 12.9; width, 23.7; diameter of stem impression, 5.0.

Types.—Holotype (OU 3279) collected by C. E. Decker; paratype dorsal cup (KUMIP 45281) collected by R. Rose; paratype plates (KUMIP 41914a-k) and infrabasal circlet (KUMIP 41914l) collected by R. C. Moore and others; hypotype arms and crushed cup (USNM S 4336) collected by Audd Dailey; hypotypes (SUI 33170 [3 specimens]) collected by H. L. Strimple and R. H. Lane; hypotypes (OU 231, 232) collected by C. Rowett; hypotypes (SUI 10940, 33369, 33439) collected by H. L. Strimple; hypotype arms (SUI 35422-35425) collected by H. L. Strimple.

Occurrence.—Holotype (OU 3279), paratype (KUMIP 45231) probably Brentwood interval, Bloyd Formation, ?Keough quarry north of Ft. Gibson, Muskogee County, Oklahoma [Loc. 1]. Other localities listed by Moore & Plummer (1938, p. 259), applicable to dis-

EXPLANATION OF PLATE 15

Morrowan species of inadunate crinoids—*Arkacrinus*, *Paracromyocrinus*, and *Diphuicrinus*.

FIGURE

1a-d. *Arkacrinus constrictus* Moore & Strimple, new species, dorsal, posterior, anterior, and ventral views of holotype (SUI 33182) from Brentwood interval, Bloyd Formation, on Flat Rock Creek, north of Wagoner, Wagoner County, Oklahoma, ×3.

2a-c. *Paracromyocrinus?* species, facetal, interior, and side views of pluribrachial (SUI 35426) with shorter, more regular brachials than *P. oklahomensis* (Moore & Plummer) in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×3.

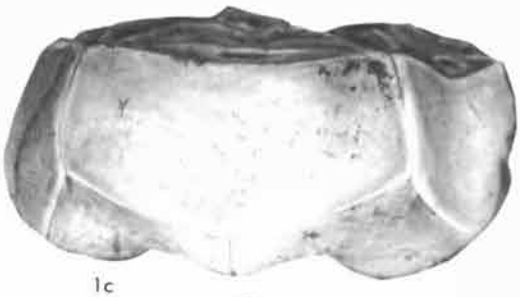
FIGURE

3a-d. *Diphuicrinus croneisi* Moore & Plummer, 1938, dorsal, posterior, ventral, and anterior views of paratype (P 9267) from Brentwood interval, Bloyd Formation; 0.2 miles north of Woolsey, Washington County, Arkansas, ×1.5.

4a,b. *Diphuicrinus faustus* Moore & Strimple, new species, right posterior and dorsal views of paratype crown (OU 262) from middle part of Wapanucka Formation, 2 miles east of Clarita, Coal County, Oklahoma, ×1.5.

1a

1b



1c

1d

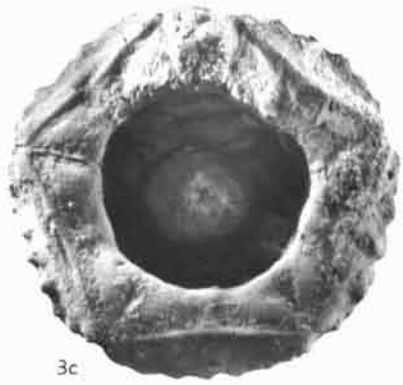
2a

2b

2c

3a

3b

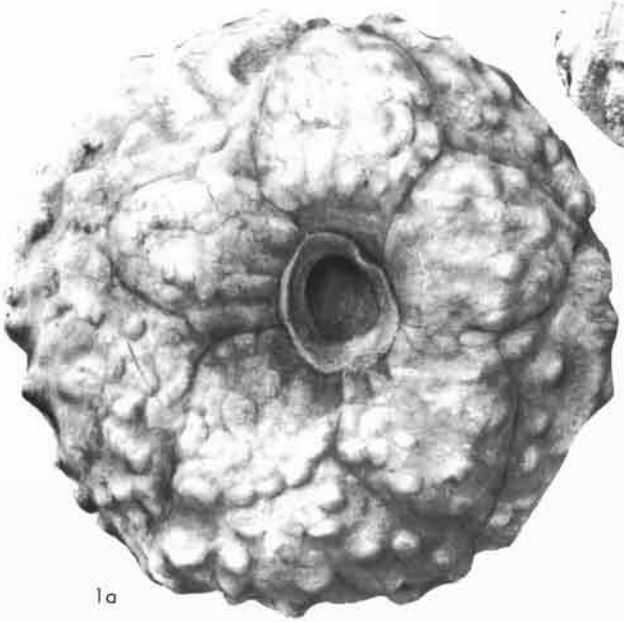


3c

3d

4a

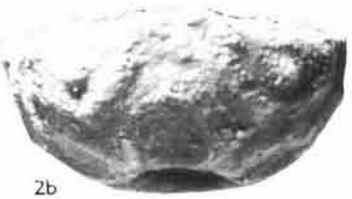
4b


1a


1b


1c


2a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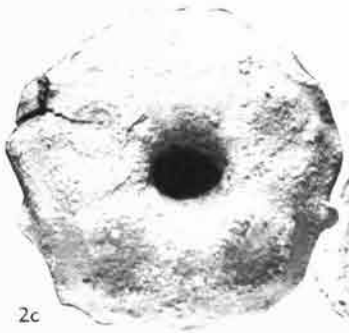
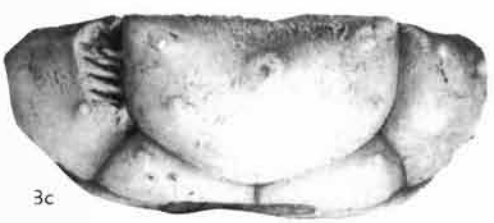

2c


2d


3a


3b


3c

articulated parts are Braggs Mountain, about 3 miles southeast of Ft. Gibson; road cut on U.S. Highway 71 opposite Woolsey, Arkansas, and several other localities. Presently considered material includes hypotypes (SUI 33369, 10940), Brentwood interval, Bloyd Formation, at abandoned quarry on Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16]; hypotype (SUI 33370), Woolsey Member, Bloyd Formation, just above Brentwood contact, west side Hwy. 59, Evansville Mountain, Washington County, Arkansas [Loc. 11]; hypotype (OU 231, 232), lower part of Wapanucka Formation, on Canyon Creek, Pontotoc County [Loc. 12a]; hypotype arms (SUI 35422-35425, 33439) from lower part of Wapanucka Formation, Pontotoc County, Oklahoma [Loc. 13].

PARACROMYOCRINUS? species

Plate 15, figures 2a-c

Description.—A single portion of arm, which is somewhat different from others ascribed to *Paracromyocrinus oklahomensis*, differs both in outer and inner appearance, the latter showing the ambulacral groove and pinnular attachment areas. It is figured for comparison with specimens which may be subjects of future studies.

Figured Specimen.—SUI 35426, collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma [Loc. 13].

Superfamily ERISOCRINACEA Wachsmuth & Springer, 1886 (S. A. Miller, 1890) (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (*ex* Erisocrinidae S. A. Miller, 1890, p. 351)]

Type Genus.—*Erisocrinus* Meek & Worthen, 1865, p. 174.

Diagnosis.—Crown mostly tall, cylindrical, with erect arms closely adjoining. Cup broadly truncate cone-shaped or bowl- to shallow saucer-shaped; infrabasals mostly five but may be three or fused solidly together in some; radial articular facets plenary, almost universally planate; three, two, or one anal plates in cup, none visible externally in some. Anal sac generally prominent. Arms pinnulate, uniserial or biserial, branching isotomously. Stem round transversely.

Discussion.—Includes Erisocrinidae S. A. Miller, 1890; Decadocrinidae Bather, 1890; Graphiocrinidae Wachsmuth & Springer, 1886; Paradelocrinidae Knapp, 1969; Arkacrinidae Knapp, 1969; Diphuicrinidae Strimple & Knapp, 1966; Protencrinidae Knapp, 1969; Catacrinidae Knapp, 1969; and Stachyocrinidae Moore & Strimple, n. fam.

Occurrence.—Middle Devonian-Upper Permian.

Family ERISOCRINIDAE Wachsmuth & Springer, 1886 (S. A. Miller, 1890)

Type Genus.—*Erisocrinus* Meek & Worthen, 1865, p. 174.

Diagnosis.—Crown tall, cylindrical, with closely abutting erect arms. Cup broadly truncate conical, with planate or faintly concave or convex base; five infrabasals not visible from side; proximal tips of radials well above basal plane of cup; single anal plate in *CD* interray. Arms ten, branching isotomously in all rays on first primibrach. Stem transversely round, lacking cirri.

Occurrence.—Lower Pennsylvanian (Morrowan)-Lower Permian (Wolfcampian).

Genus ERISOCRINUS Meek & Worthen, 1865

[=*Libratocrinus* Knapp, 1969; *Pontotocrinus* Knapp, 1969; *Parerisocrinus* Knapp, 1969]

Diagnosis.—Characters of family, primanal mostly not visible from outside of cup; arms biserial.

Occurrence.—Lower Pennsylvanian (Morrowan)-Lower Permian (Wolfcampian), USA (Illinois-Iowa-Missouri-Nebraska-Kansas-Oklahoma-Texas)-Nevada.

ERISOCRINUS WAPANUCKA (Strimple), 1961

[=*Pontotocrinus wapanucka* Knapp, 1969, p. 352 (=*Paradelocrinus wapanucka* Strimple, 1961, p. 225)]

Description.—Basal concavity small, proximal tips of

EXPLANATION OF PLATE 16

Morrowan species of inadunate crinoids—*Diphuicrinus* and *Atokacrinus*.

FIGURE

1a-c. *Diphuicrinus mammifer* Moore & Strimple, new species, dorsal, anterior, and ventral views of paratype (SUI 33177) from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma, ×4.6.

2a-d. *Diphuicrinus pentanodus* Moore & Strimple, new species, anterior, posterior, dorsal, and ventral views of holotype (SUI 33246) from Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×6.

3a-c. *Atokacrinus tumulosus* Moore & Strimple, new species, dorsal, posterior, and anterior views of holotype (SUI 33172) from Brentwood interval, Bloyd Formation, at Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×4.6.

radials above basal plane of cup; primanal absent or notched between inner edges of posterior radials, not visible externally. Arms and anal sac unknown.

Discussion.—The high cup and flat base, except for stem impression, distinguish *Erisocrinus wapanucka* from *Paradelocrinus* Moore & Plummer (1938), *Protencrinus* Jaekel (918), *Atokacrinus* Knapp (1969), *Arkacrinus* Knapp (1969), and *Neoprotencrinus* Knapp (1969), all of which differ in having proximal tips of the radials in the basal plane of the cup. In *Libratocrinus* Knapp (1969), the interbasal sutures tend to become short or absent, accompanied by a reduction in size of the basals.

Occurrence.—The species *Erisocrinus wapanucka* is quite rare, the second known specimen (hypotype OU 253) having been found by C. L. Rowett in the middle part of the Wapanucka Formation, on Canyon Creek in SE ¼ sec. 8, T. 1 N., R. 7 E.), Pontotoc County, Oklahoma [Loc. 12b].

Family PARADELOCRINIDAE Knapp, 1969

[Paradelocrinidae Knapp, 1969, p. 352]

Type Genus.—*Paradelocrinus* Moore & Plummer, 1938, p. 294.

Diagnosis.—Cup low bowl-shaped, with sides well curved longitiudinally and moderately deep and narrow basal concavity, surface of plates smooth or rugose, sutures not impressed; radial articular facets plenary and planate, no anal plate visible externally, small primanal located in notch on inner side of *CD* interradial suture. Anal sac and arms unknown. Stem circular transversely, lacking cirri.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Permian (Basleoan).

Genus ATOKACRINUS Knapp, 1969

[*Atokacrinus* Knapp, 1969, p. 358]

Type Species.—*Atokacrinus obscurus* Knapp, 1969, p. 358.

Diagnosis.—Cup low bowl-shaped, basal concavity deep, infrabasals downflared; basals broad, long; radials large, proximal tips almost reaching basal plane of cup; single anal plate well above *CD* basal or on inner side at top of *CD* interradial suture, entirely concealed externally; surface of cup rough or ornamented.

Discussion.—*Atokacrinus tumulosus* Moore & Strimple, new species, of Morrowan age is more primitive than *A. obscurus* of Atokan age in that the anal plate of the former species may extend to the outer side of the dorsal cup, whereas in the latter species the anal plate is not visible externally.

Occurrence.—Lower Pennsylvanian (Morrowan)-Middle Pennsylvanian (Desmoinesian); North America mid-continent region.

ATOKACRINUS TUMULOSUS Moore & Strimple, new species

Plate 16, figures 3a-c; Plate 17, figure 5

Diagnosis.—Characters of genus, anal plate commonly visible externally.

Description.—Cup bowl-shaped, with pronounced basal concavity and greatest width just below cup summit, plates tumid with uneven surfaces and sporadic widely spaced small nodes; infrabasals small, forming a subhorizontal disc at bottom of the basal concavity, mostly covered by the circular stem attachment scar; basals large, sloping into and forming walls of basal concavity with concave median portions, distally curving upward to just below midheight of cup; radials wide, with proximal tips almost reaching basal plane of cup, articular facets plenary subhorizontal, strongly marked by transverse ridge, outer ligament furrow and pit on outer side and sharp grooves on inner side, intermuscular furrow well defined; single anal plate situated well above the *CD* basal, sloping inward and faceted for reception of a single tube plate.

Discussion.—The anal plate of *Atokacrinus tumulosus* is somewhat more firmly notched into the cup than in *A. obscurus*, type species of the genus, but it is well removed from contact with *CD* basal. The latter species has a smooth surface, whereas *A. tumulosus* has an ornate surface. *A. decorus* Strimple & Moore (1971), from the Lester Limestone (lower Desmoinesian or upper Atokan) has an ornate surface, and the anal plate is more advanced (almost excluded from the cup).

Dimensions.—Measurements of holotype (SUI 33172) in millimeters are: width of cup, 13.0; height, 5.0; width of infrabasal circlet, 2.8; width of *DE* basal, 5.0; length, 4.5; width of *E* radial, 7.2; length, 4.5; width of anal plate, 1.6; length, 2.7.

Holotype.—SUI 33172, collected by L. R. Laudon.

Occurrence.—Brentwood interval, Bloyd Formation, Keough quarry north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1].

Family ARKACRINIDAE Knapp, 1969

[*nom. transl.* Moore & Strimple, herein (*ex* Arkacrininae Knapp, 1969, p. 356)]

Type Genus.—*Arkacrinus* Knapp, 1969, p. 357.

Diagnosis.—Cup low, bearing deep basal concavity, maximum diameter of cup below summit of radials; infrabasals steeply downflared; basals large and transversely concave; commonly single anal plate not visible externally, being located on inner side at top of *CD* interradial suture; articular facets of radials broad and slightly declivate. Columnar cicatrix round. Arms and anal sac unknown.

Occurrence.—Lower Pennsylvanian (Morrowan); USA (Oklahoma-Arkansas).

Genus ARKACRINUS Knapp, 1969

[*Arkacrinus* Knapp, 1969, p. 357]

Type Species.—*Delocrinus dubius* Mather, 1915, p. 105.

Diagnosis.—Characters of the family.

Discussion.—*Arkacrinus* is one of the most widespread crinoids found in Bloyd rocks of northeastern Oklahoma and northwestern Arkansas. In Arkansas it is prevalent in the Brentwood Member, Bloyd Formation. At one exposure in NE ¼ sec. 17, T. 14 N., R. 31 W., Washington County, on Sweetwater Creek, Arkansas [Loc. 27] most specimens reveal a small anal plate externally, leading us to believe the shale may be pre-Brentwood in age. On Evansville Mountain [Loc. 11] several specimens have been collected from a thick shale slightly above the Brentwood Member, which we consider to be the Woolsey Member, Bloyd Formation.

Occurrence.—Lower Pennsylvanian (Morrowan); USA (northwestern Arkansas and northeastern Oklahoma).

ARKACRINUS DUBIUS (Mather), 1915

Diagnosis.—Characters of genus.

Discussion.—Originally described as *Delocrinus dubius* Mather (1915, p. 105), the species has been thoroughly restudied by Moore & Plummer (1938) who removed it from *Delocrinus* and assigned it to *Paradelocrinus* Moore & Plummer (*ibid.*, p. 294). Knapp (1969, p. 357) considered the species to be highly specialized and proposed the monotypic genus *Arkacrinus*. We agree with this action.

Arkacrinus dubius is prolific in the Bloyd Formation of northwestern Arkansas and northeastern Oklahoma but has not been reported from Morrowan beds elsewhere, not even in the prolific faunas of the Wapanucka Formation of east-central and southern Oklahoma.

A new species is described here from the Bloyd of northeastern *Oklahoma* as *Arkacrinus constrictus* Moore & Strimple.

Types.—Holotype (University of Chicago Walker Museum 16661), paratypes (WM 16662) collected by K. F. Mather; hypotypes (KUMIP 45191=USNM 141049, 45191a=USNM 141049A) collected by C. L. Foster; hypotype (KUMIP 45191b=USNM 141049B) collected by R. Rose; hypotype (KUMIP 45223) collected by R. C. Moore; hypotypes (SUI 33313, 33276, 33279 [4 specimens], 33378, 33368 [5 specimens] collected by H. L. Strimple; hypotypes (SUI 33391 [2 specimens], 33398 [4 specimens] collected by field parties from The University of Iowa; hypotypes (33291 [2 specimens]) collected by Melba and Harrell Strimple; hypotypes 33362 [7 specimens]) collected by J. M. Cocke; hypotypes (SUI 33384, 33340) collected by J. H. Quinn; hypotype (SUI 35418) collected by R. H. Lane; hypotypes (SUI 33396 [2 specimens], SUI 33397 [3 specimens]) collected by J. H. Quinn and Gary Gillum.

Occurrence.—Brentwood Member, Bloyd Formation, holotype (WM 16661), Mather Sta. 134, Fayetteville quadrangle [Loc. 6]; paratypes, Mather Sta. 135, Fayetteville quadrangle; Brentwood Limestone lentil 3.5 miles northeast of Fayetteville, abandoned quarry S ½ sec. 2, T. 16 N., R. 30 W.; Sta. 153, Fayetteville quadrangle; Brentwood limestone lentil, east slope of Baxter Mountain, above 160 feet of Hale sandstone and shales, SE ¼ sec. 27, T. 16 N., R. 30 W.; hypotype (KU 45223), Brentwood Limestone 0.5 mile east of Woolsey, Washington County, Arkansas; hypotypes (SUI 33378, 33368 [5 specimens]), Bloyd Mountain, south of Fayetteville, Washington County, Arkansas [Loc. 23].

Morrow Formation undifferentiated: paratypes (WM 16662), Mather Sta. 296, Muskogee quadrangle; lower portion of Morrow Formation, Keough quarry, 2 miles north of Ft. Gibson, Cherokee County, Oklahoma; Sta. 301; Morrow Formation, shaly member above thick limestone, sec. 35, T. 16 N., R. 19 E., 1.5 miles north of Ft. Gibson, Oklahoma.

Brentwood interval, Bloyd Formation; hypotypes (KUMIP 45191, 45191a, 45191b, SUI 33313), Keough quarry north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1]; hypotypes (SUI 33276, 33279 [4 specimens]) from abandoned quarry on east shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16]; hypotypes (SUI 33391 [3 specimens]) on Flat Rock Creek, Wagoner County, Oklahoma [Loc. 10]; hypotypes (SUI 33391 [2 specimens], Tenkiller Lake [Loc. 25]; hypotypes (SUI 33362 [7 specimens]), Big Frog Bayou, Windfry Valley, Crawford County, Arkansas [Loc. 21]; hypotype (SUI 33384), east flank of Kessler Mountain, Washington County, Arkansas [Loc. 28]; hypotypes (SUI 33396, 33397 [3 specimens], 33340), Sweetwater Creek near Strickler, Washington County, Arkansas [Loc. 27].

Woolsey Member (shale above Brentwood Member), Bloyd Formation, Evansville Mountain, about 3 miles southeast of Evansville, Arkansas [Loc. 11].

ARKACRINUS CONSTRICTUS Moore & Strimple, new species

Plate 15, figures 1a-d

Diagnosis.—Like *Arkacrinus dubius* except that the basal concavity and cup summit are more constricted, and the transverse median depression of the basals is more pronounced.

Dimensions.—Measurements of holotype (SUI 33182) in millimeters are: width of cup, 21.3; height, 9.9; width of infrabasal circlet, 4.2; width of *DE* basal, 11.2; length (approx.), 9.3; width of *E* radial, 12.0; length, 8.5.

Holotype.—SUI 33182, collected by Albert Hanson.

Occurrence.—Brentwood interval, Bloyd Formation, Flat Rock Creek north of Wagoner, Wagoner County, Oklahoma [Loc. 10].

Family DIPHUICRINIDAE Strimple & Knapp, 1966

[incl. Graffhamicrininae Knapp, 1969, p. 362]

Type Genus.—Diphuicrinus Moore & Plummer, 1938, p. 307.

Diagnosis.—Crown moderately tall, with arms closely opposed, each brachial bearing pinnule, brachials obliqui-uniserial in geologically older forms, biserial in younger ones. Cup wider than high, may be covered by pustules and granules which vary in crowding, base markedly to moderately concave, infrabasals downflared, single primanal followed by two sac plates (*Diphuicrinus*) or one plate (*Graffhamicrinus*); radial facets plenary and subhorizontal. Stem round transversely.

Discussion.—The Morrowan genus *Diphuicrinus* is inferred to have led to the Atokan forms with narrow anal and nodose surface, *Parallelocrinus* Knapp (1969), and finely granulose surface, *Palmerocrinus* Knapp (1969). Most specimens of *D. croneisi*, type species of *Diphuicrinus*, have a large outer ligament area and very long, large anal plate which becomes subhorizontal in its distal part and is faceted for reception of two anal sac plates.

In one large hypotype (illustrated by Strimple & Knapp, 1966, pl. 36, fig. 27), however, the distal part of the anal plate is very broad, not much elongated, and has what appears to be a single facet for reception of a sac plate. This specimen indicates a trend toward reduction in number of sac plates in contact with the anal plate and a change in attitude of the distal portion of the anal plate to a vertical posture, both of which are characters of *Graffhamicrinus* Strimple. The typically ornate *Diphuicrinus* lineage seemingly continued into the late Desmoinesian. The elongate slender anal plate, subhorizontal distally and double-faceted terminally, was retained. The diphuicrinids are descendants of Chesteran phanocrinids.

Occurrence.—Lower Pennsylvanian (Morrowan).

Genus DIPHUICRINUS Moore & Plummer, 1938

[*Diphuicrinus* Moore & Plummer, 1938, p. 307] [=*Parallelocrinus* Knapp, 1969, p. 360]

Type Species.—Diphuicrinus croneisi Moore & Plummer, 1938, p. 308.

Diagnosis.—Distal portion of anal plate elongate and recumbent, usually faceted for 2 sac plates; pronounced forefacet near summit of radials. Arms obliqui-uniserial ornate, rounded outer surfaces; surface ornamentation pustulose and granulose.

Occurrence.—Lower Pennsylvanian (Morrowan); USA (Oklahoma-Arkansas).

DIPHUICRINUS CRONEISI Moore & Plummer, 1938

Plate 15, figures 3a-d

Discussion.—Considerable variability is exhibited by various forms ascribed to this species. Exact linear measurements of various parameters is hampered by distortion of some specimens by compaction pressures. For this reason we have elected to propose new species for some cups atypical of *Diphuicrinus croneisi.*

The holotype of the just-mentioned species is medium-sized and has a small, vertical-walled basal concavity. It is covered by closely packed granulations and large, irregular pustules, the most distinctive of which form a festoon of 5 or 6 elements crossing the distal portion of each radial. About 20 such pustules are counted on an individual radial. In the type area of Arkansas and Oklahoma (mainly the Brentwood interval of the Bloyd Formation) both small and large specimens exhibit this pattern except for the form here designated as *Diphuicrinus pentanodus* Moore & Strimple, new species.

In southern Oklahoma crinoids of *Diphuicrinus croneisi* type from parts of the Wapanucka Formation are variable. Strimple & Knapp (1966, pl. 36, fig. 1,2) illustrated a crown (OU 4597) from the lower part of the Wapanucka as *D. croneisi*, although its pustules are smaller and more numerous than typical of the species and granules are subdued or missing. The festoons of tubercles on radials vary from 7 to 9 and a total of more than 30 occurs on each radial. For this and similar forms we proposed *D. faustus* as a new species.

The specimen figured by Strimple & Knapp (1966, pl. 36, fig. 24-26) as *Diphuicrinus croneisi* has ornamentation typical of that species but the basal concavity is broader than typical and the cup walls are not as steeply inclined. For this and specimens with similar cup features (including those with more numerous pustules) we propose *D. mammifer* as a new species. A large specimen (SUI 32934) of the last-cited group has as many as 8 large pustules in the radial festoons and a total of about 35 pustules on each radial.

Types.—Holotype KUMIP 45211=USNM 141056), paratype A (KUMIP 45211=USNM 141058), and paratype dissociated plates (KUMIP 45190a=USNM 141060) were collected by R. C. Moore; paratype B (P9267) was collected by F. B. Plummer; hypotypes (SUI 11903, 33271, 33285, 33265, 33247, 33259, 33260, 33261, 33264, 33250, and 33365) were collected by H. L. Strimple and hypotype (SUI 33394) collected by a field party of the University of Iowa; hypotype (SUI 33244) collected by C. L. Foster; hypotypes (SUI 33241, 33242, 33245) collected by Albert Hanson; hypotype (SUI 33249) collected by R. C. Moore; hypotype (SUI 33270, 35416) collected by R. H. Lane; and hypotype (SUI 33272) collected by J. M. Cocke.

Occurrence.—Brentwood interval, Bloyd Formation, holotype (KUMIP 45211=USNM 141056), paratypes

(KUMIP 45211a, 451910a,b=USNM 141058), Braggs Mountain (old roadcut) north of Braggs, Muskogee County, Oklahoma [Loc. 2]; hypotype (SUI 33244) from SE ¼ sec. 35, T. 17 N., R. 19 E., Cherokee County, Oklahoma [Loc. 38]; hypotype (SUI 33394) from abandoned quarry south of Tenkiller Lake, Sequoyah County, Oklahoma [Loc. 25]; hypotypes (SUI 33271, 33285) from Flat Rock Creek, Wagoner County, Oklahoma [Loc. 10]; hypotypes (SUI 33241 [7 specimens], 33242 [3 specimens], 33245 [2 specimens]) from near Wagoner, Mayes County, Oklahoma [Loc. 19]; hypotypes (SUI 33265 [2 specimens], from Union Mission, Mayes County, Oklahoma [Loc. 9]; hypotypes (SUI 33247, 33249) from Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a]; hypotypes (SUI 11903, 33259, 33260 [2 specimens], 33261 [3 specimens], 33264 [5 specimens]) from abandoned quarry on shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16]; hypotype (SUI 33250) from 1 mile south of Choteau, Mayes County, Oklahoma [Loc. 20].

Brentwood Member, Bloyd Formation, paratype B (P 9267) from roadcut about 0.2 miles north of Woolsey, Washington County, Arkansas [Loc. 7]; hypotype (SUI 33365) from 9 miles south of Fayetteville, Washington County, Arkansas [Loc. 23].

Woolsey Member, Bloyd Formation, hypotypes (SUI 33270, 35416) from west side of Hwy. 59 about 3 miles southeast of Evansville at Evansville Mountain, Washington County, Arkansas [Loc. 11].

Bloyd Formation, from east side of bridge across Big Frog Bayou, Windfry Valley, Crawford County, Arkansas [Loc. 21].

DIPHUICRINUS FAUSTUS Moore & Strimple, new species

Plate 14, figures 1a-d; Plate 15, figures 4a,b

Description.—This species is represented by medium-sized specimens with obscured or lacking granulose surface and having small, numerous nodes including a festoon of 8 or 9 near summit of each radial. The basal concavity is wider and sides at a lower angle than found in typical *Diphuicrinus croneisi*. Arms 10, slightly cuneate uniserial branching on low primibrachs *1*.

Dimensions.—Measurements of holotype (OU 262) in millimeters are: height of crown, 44.6; width of cup, 21.5; height, 6.6; width of *DE* basal, 7.4; length (approximate), 6.8; width of *E* radial, 12.0; length, 7.3; diameter of proximal columnals, 2.2.

Types.—Holotype (OU 262) collected by C. Rowett, paratype (OU 4597) collected by Audd Dailey, and paratype (SUI 33251) collected by H. L. Strimple.

Occurrence.—Holotype (OU 262), middle part of Wapanucka Formation, 2 miles east of Clarita, Coal County, Oklahoma [Loc. 15]; paratypes (OU 4597, SUI 33341) lower part of Wapanucka Formation, Pontotoc County, Oklahoma [Loc. 13].

DIPHUICRINUS MAMMIFER Moore & Strimple, new species

Plate 14, figures 3a-d, 4; Plate 16, figures 1a-c; Plate 17, figures 4a-d

Description.—This species is typically represented by very large low, bowl-shaped, highly ornate dorsal cups. Sides of the cup are not as erect as in typical *Diphuicrinus croneisi* and the basal concavity is broader, with more gently sloped sides. Surface ornamentation consists of sharp granulations and large irregular tubercles, including a festoon of 7 to 9 below the summit of each radial. As many as 35 tubercles have been noted on each radial.

Dimensions.—Measurements of holotype (OU 233) in millimeters: width of cup, 42.8; height, 15.1; diameter of infrabasal circlet, 6.0; height of basal concavity, 5.6; length of basal plate, 15.0; width, 17.0; length of radial, 13.7; width, 23.7; length of anal plate, 11.1; width, 8.0.

Types.—Holotype (OU 233) collected by C. L. Rowett; paratypes (SUI 11902, 11903, 33177, 32934, 33179, 33252) collected by H. L. Strimple.

Occurrence.—Holotype (OU 233) lower part of Wapanucka Formation, from Canyon Creek [Loc. 12a]; paratypes (SUI 11902, 11903, 33177, 32934, 33179, 33252) from SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma [Loc. 13].

DIPHUICRINUS PENTANODUS Moore & Strimple, new species

Plate 16, figures 2a-d

Description.—Like *Diphuicrinus croneisi* except for surface ornament. As noted in discussion of *D. croneisi*, all observed specimens of that species save one, the holotype of *D. pentanodus*, possess a festoon of pustules in the upper portion of each radial. In *D. pentanodus*, a single pustule or large node is seen on the upper portion of each radial.

The entire surface of the cup is marked by fine granules and ridges composed of confluent pustules parallel to the plate sutures in basal and radial circlets. The midportions of basals are planate rather than convex.

Dimensions.—Measurements of holotype (SUI 33246) in millimeters are: width of cup, 7.2; height, 3.0; width of infrabasal circlet, 1.1; width of *DE* basal, 3.0; width of *E* radial, 4.0; length, 2.5.

Types.—Holotype (SUI 33246) collected by R. C. Moore, reposited Geology Department Repository, The University of Iowa, Iowa City.

Occurrence.—Brentwood interval, Bloyd Formation, Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a].

Family CATACRINIDAE Knapp, 1969

[*nom. transl.* Moore & Strimple, herein (*ex* Catacrininae Knapp, 1969, p. 365)] [=Palmerocrininae Knapp, 1969, p. 360; Arrectocrininae Knapp, 1969, p. 363]

Type Genus.—*Catacrinus* Knapp, 1969, p. 365 [=*Delocrinus* Miller & Gurley, 1890, p. 9 (senior objective synonym, having identical type species)] [*Zoological Code*, art. 40a, stipulates that after 1960 family-group names based on junior synonyms (objective or subjective) as type genera prevail over senior synonyms].

Diagnosis.—Crown moderately tall, cylindrical, with ten closely appressed biserial, pinnulate arms. Cup low bowl-shaped, with narrow and deep basal concavity, plate surfaces smooth or rugose; five small downflared infrabasals at bottom of concavity, sides of which are formed by basals or their proximal parts and in some genera by proximal extremities of radials; articular facets of radials plenary and planate; single anal plate in cup, resting on truncate summit of *CD* basal. Anal sac moderate in height, cylindrical, composed of longitudinal rows of small polygonal plates. Arms branching isotomously on first primibrach. Stem transversely circular.

Occurrence.—Lower Pennsylvanian (Morrowan)-Lower Permian (Wolfcampian).

Genus PALMEROCRINUS Knapp, 1969

[*Palmerocrinus* Knapp, 1969, p. 360]

Type Species.—*Palmerocrinus comptus* Knapp, 1969, p. 361.

Diagnosis.—Basal concavity narrow and deep; proximal tips of radial plates above basal plane; distally narrow primanal inclined inward at low angle to horizontal; outer surface marked by granules or irregular ridges and grooves forming an oblique lineation. Arms 10, uniserial in lower portions (to about secundibrach 7) biserial above. Pinnules very slender.

Discussion.—*Palmerocrinus* resembles *Diphuicrinus* being distinguished most readily by its lack of nodose or pustulose ornamentation. The dorsal cups of *Endelocrinus* are proportionately lower and have depressions at plate angles.

Occurrence.—Pennsylvanian (Morrowan)-Middle Pennsylvanian (Atokan); USA (Oklahoma-Arkansas-Utah).

PALMEROCRINUS PROFUNDUS Moore & Strimple, new species

Plate 17, figures 1a-c; Figure 5,3a-c

Description.—Deep bowl-shaped cup, sutures distinct but not impressed, deep broad basal concavity, downflared infrabasals, primanal extending well above cup where it curves slightly inward with distal facet impressed for 2 anal sac plates. Cup ornamented by vermicular markings.

Discussion.—*Palmerocrinus profundus* has a deeper cup and broader more erect anal plate than *P. kesslerensis*.

A form described as *Delocrinus* sp. cf. *D. matheri* Moore & Plummer (1938) by Washburn (1968, p. 124) has a deeper cup (see Fig. 5,*3a-c*) than is typical. The Utah form is here referred to *Palmerocrinus profundus*, which typically occurs in the lower part of the Wapanucka Formation of southern Oklahoma. Washburn's specimen is reported from the Bridal Veil Falls Member, Oquirrh Formation (Morrowan), in Provo Canyon. The lower 6 or 7 secundibrachs are cuneate but higher brachials are interlocking (biserial) (Fig. 5,*3b*).

Dimensions.—Measurements of holotype (OU 3913) in millimeters are: width of cup, 23.0; height, 7.2; width of infrabasal circlet, 3.7; width of *DE* basal, 8.2; length, about 7.5; width of *E* radial, 12.9; length, 6.6; width of anal plate, 3.3; length, 4.9.

Types.—Holotype (OU 3913) collected by C. Rowett; paratype (SUI 33415) collected by H. L. Strimple; hypotype (BYU 1493) collected by A. T. Washburn.

Occurrence.—Lower part of Wapanucka Formation, holotype (OU 3913) Canyon Creek [Loc. 12], paratype (SUI 33415), Pontotoc County, Oklahoma [Loc. 13]; hypotype (BYU 1493), Bridal Veil Falls Member,

EXPLANATION OF PLATE 17

Morrowan species of inadunate crinoids—*Palmerocrinus*, *Endelocrinus*, *Diphuicrinus*, and *Atokacrinus*.

FIGURE

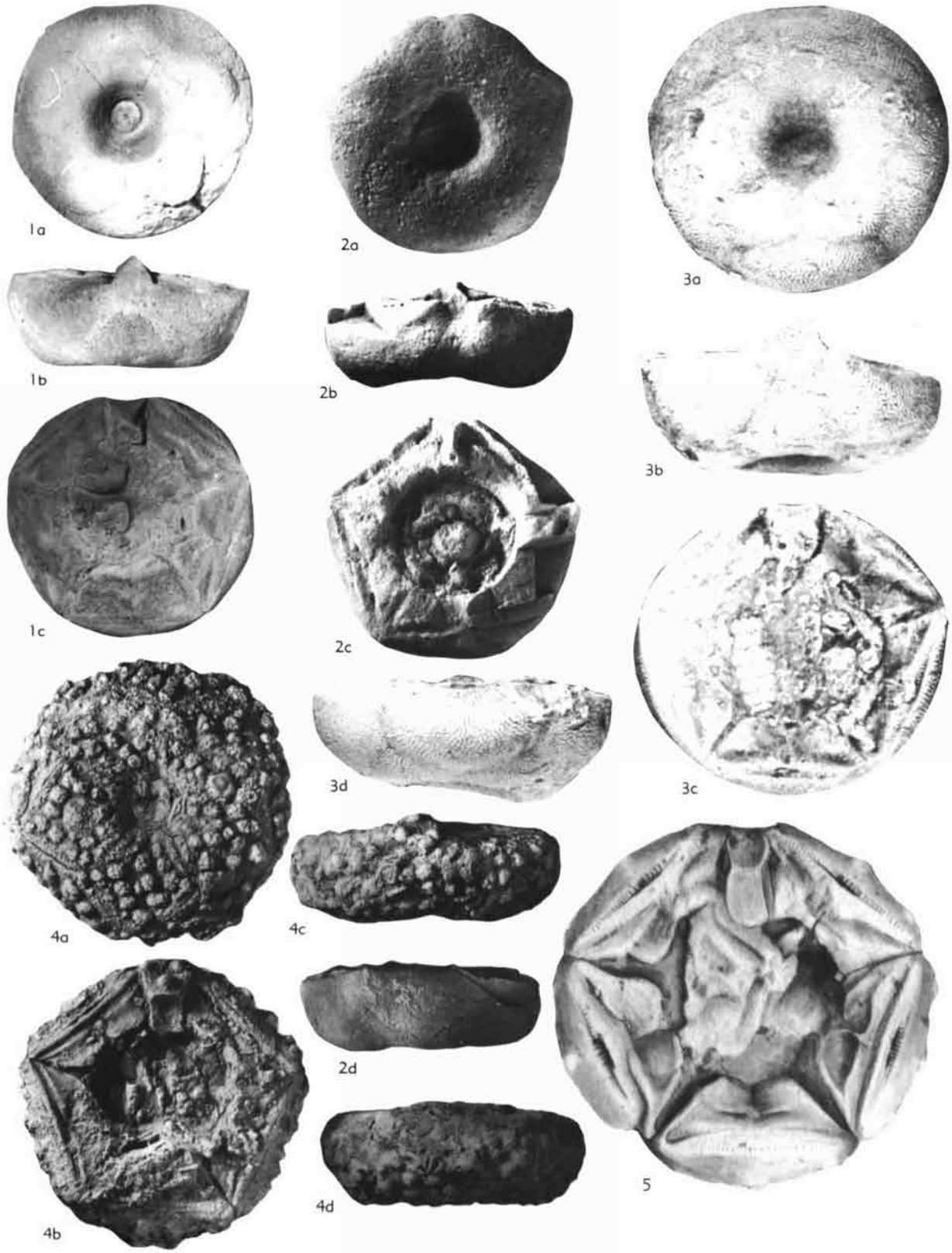
1a-c. *Palmerocrinus profundus* Moore & Strimple, new species, dorsal, posterior, and ventral views of holotype (OU 3913) from lower part of Wapanucka Formation in SE ¼ sec. 8, T. 1 N., R. 7 E., on Canyon Creek southeast of Fittstown, Pontotoc County, Oklahoma, ×2.

2a-d. *Palmerocrinus kesslerensis* Moore & Strimple, new species, dorsal, posterior, ventral, and anterior views of holotype (SUI 33402) from ?post-Brentwood beds, Bloyd Formation, on east flank of Kessler Mountain, south of Fayetteville, Washington County, Arkansas, ×2.3.

3a-d. *Endelocrinus matheri* (Moore & Plummer), 1938, dorsal, posterior, ventral, and anterior views of hypotype (SUI 33316) from Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×4.6.

4a-d. *Diphuicrinus mammifer* Moore & Strimple, new species, dorsal, ventral, posterior, and anterior views of paratype (SUI 32934) from same beds and locality as 1a-c, ×1.

5. *Atokacrinus tumulosus* Moore & Strimple, new species, ventral view of holotype (SUI 33172) from Brentwood interval, Bloyd Formation, at Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma, ×4.6.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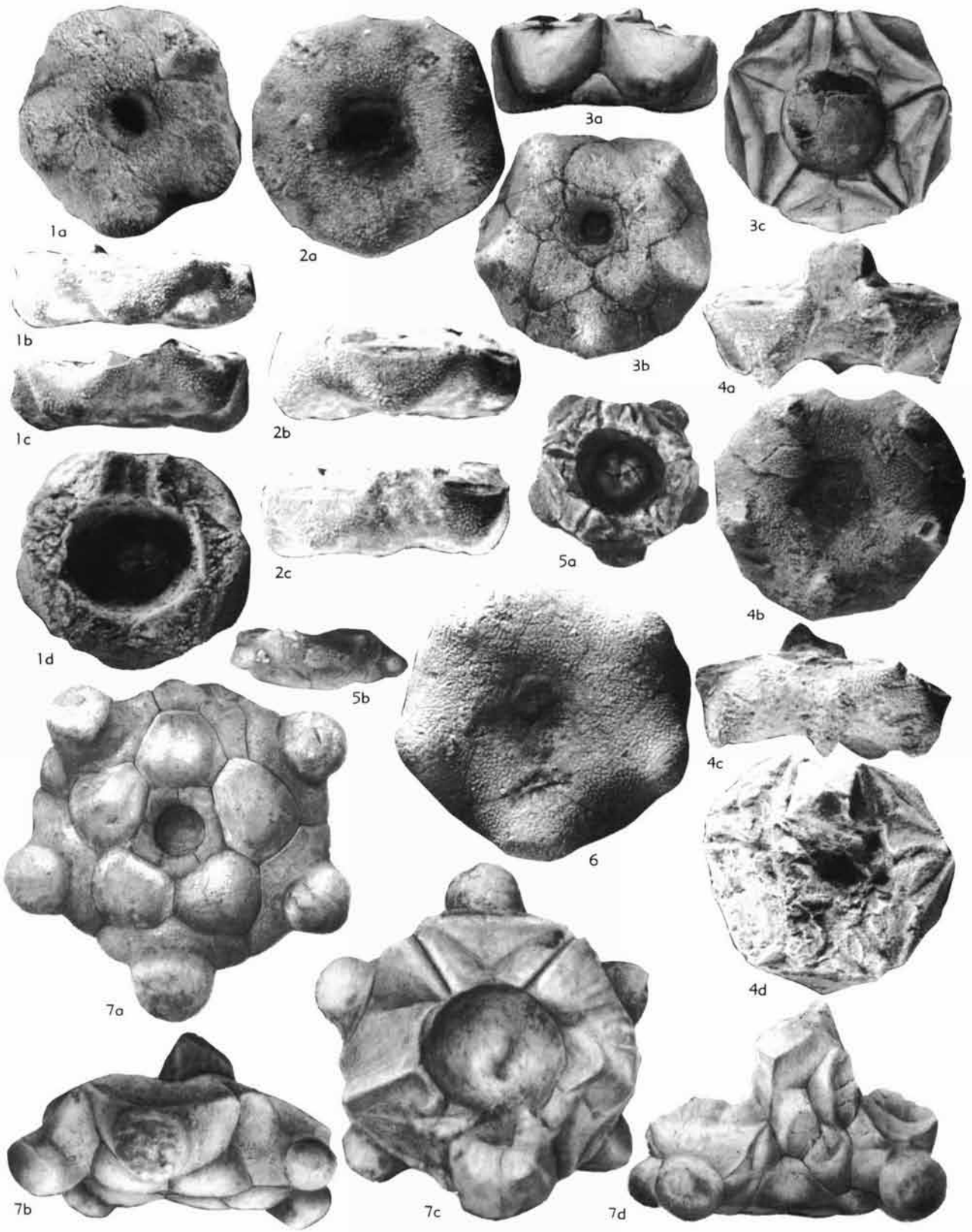
1a
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3c
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4a
1c
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2c
5a
1d
4b
5b
6
4c
7a
4d
7b
7c
7d

Oquirrh Formation (Morrowan), west side of Slide Canyon in Provo Canyon, Utah.

PALMEROCRINUS KESSLERENSIS Moore & Strimple, new species

Plate 17, figures 2a-d

Diagnosis.—Cup low bowl-shaped, with pronounced moderately deep basal concavity and slightly downflared infrabasals; surface of cup smooth, sutures distinct but not impressed; wide radials reaching basal plane, their distal edges curving slightly inward; distal parts of large basals visible in side view of cup; primanal small, with narrow distal end sloping upward-inward and faceted for 2 sac plates, largest facet left of center. Radial articular facets plenary and planate, with rather prominent transverse ridge backed by ligament furrow which is most pronounced at ends.

Discussion.—A paratype (USNM 14807) of *Palmerocrinus comptus* Knapp (1969, pl. 61, fig. 19-21) from the Atokan of Missouri is remarkably similar to *P. kesslerensis*, indicating the probability that the Atokan species is a direct descendant of the Morrowan species. *Endelocrinus matheri* (Moore & Plummer, 1938) is similar also but differs in having a broader, more erect primanal (*X*), slight depressions at plate angles, and finely vermicular surface ornament.

Dimensions.—Measurement of holotype (SUI 33402) in millimeters: width of cup, 17.8; height, 6.7; width of basal, 7.3; width of radial, 11.0; length, 5.6; width of anal plate, 1.5; length, 3.7.

Types.—Holotype (SUI 33402) and paratypes (SUI 33433 [3 specimens]) collected by H. L. Strimple.

Occurrence.—Undetermined (probably post-Brentwood) shale in Bloyd Formation, on east flank of Kessler Mountain, south of Fayetteville, Washington County, Arkansas [Loc. 28].

Genus ENDELOCRINUS Moore & Plummer, 1940

[*Endelocrinus* Moore & Plummer, 1940, p. 296]

Type Species.—*Eupachycrinus fayettensis* Worthen, 1873, p. 585.

Diagnosis.—Like *Delocrinus* except for moderate tumidity of cup plates, depressions at the angles of cup plates, and more numerous cuneate brachials in proximal portions of arms.

Discussion.—Affinities of this genus are still in doubt. Probably it is an offshoot of *Palmerocrinus* which would indicate placement in the family Catacrinidae rather than Apographiocrinidae, as proposed by Strimple & Moore (1971a, p. 13).

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Virgilian)-Lower Permian, USA (Oklahoma-Texas-Ohio-Arkansas-Nevada-Kansas-Nebraska-Missouri-Iowa-Illinois).

ENDELOCRINUS MATHERI (Moore & Plummer), 1938

[=*Delocrinus matheri* Moore & Plummer, 1938, p. 289]

Plate 17, figures 3a-d

Description.—Cup shallow bowl-shaped, with well-defined basal concavity, outline circular when viewed from above or below, typically with mild depressions at plate angles, sutures distinct but not impressed; radials large, reaching basal plane of cup, distally curving slightly inward; basals wide, with distal tips visible in side view; primanal elongate, extending well above radial summits, distally indented for 1 or 2 sac plates. Surface of cup typically covered by fine vermicular markings. Anal sac unknown. Arms 10, uniserial, branching iso-

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EXPLANATION OF PLATE 18

Morrowan species of inadunate crinoids—*Lasanocrinus*.

FIGURE

1,2. *Lasanocrinus strigosus* (Moore & Plummer) from the Brentwood horizon, Bloyd Formation, at spillway of Greenleaf Lake, southeast of Braggs, Muskogee County, Oklahoma; 1a-d, dorsal, anterior, posterior, and ventral views of paratype SUI 33339, ×4.5; 2a-c, dorsal, anterior, and posterior views of paratype SUI 33342, ×4.5.

3,4. *Lasanocrinus minutus* Moore & Strimple, new species; 3a-c, Brentwood horizon, Bloyd Formation, from Wagoner County, Oklahoma, posterior, dorsal, and ventral views of paratype SUI 33186, ×5; 4a-d, Brentwood horizon, Bloyd Formation, at spillway of Greenleaf Lake, southeast of Braggs, Muskogee County, Oklahoma, posterior, dorsal, anterior, and ventral views of holotype (SUI 33343), ×4.5.

FIGURE

5a,b;6. *Lasanocrinus nodatus* Moore & Strimple, new species, Brentwood horizon, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ventral and anterior views of paratype (SUI 33418), ×3.1; 6, paratype (SUI 33417) from same beds and locality, dorsal view, ×6.2.

7a-d. *Lasanocrinus nodus* Moore & Strimple, new species, Morrowan from 1 mile south of Muskogee, Muskogee County, Oklahoma, dorsal, anterior, ventral, and posterior views of holotype (SUI 33176), ×4.5.

tomously on primibrachs *1*. Stem attachment scar small, circular.

Discussion.—Relationship with *Palmerocrinus kesslerensis* is discussed under that species. *P. matheri* has not been found in lower beds of the Wapanucka Formation but is fairly common in the middle beds.

Types.—Holotype (KUMIP 45202=USNM 141042) collected by R. C. Moore; paratype (KUMIP 45196=USNM 141043) collected by C. R. Foster; hypotypes (SUI 33316, 33159, 33326, 33328, 33322, 33274, 33277, 33273, 33156, 33382) collected by H. L. Strimple; (SUI 33387) collected by Jack Hood; (SUI 33315, 33325) collected by R. C. Moore.

Occurrence.—Brentwood interval, Bloyd Formation, holotype (KUMIP 45202=USNM 141042), paratype (KUMIP 45196-USNM 141043) from Keough quarry, 2 miles north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1]; hypotypes (SUI 33316, 33159, 33322, 33387, 33315, 33325) from Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8]; hypotype (SUI 33326) from outcrop 1 mile south of Choteau, Mayes County, Oklahoma [Loc. 20]; hypotype (SUI 33328) from Flat Rock Creek north of Wagoner, Wagoner County, Oklahoma [Loc. 10]; hypotypes (SUI 33327, 33277) from east side of Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16]; hypotype (SUI 33273) from Union Mission, Mayes County, Oklahoma [Loc. 9].

Middle part of Wapanucka Formation, hypotype (OU 256) from Canyon Creek, Pontotoc County, Oklahoma [Loc. 12b]; hypotypes (OU 291, 292) from Coal County, Oklahoma [Loc. 42]; hypotype (SUI 33382) from Burr Valley Ranch, Coal County, Oklahoma [Loc. 14]; hypotype (SUI 33156) from Olney road east of Clarita, Coal County, Oklahoma [Loc. 15].

Superfamily PIRASOCRINACEA Moore & Laudon, 1943 (Moore & Strimple, new superfamily)

[*nom. transl.* Moore & Strimple, herein (ex Pirasocrinidae Moore & Laudon, 1943)]

Type Genus.—*Pirasocrinus* Moore & Plummer, 1940, p. 370.

Diagnosis.—Crown pyriform; cup very low bowl-shaped, with mostly deep basal concavity and rounded steep sides incurved to rim, arm facets peneplenary and declivate, interradial notches between facets, three anals in cup; anal sac taller than arms, mushroom-shaped, with girdle of horizontal spines around summit platform.

Discussion.—As now defined, the Pirasocrinacea include the following families: Pirasocrinidae Moore & Laudon, 1943; Adinocrinidae Strimple, 1961.

Occurrence.—Lower Mississippian-Lower Permian.

Family PIRASOCRINIDAE Moore & Laudon, 1943

Type Genus.—*Pirasocrinus* Moore & Laudon, 1943, p. 370.

Diagnosis.—Crown tall, relatively slender, widest at height of secundaxils, isotomous branching of arms at uniform heights in each ray, which, with bulbous nature of axillary brachials, provides pagodalike appearance. Cup saucerlike with deep basal concavity; radial articular facets peneplenary and declivate; three anals in cup. Arms recti-uniserial, exceptionally biserial. Anal sac mushroom-shaped, with spine-girdled summit platform slightly above arm tips. Stem circular in section.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Virgilian).

Genus LASANOCRINUS Moore & Plummer, 1940

[*Lasanocrinus* Moore & Plummer, 1940, p. 181]

Type Species.—*Hydreionocrinus daileyi* Strimple, 1940, p. 93.

Diagnosis.—Cup low bowl-shaped, basal concavity shallow but distinct; infrabasals mildly downflared or subhorizontal, radial plates characterized by centrally located protuberance, proximal tips not visible in side view of cup; anal plates typically three in normal (primitive) arrangement but may be two.

Discussion.—It is not now clear whether or not this highly specialized genus extends above the Atokan. Knapp (1969, p. 370) reported it as restricted to the Lower Pennsylvanian.

Occurrence.—Pennsylvanian (Morrowan-Atokan); USA (Oklahoma, Arkansas, Texas).

LASANOCRINUS DAILEYI (Strimple), 1940

[*Hydreionocrinus daileyi* Strimple, 1940, p. 93]

Discussion.—The holotype of *Lasanocrinus daileyi*, which comes from the lower part of the Wapanucka Formation in southern Oklahoma, has a rounded, somewhat projecting posterior (*CD*) interray, whereas specimens designated as hypotypes from the Brentwood Limestone, Bloyd Formation, of northeastern Oklahoma by Moore & Plummer (1940, p. 183) have a planate posterior interray. Specimens (KU 451925=USNM 140948) from the Bloyd Formation similar to that figured by Moore & Plummer (1940, pl. 7, fig. 5), are designated here as *Lasanocrinus nodatus* Moore & Strimple, new species. Distinctive other forms are described as *L. nodus* Moore & Strimple, new species, and *L. multinodulus* Moore & Strimple, new species. The specimen (KU 451925A=USNM 140948A) figured by Moore & Plummer (1940, pl. 7, fig. 6) is ascribed to *L. multinodulus*.

The holotype of *Lasanocrinus nodatus* is from a shale lentil at the base of the spillway of Greenleaf Lake, southeast of Braggs, Muskogee County, Oklahoma, where is it associated with the ammonoid *Brannerоceras branneri*. A figured paratype (SUI 35412) with advanced arrangement of anal plates was collected from a shale lentil thought to belong slightly lower in the section exposed in an abandoned quarry on the east shore of Ft. Gibson Reservoir, east of Wagoner, Oklahoma. *Brannerоceras branneri* has also been found in closely associated limestones at this outcrop.

Types.—Holotype (USNM S4335); topotypes (metatypes SUI 35429, 35430) collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation, Pontotoc County, Oklahoma [Loc. 13].

LASANOCRINUS NODATUS Moore & Strimple, new species

[=*Lasanocrinus daileyi* (Strimple, 1940) Moore & Plummer, 1940, pl. 7, fig. 5]

Plate 9, figures 4a,b; Plate 18, figures 5a,b, 6; Plate 19, figures 2a-d, 3a,b

Description.—Cup very low and wide, with broad shallowly concave base and broadly flattened *CD* interray; prominent broad projections of the radials. Infrabasals, confined to base of concavity, extend slightly beyond the relatively large circular impressed socket for stem attachment; they are mildly downflared; basals are very large, curved evenly from basal concavity to the walls of cup, truncated distal end of *CD* basal visible in side view of cup; radials are extended in midsection as wide, thick, blunt projections which are directed slightly downward, proximal ends entering well into the basal plane of the cup; radial articular facets subhorizontal; anal plates 2 or 3 but usually advanced (2 plates), with primanal (radianal) moved toward or into direct posterior position. Surface of cup granulose.

Dimensions.—Measurements of the holotype (SUI 35486) in millimeters are: width of cup, 8.1; height, 2.2; width of infrabasal circlet, about 2.0; width of *DE* basal, 1.9; length, 2.2; width of *E* radial, 4.1; length, 2.3.

Types.—Holotype (SUI 35486) and paratypes (SUI 33417, 33418) collected by H. L. Strimple, paratype (SUI 33341) collected by R. C. Moore, paratype (SUI 35412) collected by Amel Priest; paratype (KUMIP 41925) collected by C. L. Foster.

Occurrence.—Brentwood interval, Bloyd Formation (Morrowan), SUI 33417, 33418, 35486, from Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a]; SUI 35412 from abandoned quarry on east shore of Ft. Gibson Reservoir, Cherokee County [Loc. 16], KU 41825 from Keough Quarry north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1].

LASANOCRINUS NODUS Moore & Strimple, new species

Plate 18, figures 7a-d

Description.—This species is different from *Lasanocrinus nodatus* in possessing ball-like terminations at ends of the radial projections; these extend below the general basal plane of the cup and prominent bulbous basals. Also, the radial articular facets slope outward-downward at a higher angle than in *L. nodatus*. The 3 anal plates are in normal (primitive) arrangement in the holotype of *L. nodus*.

Dimensions.—Measurements of the holotype (SUI 33176) in millimeters are: width of cup, 12.0; height, 4.0; width of infrabasal circlet, 3.2; width of *DE* basal, 3.3; length, 3.0; width of *E* radial, 5.9; length, 3.0.

Holotype.—SUI 33176, collected by Albert Hanson, The University of Iowa, Iowa City.

Occurrence.—Morrowan, 1 mile south of Muskogee, Muskogee County, Oklahoma [Loc. 17].

LASANOCRINUS MULTINODULUS Moore & Strimple, new species

Description.—This species is more clearly similar to *Lasanocrinus nodatus* than to *L. nodus*. It differs in development of 2 or more small nodes on the projection of each radial plate.

Discussion.—The holotype was figured by Moore & Plummer (1940, p. 7, fig. 6) as *Lasanocrinus daileyi* (Strimple).

Holotype.—KUMIP 451925A, collected by C. L. Foster.

Occurrence.—Brentwood interval, Bloyd Formation (Morrowan); Keough quarry north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1].

LASANOCRINUS STRIGOSUS (Moore & Plummer), 1938

Plate 18, figures 1a-d, 2a-c; Figure 6,1a,b

Description.—This species was described as *Plaxocrinus strigosus* Moore & Plummer (1938, p. 279) but certainly is atypical of *Plaxocrinus* in several significant characters. The cup of *L. strigosus* is proportionally wider than in typical *Plaxocrinus*, the sides of the cup are more erect, the base is broader, and, most significantly, the radial articular facets are almost horizontal and there is a pronounced forefacet. Proximal ends of the radials extend well into the basal area. The cup has a quinquelobate outline when viewed from below. The basal concavity is broad and shallow except for a centrally depressed area in some specimens. Infrabasals are subhorizontal and the central portion of circlet is sharply impressed for reception of proximal columnals; anal plates usually are in advanced position with the primanal (radianal) dominant.

Discussion.—The prominent long bulbous radials, broad shallow basal concavity, and advanced anal plates have led us to designate this form as *Lasanocrinus strigosus* (Moore & Plummer) Moore & Strimple, new combination.

Types.—Holotype (KU 45203=USNM 141036); paratypes (KUMIP=45203a=USNM 141037, 45224=

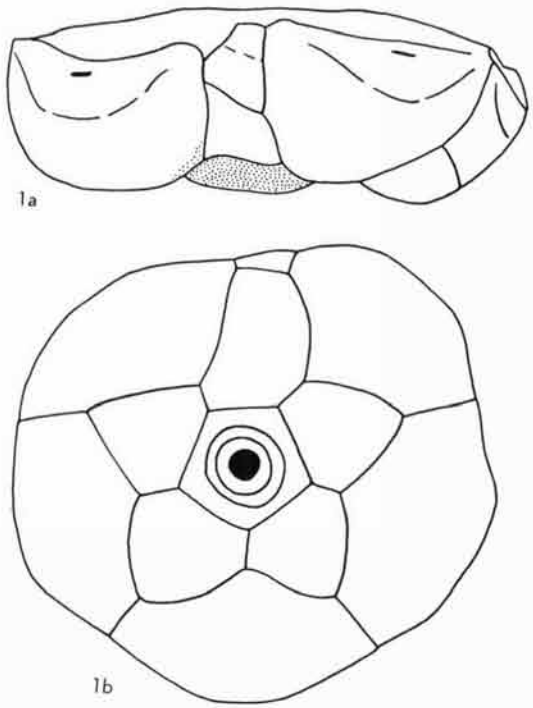


FIG. 6. Camera lucida drawings of *Lasanocrinus strigosus*; 1a,b, posterior and dorsal sides of hypotype (SUI 33339) from Brentwood interval, Bloyd Formation at Greenleaf Lake spillway southeast of Braggs, Cherokee County, Oklahoma, showing oblique suture between *CD* basal and overlying primanal (radianal indicated by the suture), ×5.

USNM 141038), collected by R. C. Moore; hypotype (SUI 33366) collected by H. L. Strimple; hypotypes (SUI 33339, 33342) collected by R. C. Moore.

Occurrence.—Holotype (USNM 141036), paratype (USNM 141037), Brentwood interval, Bloyd Formation, Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1]; paratype (USNM 141038), Brentwood Limestone, Bloyd Formation, road cut on U.S. Hwy. 71 opposite Woolsey, Washington County, Arkansas [Loc. 3], hypotype (SUI 33366), Bloyd Mountain, 9 miles south of Fayetteville, Washington County, Arkansas; Brentwood interval, Bloyd Formation, hypotypes (SUI 33339, 33342) Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a].

LASANOCRINUS MINUTUS Moore & Strimple, new species
Plate 18, figures 3a-c, 4a-d

Description.—Cup low bowl-shaped, with broad basal concavity, surface covered by fine vermicular markings. Sides of the cup are almost vertical and are elongated owing to downward projections of the radials, which protrude well below the general basal plane of the cup. Articular facets of radials slope at a higher angle than normal in the genus and their proximal portions are projected downward to sharp points. Proximal ends of the radials enter the basal concavity. Anal plates (2) are in advanced arrangement and may be essentially eliminated from the cup (e.g., paratype SUI 33186, Pl. 18, fig. 3a-c).

Discussion.—*Lasanocrinus minutus* is closely related to *L. strigosus*, differing in the spinose extension of lower parts of radials in the former.

Dimensions.—Measurements of holotype (SUI 33343) in millimeters are: width of cup, 9.3; height, 3.0; width of infrabasal circlet, 2.7; width of *DE* basal, 2.5; length, 2.3; width of *E* radial, 4.2; length, 3.0.

Types.—Holotype (SUI 33343) collected by R. C. Moore and A. L. Bowsher, paratype (SUI 33186) collected by Albert Hanson.

Occurrence.—Brentwood interval, Bloyd Formation, holotype (SUI 33343), Greenleaf Lake spillway, southeast of Braggs, Muskogee County [Loc. 8a]; paratype (SUI 33186), Wagoner County, Oklahoma [Loc. 19].

EXPLANATION OF PLATE 19

Morrowan species of inadunate crinoids—*Proallosocrinus*, *Metutharocrinus*, *Utharocrinus*, *Lasanocrinus*.

FIGURE

1. *Proallosocrinus antonis* (Washburn) from Oquirrh Formation (Morrowan), Utah County, Utah; posterior view of lower part of crown (BYU 1484), ×2.3.
2,3. *Lasanocrinus nodatus* Moore & Strimple, new species, from Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma; 2a-d, dorsal, ventral, anterior, and posterior views of holotype (SUI 35486), ×6.2; 3a,b, posterior and ventral views of paratype (SUI 33417) from same beds and locality as the holotype, ×6.2.
4a-d. *Metutharocrinus cockei* Moore & Strimple, new genus, new species, from thick ?post-Brentwood beds, Bloyd Formation, Windfry Valley, Crawford County, Arkansas, ventral, anterior, posterior, and dorsal views of holotype (SUI 33364), ×4.7.
5a-d. *Utharocrinus pentanodus* (Mather), 1915, from Brentwood interval, Bloyd Formation, at Keough Quarry, north of Ft. Gibson, Cherokee County, Oklahoma, anterior, posterior, dorsal, and ventral views of hypotype (SUI 33282), ×4.7.

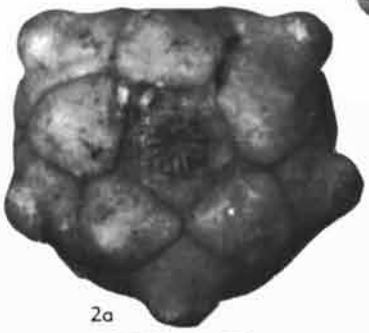

1


2c


3a


2d


3b


2a

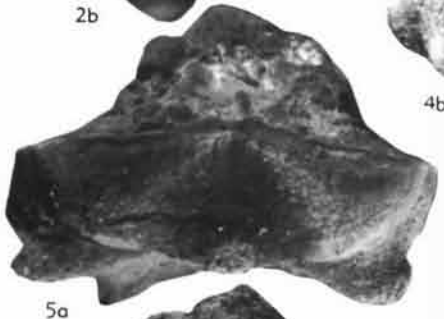

4a


4c


2b

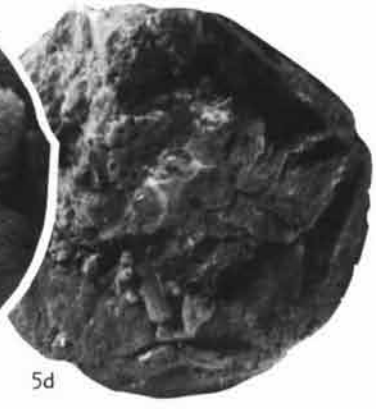

4b

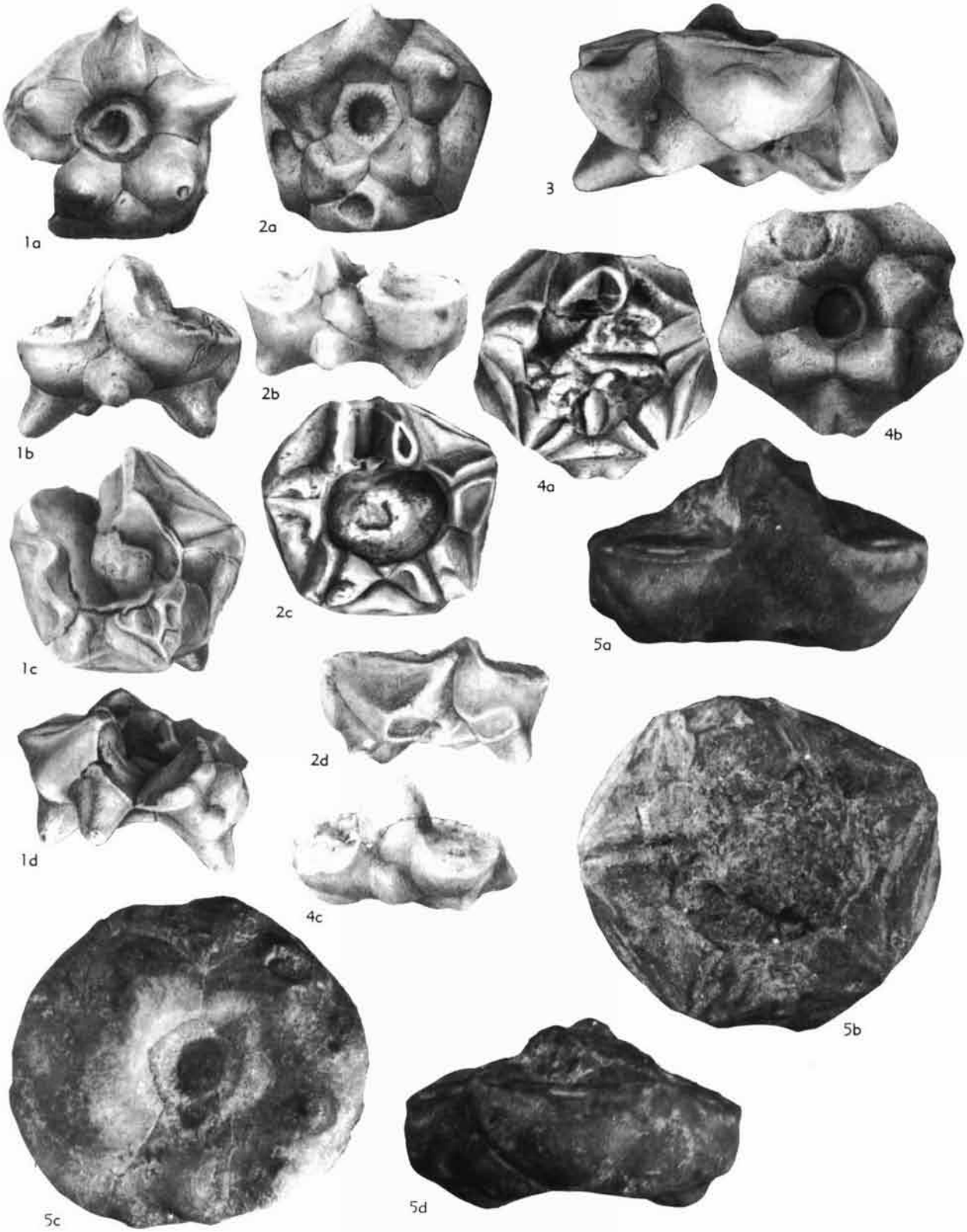

4d


5a


5b


5c


5d


1a
2a
3
1b
2b
4a
4b
2c
5a
1c
2d
1d
4c
5b
5c
5d

Genus UTHAROCRINUS Moore & Plummer, 1938

Type Species.—*Delocrinus pentanodus* Mather, 1915, p. 106.

Description.—Cup small, bowl-shaped, with broad shallow basal concavity; infrabasals five, subhorizontal or slightly downflared, projecting beyond shallow circular stem impression; basals five, gently convex transversely and longitudinally save for subcentrally located horn-shaped projection on each plate protruding outward-downward; radials strongly convex longitudinally, with proximal ends entering the basal plane of the cup, peneplenary radial articular facets subhorizontal or sloped slightly outward-downward; anal plates three to one, usually in advanced arrangement.

Discussion.—Close relationship of *Utharocrinus* with both *Lasanocrinus* and *Metutharocrinus* is apparent. Stout projections or a tendency toward projections of the radials typify *Lasanocrinus* and those of the basals typify *Utharocrinus*. Projection of both radials and basals distinguish *Metutharocrinus*. It seems evident that all three forms had a common raison d'être which was to provide means for keeping the cup above the substrate, possibly when the animals were in repose; likely they were bottom-dwellers with the stems, if retained, acting as a tether rather than stalk.

The advanced nature of the anal plates, particularly as found in the holotype of *Utharocrinus pentanodus*, with only the radianal remaining in the cup, indicates an advanced evolutionary state. The primary stock (with normal anal plates) might have continued into younger strata but most forms first ascribed to *Utharocrinus* subsequently have been assigned to other genera.

Occurrence.—Pennsylvanian (Morrowan); USA (Oklahoma, Arkansas).

UTHAROCRINUS PENTANODUS (Mather), 1915

Plate 19, figures 5a-d; Plate 20, figures 1a-d, 2a-d

Diagnosis.—Characters of genus, with sharp-pointed central projections on basals.

Description.—The holotype of *Utharocrinus pentanodus* is advanced in that a single anal plate (radianal) is retained in the cup. Several specimens are now available and show variability from 3 anal plates in normal (primitive) arrangement (Pl. 20, fig. 2a-d) to a single one as found in the holotype. Some specimens have a more pronounced basal concavity than the holotype but this is accompanied by a somewhat deeper cup which is not considered sufficiently distinct to warrant differentiation.

Types.—Holotype (University of Chicago Walker Museum 16181), collected by Stuart Weller and L. C. Snider, reposited in Field Museum of Natural History, Chicago, Illinois; hypotype (SUI 33175, 33184), collected by Albert Hanson; (SUI 33282) collected by H. L. Strimple.

Occurrence.—Brentwood interval, Bloyd Formation, 1.5 miles north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 5 and Loc. 1].

Genus METUTHAROCRINUS Moore & Strimple, new genus

Type Species.—*Metutharocrinus cockei* Moore & Strimple, new species.

Diagnosis.—Cup low, bowl-shaped with broad base, wide rather deep basal concavity, small subhorizontal infrabasal circlet, posterior interray evenly rounded (mildly protruded); basals with prominent central swellings or spines; radials swollen as blunt nodes in lower midportion, with protrusions extending to basal plane of cup; anal plates three, in normal (primitive) arrangement.

Discussion.—This genus has characters of both *Lasanocrinus* and *Utharocrinus* (i.e., pronounced median extensions of both radials and basals). The fairly stable condition of the anal plates suggests that derivatives of this stock probably survived into younger strata.

Occurrence.—Lower Pennsylvanian (Morrowan); USA (Oklahoma, Arkansas).

EXPLANATION OF PLATE 20

Morrowan species of inadunate crinoids—*Utharocrinus*, *Metutharocrinus*.

FIGURE

1,2. *Utharocrinus pentanodus* (Mather), 1915, from Brentwood interval, Bloyd Formation, 1.5 miles north of Ft. Gibson, Cherokee County, Oklahoma; 1a-d, dorsal, posterior, ventral, and anterior views of hypotype (SUI 33175), ×3.5; 2a-d, same views of another hypotype (SUI 33184), ×4.3.

3,4. *Metutharocrinus spinifer* Moore & Strimple, new genus, new species, from Brentwood interval, Bloyd Formation, 1 mile south of Muskogee, Muskogee County, Oklahoma; 3, anterior view of holotype (SUI 33178), ×4.6; 4a-c, ventral, dorsal, and posterior views of paratype (SUI 33185), ×5.

5. *Metutharocrinus cockei* Moore & Strimple, new genus, new species, from Brentwood interval, Bloyd Formation, on Flat Rock Creek, Wagoner County, Oklahoma; 5a-d, posterior, ventral, dorsal, and anterior views of paratype (SUI 33290), ×4.6.

METUTHAROCRINUS COCKEI Moore & Strimple, new species
Plate 19, figures 4a-d; Plate 20, figures 5a-d

Diagnosis.—Characters of the genus, median projections of basals and radials consisting of rounded swellings rather than spines.

Description.—The projecting basals and radials of this species have the forms of pronounced swellings rather than of spines. The swollen areas are not readily apparent in basal or summit views of the cup although a few undulations interrupt the evenly rounded contour. Distal portions of the long basals extend well up into the cup walls and proximal ends of the radials reach the near-basal plane just above that defined by downward extensions of the basals. The basal concavity is moderately wide and shallow. Infrabasals are slightly downflared with distal ends subhorizontal. The posterior interray is mildly convex and contributes to the evenly rounded contour of the cup. The 3 anal plates are in normal arrangement.

Dimensions.—Measurements of holotype (SUI 33364) in millimeters are: width of cup, 10.3; height, 4.3; width of infrabasal circlet, 2.3; width of *DE* basal, 3.9; length, 3.7; width of *E* radial, 5.4; length, 3.1.

Types.—Holotype (SUI 33364), collected by J. M. Cocke; paratype (SUI 33290), collected by Melba and Harrell Strimple, paratypes (SUI 33349, 33350) collected by Albert Hanson and (SUI 33386) collected by Jack Hood; paratypes (SUI 33283, 33314) collected by H. L. Strimple.

Occurrence.—Holotype (SUI 33364) in thick shale sequence, ?post-Brentwood Limestone, Bloyd Formation; Big Frog Bayou, Windfry Valley, Crawford County, Arkansas [Loc. 21]; paratypes (SUI 33290, 33349), Brentwood interval, Bloyd Formation, on Flat Rock Creek, Wagoner County, Oklahoma [Loc. 10]; paratype (SUI 33386) at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8b]; paratype (SUI 33350), Bloyd Formation, 1 mile south of Muskogee, Muskogee County, Oklahoma [Loc. 17]; paratype (SUI 33283 [2 specimens]), abandoned quarry on east shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16]; paratype (SUI 33314), Keough quarry north of Ft. Gibson, Cherokee County, Oklahoma [Loc. 1].

METUTHAROCRINUS SPINIFER Moore & Strimple, new species
Plate 20, figures 3,4a-c; Plate 21, figures 1a-c

Diagnosis.—Characters of the genus, median projections of basals sharp-pointed.

Description.—This species is somewhat atypical of the genus in that the protruding basals have the form of stout spines which resemble those of *Utharocrinus pentanodus* (Mather, 1915). The rounded nodelike swellings of the lower midportion of the radials are foreign to *U. pentanodus*, however. The basals have an almost planate surface extending from the contact with infrabasals to the termination of the spinose projection. The infrabasal circlet is subhorizontal and mainly covered by the round stem attachment scar, which is impressed and has closely packed prominent crenulations extending to the small circular lumen.

Dimensions.—Measurements of holotype (SUI 33178) in millimeters are: width of cup, 12.0; height, 4.9; width of infrabasal circlet, 3.4; width of *DE* basal, 4.3; length, 3.7; width of *E* radial, 6.0; length, 3.3.

Types.—Holotype (SUI 33178), collected by Albert Hanson; paratype (SUI 33185) collected by R. C. Moore.

Occurrence.—Holotype (SUI 33178), Brentwood interval, Bloyd Formation, 1 mile south of Muskogee, Muskogee County, Oklahoma [Loc. 17]; paratype (SUI 33185), Brentwood interval, Bloyd Formation, Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a].

METUTHAROCRINUS UNDULATUS Moore & Strimple, new species
Plate 21, figures 2a-d, 3a-c

Description.—Cup wide, low, with shallow basal concavity; basal plane formed by large mildly tumid basals, infrabasals subhorizontal, confined to bottom of concavity, distal tips of which extend into side walls of the cup; radials large, swollen in midportion, with a subvertical area below the subhorizontal articular facets and extending to the basal plane. Three anal plates, which generally are longer than wide and arranged in normal (primitive) manner.

Discussion.—Tumidity of the basal plates and projections of median parts of the radials are not as pro-

EXPLANATION OF PLATE 21

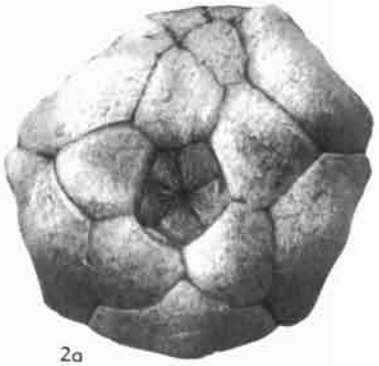
Morrowan species of inadunate crinoids—*Metutharocrinus*.

FIGURE

1a-c. *Metutharocrinus spinifer* Moore & Strimple, new genus, new species, from Brentwood interval, Bloyd Formation, 1 mile south of Muskogee, Muskogee County, Oklahoma; dorsal, posterior, and ventral views of holotype (SUI 33178), ×4.6.

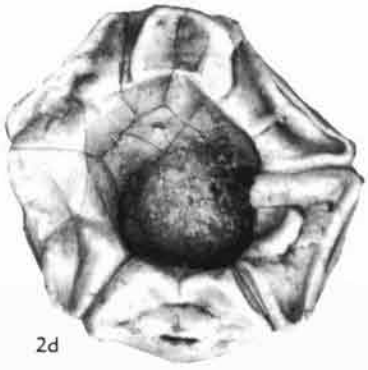
2,3. *Metutharocrinus undulatus* Moore & Strimple, new genus, new species, from lower part of Wapanucka Formation near Canyon Creek, Pontotoc County, Oklahoma; 2a-d, dorsal, posterior, anterior, and ventral views of holotype (SUI 33191), ×5; 3a-c, posterior, dorsal, and ventral views of paratype (SUI 33160), ×5.


1a


2a

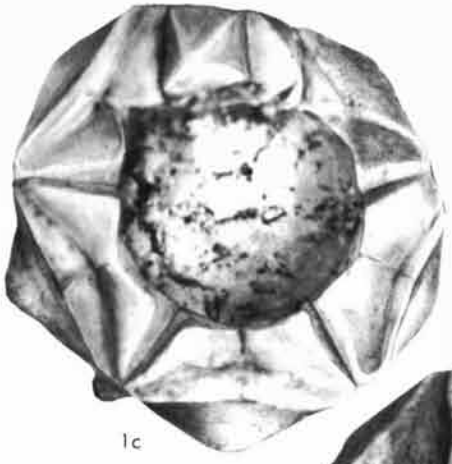

2b


2c


2d


1b


3a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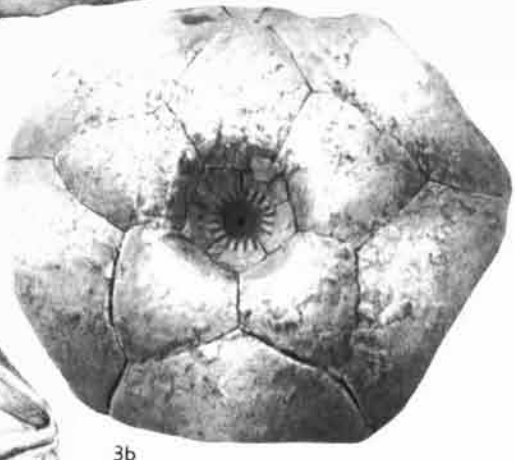
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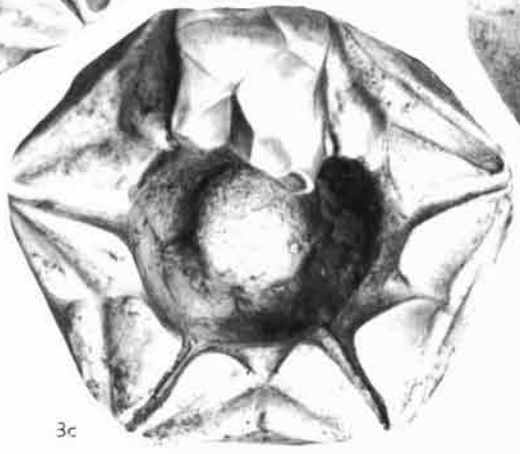
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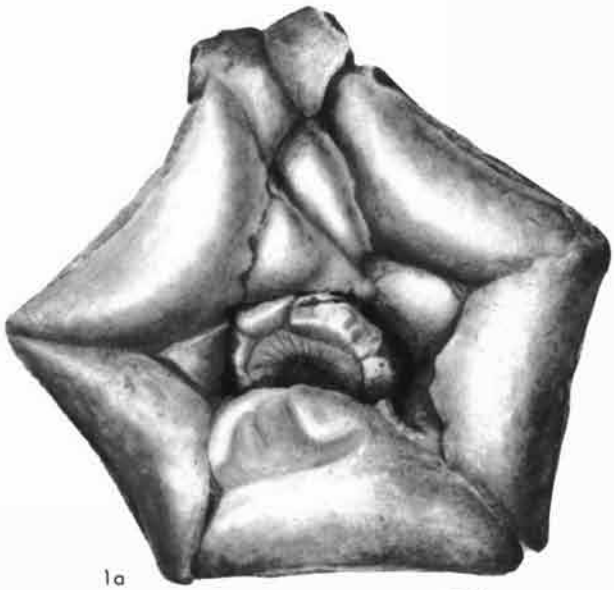

1a

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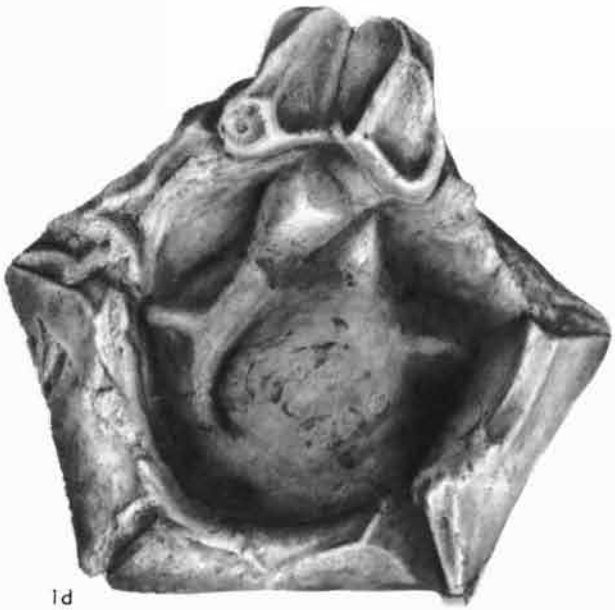

1d

2a

2b

2c

nounced in *Metutharocrinus undulatus* as in other species of the genus.

Dimensions.—The holotype (SUI 33191) has a width of 10.0 mm and a height of 3.5 mm.

Types.—Holotype (SUI 33191) and paratype (SUI 33160) collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation, near Canyon Creek, Pontotoc County, Oklahoma [Loc. 13].

Genus AFFINOCRINUS Knapp, 1969

Type Species.—*Affinocrinus concavus* Knapp, 1969, p. 372.

Diagnosis.—Cup low bowl-shaped with broad, moderately deep basal concavity; infrabasals slightly downflaring; basals have distal tips visible in side view of cup, usually transversely concave in proximal portions; a distinct impressed forefacet is present on distal portions of radials.

Discussion.—Knapp (1969, p. 372) considered *Affinocrinus* to be in a lineage leading directly to *Pirasocrinus* Moore & Plummer (1940).

Occurrence.—Pennsylvanian (Morrowan)-Middle Pennsylvanian (Atokan); USA (Oklahoma, Arkansas, Missouri).

AFFINOCRINUS GRANDIS Moore & Strimple, new species

Plate 22, figures 2a-c

Description.—Cup low bowl-shaped with evenly curved sides until approaching the articular area where a slight bulge is developed above a nearly vertical surface which is arcuate. The cup summit is distinctive owing to the occurrence of broad interradial notches which are accentuated by the projected ends of the radial articular surfaces. The basal concavity is broad and deep, with a slightly downflared infrabasal circlet at the bottom. Internally, the infrabasals form a low broad dome. Basals are wide, with only distal tips visible in side view of cup (except *CD* basal). They comprise the walls of the concavity where they are transversely concave. Radials are large, with proximal tips reaching the basal plane but not entering the basal concavity. The posterior interray is very broad and contains 3 anal plates in slightly advanced arrangement since the primanal is small and far removed from contact with the *BC* basal.

Radial articular facets are large and outwardly downsloped. The outer ligament area is short, with a prominent ligament pit. The transverse ridge is well developed, bearing prominent crenellae on each end bounded by strong lateral furrows which extend to the intermuscular notch. Muscle fields are large triangular spaces.

Sutures between cup plates are impressed. Adsutural areas and the basal concavity are decidedly granulose and coarse granules occur sporadically on other surfaces.

Discussion.—*Affinocrinus grandis* differs from *A. normalis*, *A. concavus*, and other species in having pronounced interradial notches, a less downflaring and proportionally wider infrabasal circlet, and basals with less transverse concavity. *A. abathus* Knapp (1969) has a very shallow basal concavity, lacks any transverse concavity of basals, and displays only slight interradial notches at the cup summit. *A. progressus* Moore & Strimple, new species, lacks interradial notches, the basals are petal-like in outline and proximal tips of the radials actually reach the basal concavity. *A. politus* Moore & Strimple, new species, lacks impression of interplate sutures, has a narrow basal concavity and an advanced arrangement of the anal plates. *A. normalis* Moore & Strimple, new species, has an even rounded contour when viewed from above or below for interradial notches are not developed and the basals lack transverse concavity.

Dimensions.—Measurements of the holotype (SUI 36240) in millimeters are given for width (W) and height or length (H) as follows: dorsal cup, W-31.8, H-8.6; infrabasal circlet, W-13.5; stem attachment scar, W-5.6; *DE* basal, W-9.9, H-7.5; *D*, radial, W-14.4, H-8.6.

Holotype.—SUI 36240, collected by Joe Welch.

Occurrence.—Brentwood interval, Bloyd Formation, Union Mission, Mayes County, Oklahoma [Loc. 9].

AFFINOCRINUS PROGRESSUS Moore & Strimple, new species

Plate 8, figures 1a,b; Plate 12, figures 1a-d, 2a-d; Plate 23, figures 1a-d, 2a,b

EXPLANATION OF PLATE 22

Morrowan species of inadunate crinoids—*Sciadiocrinus* and *Affinocrinus*.

FIGURE

1a-d. *Sciadiocrinus cascus* Moore & Strimple, new species, dorsal, anterior, posterior, and ventral views of holotype (SUI 33183) from Brentwood interval, Bloyd Formation, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×3.

FIGURE

2a-c. *Affinocrinus grandis* Moore & Strimple, new species, posterior, dorsal, and ventral views of holotype (SUI 36240) from Brentwood interval, Bloyd Formation, at Union Mission, Mayes County, Oklahoma, ×2.3.

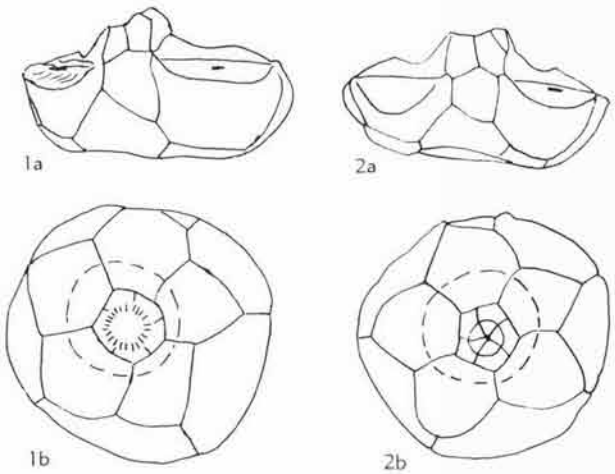

FIG. 7. *Affinocrinus politus* Moore & Strimple, new species, camera lucida drawings of posterior and dorsal sides, ×3.4; 1a,b, holotype (SUI 33295) from Brentwood interval, Bloyd Formation, from abandoned quarry on east side of Ft. Gibson Reservoir, Cherokee County, Oklahoma; 2a,b, paratype (SUI 35490) from same beds at Union Mission, Mayes County, Oklahoma.

Description.—Cup low basally concave bowl with mildly downflared infrabasals and impressed sutures. Basal concavity broad, moderately deep, with steep sides, infrabasals and all but distal ends of petal-like basals confined to the base. Radials are swollen, with proximal ends curved into the basal plane and reaching into the basal concavity; distal ends curved inward to form forefacets, articular facets sloping slightly outward-downward, with prominent transverse ridges meeting at interradial sutures so that the cup has an angular outline when viewed from above or below. Anal plates in cup 1 to 3, normally in advanced pattern, with primanal on truncate elongated *CD* basal (exception in paratype SUI 33275, Pl. 12, fig. 1).

Dimensions.—Measurements of holotype (SUI 33173) in millimeters are: width of cup, 13.8; height, 5.2; width of infrabasal circlet, 3.2; width of *DE* basal, 4.6; length, 4.9; width of *E* radial, 7.3; length, 4.5.

Discussion.—Comparison with other species is given following the description of *Affinocrinus grandis*.

Types.—Holotype (SUI 33173) and paratypes (SUI 33135, 33180, 33188, 33189, 33240, 33275); types collected by A. Hanson, R. C. Moore and H. L. Strimple.

Occurrence.—Bloyd Formation, holotype (SUI 33173) and paratypes (SUI 33188, 33275, 33189), from abandoned quarry on east side of Grand River, SE ¼ sec. 22, T. 17 N., R. 19 E., Wagoner County, Oklahoma [Loc. 16]; paratypes (SUI 33135, 33180) at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8b]; paratype SUI 33240 from 1 mile south of Muskogee, Muskogee County, Oklahoma [Loc. 17].

AFFINOCRINUS POLITUS Moore & Strimple, new species

Plate 23, figures 5a-d; Figure 7,1a,b, 2a,b

Description.—Cup low bowl-shaped, with even rounded contour when viewed from above or below, plates smooth even curved, sutures not impressed, basal concavity rather narrow, but sharply defined. Cup and plates advanced in arrangement, primanal on obliquely truncate *CD* basal (Fig. 7,*1,2*), secundanal and tertanal well above radial summits. Middle of proximal portion of basals depressed. Small forefacet in distal portion of radials; articular facets sloping slightly outward-downward.

Discussion.—*Affinocrinus politus* may be in the direct lineage that produced *A. concavus* Knapp (1969), type species of the genus. The holotype of the latter, however, has a normal compliment of 3 anal plates in primitive arrangement. Other species of the genus have deeply impressed interplate sutures.

Dimensions.—Measurements of the holotype (SUI 33295) in millimeters are as follows (W, width, H, height or length): dorsal cup, W-10.6, H-3.8; infrabasal circlet, W-2.7; *DE* basal, W-3.7, H-3.6; *E* radial, W-5.6, H-3.2.

Types.—Holotype (SUI 33295), and paratype (SUI 35490), both collected by H. L. Strimple.

Occurrence.—Brentwood interval, Bloyd Formation, abandoned quarry on east side of Ft. Gibson Reservoir, Cherokee County, Oklahoma [Loc. 16], Union Mission, Mayes County, Oklahoma [Loc. 9].

AFFINOCRINUS NORMALIS Moore & Strimple, new species

Plate 6, figures 6a-c; Plate 8, figures 2a-c

Description.—Cup low bowl-shaped, with even contour when viewed from above or below, pronounced basal concavity, all cup plates tumid with impressed sutures, cup anal plates in normal primitive arrangement.

Discussion.—*Affinocrinus normalis* is presumed to belong in the direct lineage which produced *A. concavus* Knapp (1969), of Middle Pennsylvanian (Atokan) age, as represented by a paratype (USNM 14818), Knapp (1969, pl. 62, fig. 12-14). *A. normalis* differs from *A. progressus* in lacking petal-like basals and in having an even peripheral cup contour. *A. politus* lacks tumidity of the cup plates which is typical of *A. normalis*.

Dimensions.—Measurements of the holotype (SUI 33126) in millimeters (width, W, height or length, H) are as follows: dorsal cup, W-7.5; H-5.3; infrabasal circlet, W-4.2; *DE* basal, W-4.5, H-5.0; *E* radial, W-9.2, H-5.3.

Types.—Holotype (SUI 33126) and paratype (SUI 36244) both collected by H. L. Strimple.

Occurrence.—Lower part of Wapanucka Formation, in SE ¼ sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma [Loc. 13].

Genus STENOPECRINUS Strimple, 1961

[*Stenopecrinus* Strimple, 1961, p. 39]

Type Species.—*Perimestocrinus planus* Strimple, 1952, p. 787.

Diagnosis.—Cup low bowl-shaped, with rather deep and narrow basal concavity. Proximal portions of basals form steep walls of basal concavity and curve sharply to become visible in side view of cup; radials large, proximal ends reaching into basal plane, small notches at cup summit but not prominent; anal plates normal (primitive) to advanced. Arms uniserial, endotomous, primaxils spinose. Anal sac taller than arms, terminating in a small platform surrounded by seven large outwardly directed spines.

Occurrence.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Missourian); USA (Oklahoma, Kansas, Texas, Illinois, Nebraska, Utah).

STENOPECRINUS ORNATUS Moore & Strimple, new species

Plate 23, figures 3a-d

Description.—Cup very low bowl-shaped, sides erect, shallowly concave base, outer surface marked by ridges and pronounced nodes; infrabasals gently downflared; basals large, with distal ends visible in side view; radials large, marked by 2 prominent nodes at basal plane, proximal ends entering basal plane, articular facets sloping outward-downward, nearly plane, transverse ridge rather obscure, thickening in midportion, outer ligament pit thin but well defined; 3 large anal plates in normal (primitive) arrangement. Anal sac and arms unknown.

Discussion.—*Stenopecrinus ornatus* reflects many of the characters of *Anchicrinus rugosus* but differs in having more erect lateral cup walls and in posession of large nodes on the radial plates.

Dimensions.—Measurements of holotype (SUI 33187) in millimeters are: width of dorsal cup, 8.2; height, 2.8; width of infrabasal circlet, 2.0; width of *DE* basal, 2.5; length, 2.2; width of *E* radial, 4.5; length, 2.1.

Holotype.—SUI 33187 collected by R. C. Moore.

Occurrence.—Brentwood interval, Bloyd Formation, Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a].

STENOPECRINUS species

Figure 5.2

Discussion.—A form described as *Delocrinus* aff. *D. subhemisphericus* Moore & Plummer by Washburn (1968, p. 125) has been examined by one of us (Strimple) and is here referred to the genus *Stenopecrinus*. The single anal plate preserved has 2 high-angled facets at its distal end as found in the primanal (radianal) of pirasocrinids. The thin primibrachs *1* are identical with those of *Anchicrinus rugosus* (Strimple, 1961), from the lower part of the Wapanucka Formation of Oklahoma. The Utah specimen (BYU 1491) is reported to be from the Bridal Veil Falls Member, Oquirrh Formation (Morrowan) in Provo Canyon, near Provo.

Genus SCIADIOCRINUS Moore & Plummer, 1938

Type Species.—*Zeacrinus (Hydreionocrinus) acanthophorus* Meek & Worthen, 1870, p. 28.

Diagnosis.—Cup low, with broad shallow to deep basal concavity; infrabasals subhorizontal to gently downflaring; basals downflaring to subhorizontal, not visible in side view of cup (save elongated *CD* basal); radial plates bulging, reaching to basal plane; posterior interray narrow. Arms uniserial, branching isotomously more than once.

Discussion.—The downflared basals, which are confined to the basal invagination, and bulbous radials serve to distinguish this genus from other pirasocrinids.

Occurrence.—Pennsylvanian (Morrowan-Virgilian); USA (Illinois, Texas, Oklahoma, Kansas).

SCIADIOCRINUS CASCUS Moore & Strimple, new species

Plate 22, figures 1a-d

Diagnosis.—Characters of genus, with sharp-angled pentagonal outline, broad shallow basal concavity, and longitudinally very convex radials.

Descriptions.—This species is the oldest ascribed to the genus. The holotype is somewhat disarticulated in the basal region but is well preserved and shows all essential features of *Sciadiocrinus*. The discoid cup has a moderately deep basal invaginatio. The radials are dominant cup elements and enter the basal concavity. Articular facets are at high angles, plenary, and strongly declivate. The very narrow posterior interray contains 3 narrow and elongated anal plates. The surface of the cup plates is covered by small granules.

Dimensions.—Measurements of the holotype (SUI 33183) in millimeters are: width of cup, 23.8; height, 2.6; width of infrabasal circlet, approximately 7.4; width of *DE* basal, 3.6; width of *E* radial, 13.9; length, 5.5.

Discussion.—This Lower Pennsylvanian species most closely resembles *Sciadiocrinus harrisae* Moore & Plummer (1940) from Middle Pennsylvanian (Desmoinesian) beds in north-central Texas. The form here described and figured has a shallower basal concavity, less bulbous radials, and notably smaller interradial notches than observed in *S. harrisae*.

Holotype.—SUI 33183, collected by L. R. Laudon.

Occurrence.—Brentwood interval, Bloyd Formation,

at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma [Loc. 8].

SCIADIOCRINUS CRASSACANTHUS? Moore & Plummer, 1938
Plate 23, figure 4

Discussion.—The specimen represented here consists of the terminating platform of an anal sac composed of small polygonal plates surrounded by 7 outwardly directed spines with broad bases. *Sciadiocrinus* typically has a platform composed of smaller, more numerous plates and perimeter spines are more numerous. The species *S. crassacanthus?* was proposed on disarticulated terminating spine-plates and close comparison is not undertaken.

Figured Specimen.—OU 7123.

Occurrence.—Sutherland & Henry Loc. 29 "A," interval 84.7 to 72.7 feet below top of Cookson Member, lower part of Brentwood interval, Bloyd Formation, at Greenleaf Lake Youth Camp southeast of Braggs, Muskogee County, Oklahoma [Loc. 37].

Genus PERIMESTOCRINUS Moore & Plummer, 1938

[*Perimestocrinus* Moore & Plummer, 1938, p. 281]

Type Species.—*Hydreionocrinus nodulifer* Miller & Gurley, 1894, p. 41.

Diagnosis.—Cup moderately deep crateriform with subvertical upper sides curved slightly inward at summit, base distinctly and somewhat narrowly concave, radial articular facets peneplenary, with well-marked interradial notches, gently to rather strongly declivate; three anal plates in relatively wide posterior interray. Anal sac unknown. Arms recti-uniserial, branching isotomously on primibrachs *1* in all rays. Stem round transversely.

Discussion.—*Perimestocrinus* is much less common in Morrowan (two described species) than in younger strata (20 or more species). Although yet incompletely known, the genus is easily differentiated from other pirasocrinids and thus is identifiable with confidence.

Occurrence.—Lower Pennsylvanian (Morrowan)-Lower Permian (Wolfcampian); USA (Missouri-Kansas-Arkansas-Oklahoma-Texas).

PERIMESTOCRINUS TENERIS Moore & Plummer, 1938
Plate 12, figures 3a-d

Description.—Small cup, deep bowl-shaped with a small basal concavity. Slightly downflared infrabasals occupy the floor of the concavity and internally form a small domelike structure. Basals extend well up on sides of the cup and proximal ends of radials are well above the basal plane of the cup. Three anal plates in normal (primitive) arrangement occur in the *CD* interray.

Discussion.—The shape and structure of the cup of *Perimestocrinus teneris* are very similar to those of *P. nodulifer*, type species of the genus, except for a nodose development of plate surfaces found on the latter. *P. teneris* can readily be inferred to belong in the lineage leading to most typical species of *Perimestocrinus* as well as to typical *Stenopecrinus*. Morrowan species assigned to *Stenopecrinus* are atypical of that genus in having broad shallow cups.

Figured Hypotype.—SUI 33190, collected by R. C. Moore.

Occurrence.—Holotype (UKMIP 45221), Brentwood Limestone, Bloyd Formation, road cut on U.S. Highway 71, opposite Woolsey, Washington County, Arkansas [Loc. 3]; hypotype (SUI 33190), Brentwood interval, Bloyd Formation, at base of Greenleaf Lake spillway, southeast of Braggs, Muskogee County, Oklahoma [Loc. 8a].

Superfamily TEXACRINACEA Moore & Strimple, new superfamily

[*nom. transl.* Moore & Strimple, herein (*ex* Texacrinidae Strimple, 1961)]

Type Genus.—*Texacrinus* Moore & Plummer, 1940.

Diagnosis.—Crown tall and slender; cup bowl-shaped, with basal concavity and steep sides near rim,

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EXPLANATION OF PLATE 23

Morrowan species of inadunate crinoids—*Affinocrinus*, *Stenopecrinus*, and *Sciadiocrinus*.

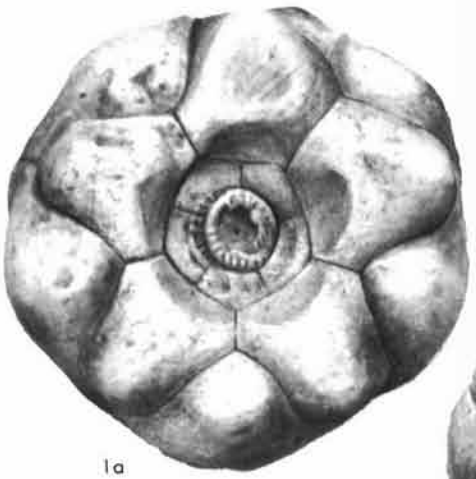
FIGURE

1-2. *Affinocrinus progressus* Moore & Strimple, new species; 1a-d, dorsal, anterior, ventral, and posterior views of paratype (SUI 33240) from Brentwood interval, Bloyd Formation, 1 mile south of Muskogee, Muskogee County, Oklahoma, ×5; 2a,b, posterior and dorsal views of paratype (SUI 33135) from same beds as 1, at Greenleaf Lake spillway southeast of Braggs, Muskogee County, Oklahoma, ×5.

3a-d. *Stenopecrinus ornatus* Moore & Strimple, new species, dorsal, posterior, ventral, and anterior views of hypotype (SUI 33187) from same beds and locality as 2a,b, ×5.

4. *Sciadiocrinus crassacanthus?* Moore & Plummer, 1938, summit view of anal sac showing peripheral spines (OU 7123) from lower part of Morrowan beds at Greenleaf Lake Youth Camp, southeast of Braggs, Muskogee County, Oklahoma, ×1.5.

5a-d. *Affinocrinus politus* Moore & Strimple, new species, dorsal, posterior, anterior, and ventral views of holotype (SUI 33295) from Brentwood interval, Bloyd Formation at abandoned quarry on east shore of Ft. Gibson Reservoir, Cherokee County, Oklahoma, ×4.6.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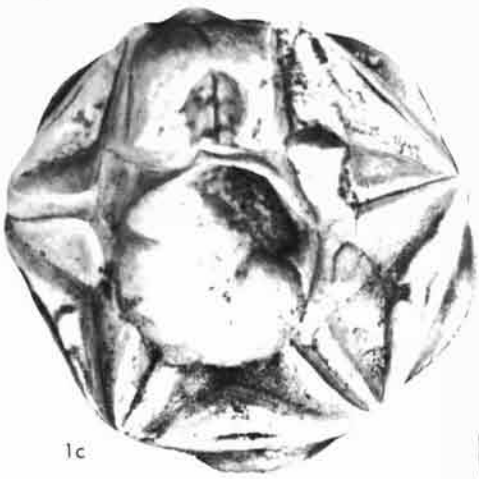
1b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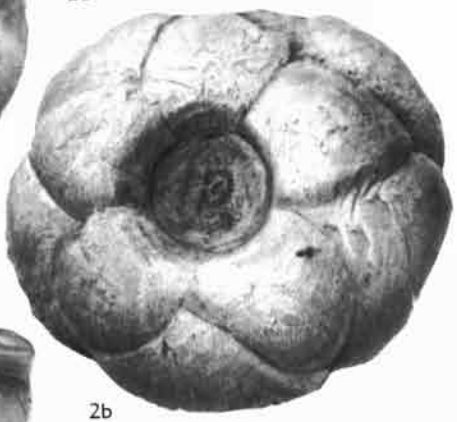
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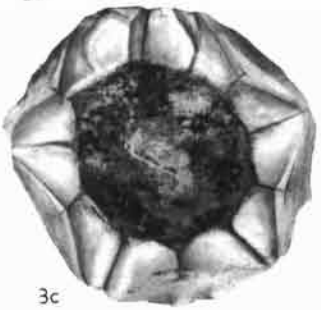
3a


3b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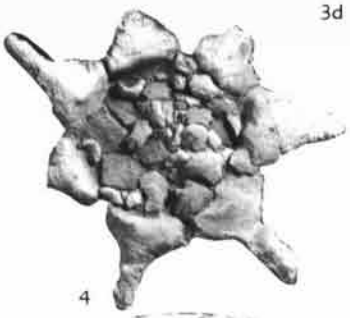
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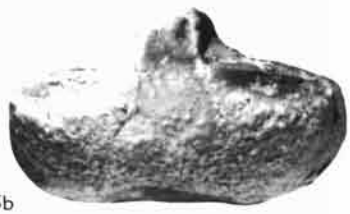
5a


5b


5c


5d

arm facets plenary, one to three anal plates in cup; anal sac tall, composed of longitudinal rows of thick plates; arms long, commonly many (to 40) but five or ten in some genera.

Discussion.—Includes Texacrinidae Strimple, 1961; Galateacrinidae Knapp, 1969; Sellardsicrinidae Strimple & Watkins, 1969; Cymbiocrinidae Strimple & Watkins, 1969; and Staphylocrinidae Moore & Strimple, n. fam.

Occurrence.—Upper Mississippian (Chesteran)-Lower Permian (Wolfcampian).

Family CYMBIOCRINIDAE Strimple & Watkins, 1969

[Cymbiocrinidae Strimple & Watkins, 1969, p. 188]

Type Genus.—*Cymbiocrinus* Kirk, 1944, p. 233.

Diagnosis.—Crown medium in height, with ten or five uniserial erect arms. Cup broadly truncate conical or bowl-shaped flat-based or with basal concavity; infrabasals not visible from side; radial articular facets equal in width to summit of these plates; single anal plate (?radianal) in cup. Anal sac cylindrical, tall, composed of few longitudinal rows of polygonal plates. Arms uniserial well rounded, pinnulate, in ten-armed genera invariably branching isotomously on primibrach 2. Stem transversely round or pentagonal, bearing long slender cirri directed obliquely upward.

Occurrence.—Upper Mississippian (Meramecian)-Middle Pennsylvanian (Desmoinesian).

Genus PROALLOSOCRINUS Moore & Strimple, new genus

Type Species.—*Proallosocrinus glenisteri* Moore & Strimple, new species.

Diagnosis.—Cup moderately deep, bowl-shaped, with pronounced but shallow basal invagination; infrabasals gently downflared; single primanal plate resting evenly on horizontal distal edge of *CD* basal and truncated above for reception of one or two tube plates. Arms 10, robust, recti-uniserial, branching isotomously on primibrachs 2.

Discussion.—*Proallosocrinus* apparently is a descendant of *Cymbiocrinus* Kirk through increase in size and height of the cup, increase in size of basals, and change of the primanal from an oblique contact with the *CD* basal to a straight horizontal one. *Allosocrinus* presumably was derived from *Proallosocrinus* through reduction of the arms from 10 to five.

Aesiocrinus secundus Washburn (1968), *Cymbiocrinus anatonis* Washburn (1968), (Pl. 19, fig. 1), and *C. cuneatus* Washburn (1968), from the Morrowan of Utah are considered to be congeneric with *Proallosocrinus* and are here referred to *Proallosocrinus secundus* (Washburn) Moore & Strimple, new combination, *P. anatonis* (Washburn) Moore & Strimple, new combination, and *P. cuneatus* (Washburn) Moore & Strimple, new combination. The three species described by Washburn may be conspecific.

Occurrence.—Lower Pennsylvanian (Morrowan); USA (Oklahoma, Utah).

PROALLOSOCRINUS GLENISTERI Moore & Strimple, new species

Plate 9, figures 2a-e

Description.—The holotype (SUI 33404) is a large, handsome crown with massive arms and a robust cup, which is low, truncate bowl-shaped with a large but shallow basal concavity and deeply impressed sutures. Five infrabasals are gently downflared next to the stem attachment area but distal ends curve to a subhorizontal attitude; proximal extremities of basals curve into the basal invagination, distal portions being turned upward to midheight of the cup; the radials are very large, with proximal ends well above the basal plane of the cup, the contact of these plates with primibrachs *1* is widely gaped, although radials and primibrachs touch closely along the transverse ridge; outer ligament pit large and wide, thin lateral furrows on the inner side of transverse ridge are separated by oblique ridges extending almost to the intermuscular furrow and another set of longer lateral fossae lies behind the oblique ridges, leaving long slender muscle areas next to the body cavity; primanal plate large, reaching well above the radial summits and widening slightly distalward, truncated for contact with a single large tube plate above. Arms 10, branching on primibrachs *2* in all rays, secundibrachs wide with well rounded exteriors, pinnules on alternating sides of successive brachials, ambulacral grooves relatively small. Columnar cicatrix small, circular. The entire crown is covered by minute granules.

Dimensions.—Measurements of the holotype in millimeters are as follows (W for width and H for height or length): crown (as preserved), H-75.3; dorsal cup (maximum), W-31.4, dorsal cup (posteroanterior), W-30.2; dorsal cup, H-11.0; infrabasal circlet, W-9.4; *DE* basal, W-11.2, H-10.0; *E* radial, W-15.9, H-9.4; anal plate, W-6.9, H-8.4; stem impression, W-3.2.

Discussion.—This species is more advanced in nature of the anal plate (i.e., anal followed by one tube plate) than either *Proallosocrinus secundus* (Washburn), *P. anatonis* (Washburn), or *P. cuneatus* (Washburn), in all of which the anal plate does not extend above the radial summits and possesses 2 distal low-angled facets for reception of tube plates. As previously noted, the 3 Utah crinoids may be conspecific.

Types.—Holotype crown (SUI 33404), paratype radial plate (SUI 35431), and paratype arm segment (SUI 35432), collected by B. F. Glenister.

Occurrence.—Gene Autry Formation, Carter County, Oklahoma [Loc. 34].

REFERENCES

All cited references may be found in Bassler, R. S., & Moodey, M. W., 1943, *Bibliographic and faunal index of Paleozoic pelmatozoan echinoderms*: Geol. Soc. America, spec. paper, 45, 734 p., with the following exceptions:

Adams, G. I., & Ulrich, E. O., 1905, *Description of the Fayetteville Quadrangle* [Ark.-Mo.]: U.S. Geol. Survey Geol. Atlas, Folio 119.

Henbest, L. G., 1953, *Morrow Group and lower Atoka Formation of Arkansas*: Am. Assoc. Petroleum Geologists, Bull., v. 37, p. 1935-1953.

———, 1962a, *Type sections for the Morrow series of Pennsylvanian age, and adjacent beds, Washington County, Arkansas*: U.S. Geol. Survey, Prof. Paper 450-D, p. D38-41.

———, 1962b, *New members of the Bloyd Formation of Pennsylvanian age, Washington County, Arkansas*: Same, Prof. Paper 450-D, p. D42-44.

Knapp, W. D., 1969, *Declinida, a new order of late Paleozoic inadunate crinoids*: Jour. Paleontology, v. 43, p. 340-391, pl. 61, 62.

Lane, N. G., 1964, *New Pennsylvanian crinoids from Clark County, Nevada*: Jour. Paleontology, v. 38, p. 677-684, pl. 112.

Manger, W. L., 1971, *The stratigraphy of the Hale Formation (Morrowan) in its type region, northwestern Arkansas*: Ph.D. Thesis, Univ. Iowa, 150 p.

Mather, Kirtley F., 1915, *The fauna of the Morrow Group of Arkansas and Oklahoma*: Denison Univ., Jour. Sci. Labs., v. 18, p. 59-284, 16 pl.

Moore, C. A., 1947, *The Morrow Series of northeastern Oklahoma*: Okla. Geol. Survey, Bull. 66, 151 p., 15 pl., 8 fig.

Moore, R. C., 1952, *Crinoids*: in R. C. Moore, C. G. Lalicker, & A. G. Fischer, Invertebrate fossils (1st edit., xiii + 766 p.), McGraw-Hill, New York, Toronto, London, p. 604-652, text fig. 16-21.

———, & Laudon, L. R., 1942, Megaliocrinus, *a new camerate crinoid genus from the Morrow Series of northeastern Oklahoma*: Denison Univ. Bull., Jour. Sci. Labs., v. 37, p. 1-76, fig. 1-5.

———, & ———, 1943, *Evolution and classification of Paleozoic crinoids*: Geol. Soc. America, spec. paper 46, 167 p., fig. 1-18, pl. 1-16.

———, & Strimple, H. L., 1969, *Explosive evolutionary differentiation of unique group of Mississippian-Pennsylvanian camerate crinoids (Acrocrinidae)*: Univ. Kansas Paleont. Contrib., paper 39, p. 1-44, fig. 1-24.

Morgan, G. D., 1924, *Geology of the Stonewall Quadrangle, Oklahoma*: Bureau Geology, Bull. 2, 248 p., 33 pl.

Purdue, A. H., 1907, *Description of the Winslow Quadrangle* [*Ark. Indian Terr.*]: U.S. Geol. Survey Geol. Atlas, Folio 154.

Rowett, C. L., & Sutherland, P. K., 1964, *Biostratigraphy and rugose corals of the lower Wapanucka Formation in Oklahoma*: Okla. Geol. Survey, Bull. 104, 124 p., 9 pl.

Simonds, F. W., 1891, *The geology of Washington County, Arkansas*: U.S. Geol. Survey, Ann. Report, 1888, v. 4, p. 1-148, 2 pl., 6 text fig.

Strimple, H. L., 1951, *Some new species of Carboniferous crinoids*: Bull. Am. Paleontology, v. 33 (137), 40 p., 5 pl.

———, 1960, *The genus* Paragassizocrinus *in Oklahoma*: Okla. Geol. Survey, circ. 55, 35 p., 3 pl.

———, 1961, *Late Desmoinesian crinoid faunule from Oklahoma*: Okla. Geol. Survey, Bull. 93, 189 p., 19 pl.

———, 1961, *New species of* Bronaughocrinus *and* Stuartwellercrinus *from the Carboniferous of Oklahoma*: Okla. Geol. Survey, Okla. Geol. Notes, v. 21, p. 186-189, pl. 1.

———, & Knapp, W. D., 1966, *Lower Pennsylvanian fauna from eastern Kentucky, Part 2. Crinoids*: Jour. Paleontology, v. 40, p. 309-314, pl. 36.

———, & Moore, R. C., 1971a, *Crinoids of the LaSalle Limestone (Pennsylvanian) of Illinois*: Univ. Kansas Paleont. Contrib., Art. 55, 48 p., 23 pl.

———, & ———, 1971b, in H. L. Strimple, *et al., Fossil crinoid studies, Part 1, The family Diphuicrinidae*: Same, Paper 56, p. 2-9, fig. 1-3.

———, & Watkins, W. T., 1969, *Carboniferous crinoids of Texas with stratigraphic implications*: Palaeont. Americana, v. 6 (40), 275 p., pl. 30-56.

Taff, J. A., 1905, *Description of the Tahlequah Quadrangle* [*Indian Terr.-Ark.*]: U.S. Geol. Survey Geol. Atlas, Folio 122.

Washburn, A. T., 1968, *Early Pennsylvanian crinoids from the south-central Wasatch Mountains of central Utah*: Brigham Young Univ., Geol. Studies, v. 15, p. 115-132, pl. 1-3.

Webster, G. D., & Lane, N. G., 1970, *Carboniferous echinoderms from the southwestern United States*: Jour. Paleontology, p. 276-296, pl. 55-58.

LOCALITY REGISTER

1. *Brentwood interval, Bloyd Formation*, Keough quarry (abandoned), sec. 36, T. 16 N., R. 19 E., about 2 miles north of Ft. Gibson, Cherokee County, Oklahoma (Moore & Plummer loc. 4519, 4520).
2. *Brentwood interval, Bloyd Formation*, Braggs Mountain, sec. 29, T. 15 N., R. 20 E., old highway replaced by new Oklahoma Highway 10, about 3 miles southeast of Ft. Gibson, Muskogee County, Oklahoma (Moore & Plummer loc. 4520).
3. *Brentwood Limestone*, on U.S. Hwy. 71, opposite Woolsey, Washington County, Arkansas (Moore & Plummer loc. 4522).
4. *Kessler Limestone*, Hale Mountain, 0.5 mile south of Washington County, Morrow, Arkansas (Moore & Plummer loc. 4527).
5. *Morrow Formation*, shaly member above heavy limestone, sec. 35, T. 16 N., R. 19 E., 1.5 mile north of Ft. Gibson, Cherokee County, Oklahoma.

6. *Brentwood Limestone*, center sec. 10, T. 16 N., R. 30 W., near northeast edge of Fayetteville, Washington County, Arkansas.
7. *Morrowan*, about 0.2 mile north of Iron Bridge at Woolsey, Washington County, Arkansas (Moore & Plummer loc. 4522a).
8. *Brentwood interval, Bloyd Formation*, near center sec. 10, T. 13 N., R. 20 E., spillway of Greenleaf Lake, Muskogee County, Oklahoma.
   a. Shale lentil at base of spillway.
   b. *Pentremites* zone in limestone about 6 feet above "a."
   c. Limestone and shale above "a" and "b."
9. *Brentwood interval, Bloyd Formation*, sec. 17, T. 19 N., R. 18 E., railroad cut near Union Mission, Mayes County, Oklahoma.
10. *Morrow Formation*, sec. 7, T. 17 N., R. 19 E., Flat Rock Creek, Wagoner County, Oklahoma.
11. *Shale slightly above Brentwood Limestone*, SE ¼ sec. 35, T. 13 N., R. 33 W., Evansville Mountain, about 3 miles east of south of Evansville, Washington County, Arkansas.
12. *Wapanucka Formation*, sec. 8, T. 1 N., R. 7 E., Canyon Creek, southeast of Fittstown, Pontotoc County, Oklahoma (Rowett & Sutherland loc. 3).
    a. Massive shale, lower part of Wapanucka (Rowett & Sutherland's Unit A).
    b. Limestone and brachiopod coquina, middle part of Wapanucka Formation (Rowett & Sutherland's Units E and F).
13. *Lower part of Wapanucka Formation*, NW ¼, SE ¼, SE ¼ sec. 8, T. 1 N., R. 7 E., northeast side of small knoll, Pontotoc County, Oklahoma (Morgan's loc. 28, Rowett & Sutherland's loc. 4-Unit A).
14. *Wapanucka Formation*, section line between sec. 4 and 9, T. 1 S., R. 8 E., west of Clarita, Coal County, Oklahoma.
15. *Middle part of Wapanucka Formation*, near center north line sec. 18, T. 1 S., R. 9 E., 2 miles east of Clarita, Coal County, Oklahoma (near Rowett & Sutherland's loc. 9, Unit C).
16. *Brentwood interval, Bloyd Formation*, SE ¼ sec. 22, T. 17 N., R. 19 E., abandoned quarry on east side of Grand River, east of Wagoner, Wagoner County, Oklahoma.
17. *Brentwood interval?, Morrowan*, sec. 29, T. 15 N., R. 20 E., 1 mile south of Muskogee, Muskogee County, Oklahoma.
18. *Brentwood interval?, Morrowan*, sec. 7, T. 18 N., R. 19 E., near Muskogee, Muskogee County, Oklahoma.
19. *Brentwood interval?, Morrowan*, sec. 12, T. 18 N., R. 18 E., near Muskogee, Muskogee County, Oklahoma.
20. *Morrowan*, 1 mile south of Choteau, Mayes County, Oklahoma.
21. *Morrowan*, bluff nearest stream east of bridge on south side of Big Frog Bayou, Windfry Valley, Crawford County, Arkansas.
22. *Wapanucka Formation*, Limestone Gap, north of Atoka, Atoka County, Oklahoma.
23. *Brentwood Limestone, Bloyd Formation*, Bloyd Mountain, 9 miles south of Fayetteville, Washington County, Arkansas.
24. *Upper part of Hale Formation*, sec. 15, T. 16 N., R. 30 W., House-of-Hess, south of Fayetteville, Washington County, Arkansas.
25. *Brentwood interval, Morrowan*, abandoned quarry south of Longhorn Landing, Tenkiller Lake, Sequoyah County, Oklahoma.
26. Gaitherites *zone, above Brentwood Limestone*, Gaither Mountain, south of Harrison, Boone County, Arkansas.
27. *Morrowan*, NE ¼ sec. 17, T. 14 N., R. 31 W., Sweetwater Creek, Washington County, Arkansas.
28. *Bloyd Formation*, east flank of Kessler Mountain, south of Fayetteville, Washington County, Arkansas.
29. *Bloyd Formation*, sec. 27, T. 18 N., R. 21 W., roadcut 8 miles south of Harrison, Boone County, Arkansas.
30. *Middle part of Wapanucka Formation*, NW ¼ sec. 19, T. 1 S., R. 9 E., east of Clarita, Coal County, Oklahoma.
31. *Upper part of Brentwood Limestone, Bloyd Formation*, State Hwy. 45 E in Fayetteville, Washington County, Arkansas (Mather's loc. 134).
32. *Lower part of Wapanucka Formation*, SE ¼ NW ¼ SE ¼ sec. 6, T. 1 S., R. 9 E., abandoned quarry east of Clarita, Coal County, Oklahoma.
33. *Lower part of Wapanucka Formation*, NE ¼ NW ¼ sec. 22, T. 2 S., R. 8 E., reservoir near Wapanucka, Johnson County, Oklahoma.
34. *Gene Autry Formation*, NW of center NW ¼ sec. 34, T. 3 S., R. 4 E., Carter County, Oklahoma.
35. *Morrowan*, 2 miles south of Hulbert, Cherokee County, Oklahoma.
36. *Morrow Formation* of Sutherland & Henry, "grainstone-shale member in lower part of Morrow Formation, collected from interval from 43.7 to 32.7 feet below top of Cookson Member"; N ½ sec. 34, T. 14 N., R. 22 E., southeast side of Buckhorn Mountain, Cherokee County, Oklahoma (Sutherland & Henry's loc. 39-4).
37. *Morrow Formation* of Sutherland & Henry, "interval 84.7 to 72.7 feet below top of Cookson Member, lower part of Morrow Formation"; secs. 2 and 3, T. 13 N., R. 20 E., Greenleaf Lake Youth Camp,

Muskogee County, Oklahoma (Sutherland & Henry's loc. 29 "A").

38. *Brentwood interval, Bloyd Formation*, NW ¼ SE ¼ sec. 35, T. 17 N., R. 19 E., Cherokee County, Oklahoma.
39. *Middle part of Wapanucka Formation*, NE ¼ NE ¼ sec. 30, T. 1 N., R. 8 E., Coal County, Oklahoma.
40. *Brentwood interval, Bloyd Formation*, SW ¼ NW ¼ sec. 35, T. 13 N., R. 20 E., west of Gore, Muskogee County, Oklahoma.
41. *Brentwood Limestone, Bloyd Formation*, 2 miles northwest of Brentwood, S ½ sec. 23, T. 14 N., R. 30 W., Washington County, Arkansas (Mather loc. 145).

INDEX

Explanation:——1) Superfamilies and higher-rank taxa are cited in boldface type.——2) Taxa recorded from Lower Pennsylvanian (Morrowan) are marked by a dagger (†) and type species of genera by an asterisk (*).