Some Crinoids from the Argentine Limestone (Late Pennsylvania-Missourian) of Southeastern Nebraska and Southwestern Iowa

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SOME CRINOIDs FROM THE ARGENTINE LIMESTONE
(LATE PENNSYLVANIAN-MISSOURIAN)
OF SOUTHEASTERN NEBRASKA AND SOUTHWESTERN IOWA

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Familial diversity of crinoids is relatively constant throughout the Missourian Series of southeastern Nebraska and southwestern Iowa. Beginning with the deposition of the Argentine Limestone, there appears to be an important increase in the number of crinoid specimens. The abundance of crinoids in older Missourian strata in other areas to the south suggests the presence of a pre-Argentine east-west ecological barrier that prevented the establishment of successful crinoid colonies in the Nebraska-Iowa area.

The Argentine crinoids of Nebraska and Iowa are quite similar to the lower crinoid fauna in the coeval Wann Formation of northeastern Oklahoma. Samples of Delocrinus hemisphericus (Shumard) from the Argentine of Iowa and the Wann of Oklahoma show crinoids of similar statistical parameters, suggesting they represent the same statistical population. The presence of Plummericrinus nettingi Burke in the Argentine of Iowa may help refine biostratigraphic correlations between Midcontinent Missourian strata and Appalachian Conemaugh units.

Bathronocrinus madisonensis n. sp. is described here.

INTRODUCTION

Although uncommon, crinoids in lower Missourian strata of Iowa and Nebraska show a high degree of diversity, and practically all of the Late Paleozoic inadunate families are represented. Beginning with the deposition of the Argentine Limestone, there is a dramatic increase in the abundance of crinoids, and they become more important as a major component of the total fauna throughout the Missourian and Virgilian.

Crinoids utilized in this study were collected from 11 localities in Iowa, Nebraska, Kansas, Missouri, and Oklahoma. Most of the Iowa specimens were collected without regard to stratigraphic position within the Argentine Limestone. Thus, it is impossible in this case to relate crinoid species to their positions in cyclothems or to provide ecological interpretations based on cyclothemic models sensu Heckel and Buesemann (1975), or Heckel (1977). An alternative model is that of Stout (1978, Fig. 2). In the Nebraska samples stratigraphic position within the Argentine was recorded, and the crinoids were collected from near the base of the unit. Most of the specimens from Nebraska are small, inornate forms that one should expect to find near the core of the cyclothem. Most of the Iowa crinoids appear to be near-core species, but this cannot be ascertained.

The crinoids were collected from several quarries, the largest collection coming from the Schildberg Construction Company Quarry near Stanzel in Madison County, Iowa. A smaller Iowa sample was collected from a quarry near Greenfield in Adair County. Most Nebraska specimens were collected from the abandoned Cedar Creek Quarry near Louisville, in Cass County, and a single cup of Haeretocrinus missouriensis Moore and Plummer, 1940, was collected from an abandoned quarry in Washington County, Nebraska. Several specimens were collected from Kansas locations, and these are listed in the systematics.

BIOSTRATIGRAPHY

Correlation of Late Pennsylvanian units in the North American Midcontinent is complicated by strong provincialism of crinoid faunas (Pabian and Strimple, 1977), and by the fact that several traceable limestone units in Iowa, Nebraska, northwestern Missouri, and northeastern Kansas pinch out in southern Kansas. The Argentine Limestone Member of the Wyandotte Formation pinches out just south of the Kansas River, near Lane, and the Plattsburg limestones pinch out near T. 30 S. in southern Kansas (Moore, 1949). (See Fig. 1.)
Thus, crinoids of the Argentine Limestone of Nebraska and Iowa are of considerable importance since they are very similar to the lower crinoid fauna occurring in the Wann Formation of northeastern Oklahoma (Figs. 1 and 2). The older Wann crinoid fauna is found at the Mound west of Bartlesville (Fig. 2, Locality 9) and at the airport road-cut (Fig. 2, Locaion 10) in Osage County, Oklahoma. The upper part of this crinoidal zone also crops out in the E½ S½ Sec. 22, T. 25 N., R. 12 E. near Ochelata. The younger Wann crinoid fauna occurs at the hairpin turn exposed in the S½ Sec. 15, T. 25 N., R. 12 E. Moore and Plummer (1940) indicated these beds to be Plattsburg equivalent, and Pabian and Strimple (1979) showed that *Ciblocrinus conicus* Strimple from this fauna was biometrically similar to *C. conicus* from the Plattsburg of Kansas. Thus, it is the older Wann crinoid assemblage that is of concern here. All crinoids listed in Table I occur in the Argentine Limestone of Nebraska and Iowa, and in the older Wann crinoid fauna of Oklahoma (Fig. 1). It is of interest to note that flexible crinoids, which make up an important constituent of the Wann crinoid assemblage, are virtually absent in the Nebraska-Iowa region. This is probably of provincial importance as indicated by the observations of Pabian and Strimple (1977:26; 1979:725).

Samples of *Delocrinus hemisphericus* (Shumard) from the Argentine Limestone of Iowa and Wann Shale of Oklahoma were examined biometrically (Table II; Fig. 3), and this shed some interesting light on the two assemblages in addition to rectilinear growth shown by specimens of both samples throughout the observed range. Although the Oklahoma sample was much larger and covered a greater observed range, the means and standard deviations were all very similar. Students’ *t*-test values for the two dimensions were low, suggesting no significant difference in means. *F*-distributions are probably more reliable to analyze large samples since *t* approaches the standard normal distribution as sample size increases. Group centroids for samples of *Delocrinus*

| TABLE I. Crinoids occurring in the Argentine Limestone of Nebraska and Iowa, and Wann Shale of northern Oklahoma. |
| Apographeocrinus typicalis* (Moore and Plummer, 1940) |
| Delocrinus hemisphericus* (Shumard, 1858) |
| Eriscocrinus obovatus* (Moore and Plummer, 1940) |
| *F*. *typus* Meek and Werthen, 1865 |
| Exocrinus multirami* Strimple, 1949 |
| Hydriocrinus turbinatus* (Strimple, 1971) |
| Laudonocrinus subsinuatus* (Miller and Gurley, 1894) |
| Parethelocrinus expansus* (Strimple, 1938) |
| Perimestocrinus nodulifer* (Miller and Gurley, 1894) |
| Plaxocrinus crassidiscus* (Miller and Gurley, 1890) |
| Stellarocrinus exsculptus* (Strimple, 1939) |
| Stenopeocrinus hexagonus* (Strimple, 1962) |
| *S*. *planus* (Strimple, 1952) |
| Terponocrinus ellipticus* Pabian and Strimple, 1974 |
| *Ulocrinus buttisi* Miller and Gurley, 1894 |
FIGURE 2. Index map showing localities from which crinoids treated in this study were collected. Localities:

<table>
<thead>
<tr>
<th>Location Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Schaldberg Construction Company Quarry, SE ¼ SE ¼ Sec. 17, T. 22 N., R. 31 N., Adair County, Iowa.</td>
</tr>
<tr>
<td>2</td>
<td>Schaldberg Construction Company Quarry, SE ¼ SW ¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.</td>
</tr>
<tr>
<td>3</td>
<td>Cedar Creek Quarry, SW ¼ SW ¼ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.</td>
</tr>
<tr>
<td>4</td>
<td>Ash Grove Cement Company Quarry, NE ¼ NE ¼ Sec. 14, T. 12 N., R. 11 E., Cass County, Nebraska.</td>
</tr>
<tr>
<td>5</td>
<td>Clark Construction Company Quarry, W ½ SE ½ SE ½ Sec. 28, T. 17 N., R. 13 E., Washington County, Nebraska.</td>
</tr>
<tr>
<td>6</td>
<td>Inland Drive, Kansas City, Missouri (R. C. Moore Location, no legal description given).</td>
</tr>
<tr>
<td>7</td>
<td>Lone Star Cement Company Quarry, northeast of Bonner Springs, Kansas.</td>
</tr>
<tr>
<td>8</td>
<td>Monarch Cement Company Quarry, NE ¼ Sec. 2, T. 25 S., R. 18 E., Allen County, Kansas.</td>
</tr>
<tr>
<td>9</td>
<td>The Mound, SW ¼ Sec. 4, T. 26 N., R. 12 E., Osage County, Oklahoma.</td>
</tr>
<tr>
<td>10</td>
<td>Airport Road-cut, NW ¼ SW ¼ Sec. 6, T. 26 N., R. 12 E., Osage County, Oklahoma.</td>
</tr>
<tr>
<td>11</td>
<td>Hairpin Turn, S ½ Sec. 15, T. 25 N., R. 12 E., Osage County, Oklahoma.</td>
</tr>
</tbody>
</table>
**PALEOECOLOGY**

Our collections contain crinoid faunas from the older Winterset and Westerville, and Raytown limestones of Nebraska and Kansas. It is of interest to point out that the largest of these faunas is from the Winterset Limestone. The lower Missourian Winterset crinoids still show affinities to Desmoinesian crinoids. The number of crinoids in the older pre-Argentine Missourian units is quite small. With the advent of the deposition of the Argentine Limestone in Nebraska and Iowa, and the Wann Formation in Oklahoma, there is a dramatic increase in the number of crinoids. Our collections indicate that familial diversity of crinoids was already established by the beginning of the Missourian, but such diversity is built around families and genera held over from the Desmoinesian. It is not only in Nebraska and Iowa that crinoids begin large population increases in Argentine time. In southeastern Kansas and northeastern Oklahoma, crinoids are relatively few until the deposition of the Wann shales. Crinoids are relatively rare in the Hosgoshooter, Dewey, and Avant formations. Crinoids are abundant in the LaSalle Limestone of Illinois, which is of about the same age as the Avant of Oklahoma, and in the Iola Limestone of Nebraska and Kansas. This may suggest that conditions that favored increases in crinoids began in the east and moved rapidly westward and southward.

**MATERIALS AND REPOSITORIES**

Crinoid specimens reported in this study are reposited in the University of Nebraska State Museum, Lincoln (UNSM); University of Iowa Geological Collections, Iowa City, Iowa (SUI); the United States National Museum of Natural History, Smithsonian Institution, Washington, D.C. (NMNH); Carnegie Museum, Pittsburgh, Pennsylvania (CM); Cleveland Museum of Natural History, Cleveland, Ohio (CMNH); Illinois Geological Survey, University of Illinois, Champaign-Urbana (IGS); and Field Museum of Natural History, Chicago, Illinois (UC).

Localities from which crinoid materials reported in this study were collected are shown in Figure 2.

---

hemisphericus from both areas were determined (Table II). The determination of F is given by the formula:

\[
F = \frac{\left| \begin{array}{cc} N_1 & 0 \\ 0 & N_2 \end{array} \right|}{N_1 + N_2 - 2} \times D^2
\]

where \(N_1\) and \(N_2\) are the numbers of each sample and \(D^2\) is Mahalanobis distance (Davis, 1973:451-452). \(D^2\) is calculated from the formula:

\[
D^2 = \frac{\lambda X (X_1 - X_2) + \lambda Y (Y_1 - Y_2)}{2}
\]

where \(\lambda X\) and \(\lambda Y\) are derived from the relationship

\[
S_{XX} \lambda Y + S_{XY} \lambda Y = d_{X} = X_1 - X_2
\]

\[
S_{XY} \lambda X + S_{YY} \lambda Y = d_{Y} = Y_2 - Y_1
\]

The calculated values of \(S_{XX} = 18.09, S_{XY} = 5.73\) and \(S_{YY} = 2.09\) can be placed into (ii) above and

\[
1.809 \lambda X + 5.73 \lambda Y = 14.24 - 14.76 = -0.52
\]

\[
5.73 \lambda X + 2.09 \lambda Y = 4.98 - 5.20 = -0.22
\]

Normalizing for \(\lambda Y\), and solving (iii), we get

\[
3.16 \lambda X + \lambda Y = -0.09
\]

\[
-2.74 \lambda X - \lambda Y = 0.11
\]

\[
0.42 \lambda X = 0.02
\]

or \(\lambda X = 0.05\) and \(\lambda Y = -0.24\)

Then \(D^2\), from (ii) above is

\[
D^2 = 0.05 (14.24 - 14.76) + (0.24) (4.98 - 5.20)
\]

or \(D^2 = 0.027\)

and from (i) \(F = \frac{\left| \begin{array}{cc} 36 + 247 - 3 \end{array} \right|}{36 + 247 - 2} \times 0.027 = 0.42\)

At a 5% level of significance, \(F = 3.00\). The calculated \(F_{Y} = 0.42\) shows no significant difference between the two samples; thus, we conclude that the two samples of Delocrinus hemisphericus are from the same statistical population.

We suggest that the crinoid fauna of the Argentine Limestone of Madison County, Iowa, is the equivalent of the older crinoid fauna in the Wann Shale of Oklahoma. Moore (1949) has shown that the Argentine Limestone, indeed all of the Wyandotte limestones, pinches out south of the Kansas River in Kansas, and that the Plattsburg Limestone is underlain by the Lane-Bonner Springs Shale sequence (Fig. 1). Although similar crinoid faunas may occur in Iowa, Nebraska, Kansas, and Oklahoma, in strata of Argentine through Plattsburg ages, these faunas, of necessity, will be found in differing lithologies in the northern and southern outcrop areas.
TABLE II. Univariate and bivariate statistics for measurements of *Delocrinus hemisphericus* from the Argentine Limestone of southwestern Iowa, and the Wann Shale of northeastern Oklahoma.

### UNIVARIATE DATA

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Observed Range (mm)</th>
<th>Standard Deviation</th>
<th>Mean</th>
<th>N</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of Cup (D&lt;sub&gt;PA&lt;/sub&gt;)</td>
<td>8.2 - 22.3</td>
<td>3.809</td>
<td>14.36</td>
<td>37</td>
<td>Iowa Sample</td>
</tr>
<tr>
<td>Height of Cup (H&lt;sub&gt;A&lt;/sub&gt;)</td>
<td>2.5 - 8.2</td>
<td>1.444</td>
<td>4.97</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>D&lt;sub&gt;PA&lt;/sub&gt;</td>
<td>3.0 - 22.8</td>
<td>4.312</td>
<td>14.79</td>
<td>247</td>
<td>Oklahoma Sample</td>
</tr>
<tr>
<td>H&lt;sub&gt;A&lt;/sub&gt;</td>
<td>1.5 - 8.0</td>
<td>1.448</td>
<td>5.18</td>
<td>246</td>
<td></td>
</tr>
</tbody>
</table>

### COMPARISON OF MEANS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Degrees Freedom</th>
<th>Students' t</th>
</tr>
</thead>
<tbody>
<tr>
<td>D&lt;sub&gt;PA&lt;/sub&gt;</td>
<td>316</td>
<td>.589</td>
</tr>
<tr>
<td>H&lt;sub&gt;A&lt;/sub&gt;</td>
<td>283</td>
<td>.790</td>
</tr>
</tbody>
</table>

### BIVARIATE DATA

<table>
<thead>
<tr>
<th>Paired Dimensions</th>
<th>N</th>
<th>r</th>
<th>Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>H&lt;sub&gt;A&lt;/sub&gt;/D&lt;sub&gt;PA&lt;/sub&gt;</td>
<td>36</td>
<td>.965</td>
<td>H&lt;sub&gt;A&lt;/sub&gt; = .358D&lt;sub&gt;PA&lt;/sub&gt; - .164 Iowa</td>
</tr>
<tr>
<td>H&lt;sub&gt;A&lt;/sub&gt;/D&lt;sub&gt;PA&lt;/sub&gt;</td>
<td>247</td>
<td>.929</td>
<td>H&lt;sub&gt;A&lt;/sub&gt; = .311D&lt;sub&gt;PA&lt;/sub&gt; + .598 Oklahoma</td>
</tr>
</tbody>
</table>

**FIGURE 3.** Scatter diagram showing paired dimensions H<sub>A</sub> and D<sub>PA</sub> for cups of *Delocrinus hemisphericus* from Stanzel, Iowa, and Bartlesville, Oklahoma.
TABLE III. Measurements of Bathronocrinus madisonensis.*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Holotype SUI 38165 (mm)</th>
<th>Paratype UNSM 16891 (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of cup, posterior-anterior</td>
<td>11.5</td>
<td>13.8</td>
</tr>
<tr>
<td>Anterior height of cup</td>
<td>4.2</td>
<td>5.2</td>
</tr>
<tr>
<td>Diameter of infrabasal circlet, $D_{IBB}$</td>
<td>4.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Length of AB basal</td>
<td>2.9</td>
<td>4.0</td>
</tr>
<tr>
<td>Width of AB basal</td>
<td>3.7</td>
<td>5.0</td>
</tr>
<tr>
<td>Length of A radial</td>
<td>3.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Width of A radial</td>
<td>7.2</td>
<td>8.5</td>
</tr>
</tbody>
</table>

*Measurements from Pabian and Strimple (1974b).

SYSTEMATIC PALEONTOLOGY

Phylum Echinodermata Laske, 1778
Subphylum Crinozoa Matsumuto, 1929
Class Crinoidea Miller, 1821
Subclass Inadunata Wachsmuth and Springer, 1885
Order Cladida Moore and Laudon, 1943
Suborder Poteriocrinina Jaekel, 1918
Superfamily Cromyocrinacea Bather, 1890
Family Cromyocrinidae Bather and May, 1890
Genus Aglaocrinus Strimple, 1961

Type species: Ethelocrinus magnus Strimple, 1949.

Diagnosis

Cup broad, rather low, with shallow or no basal concavity and broad, subhorizontal infrabasal disk. Two anal tubes in cup. Basals 5; radials 5, separated in CD interray by radianal and anal plates. Surface mildly ornamented, sutures deeply impressed. Arms biserial, more than 10, branching in first primibrachial.

Other species included: Aglaocrinus periodus (Strimple, 1949); A. iatani (Strimple, 1949); A. expansus (Strimple, 1938); A. compactus (Moore and Plummer, 1940); A. pustulosus (Moore and Plummer, 1940); A. rectilatus Lane and Webster, 1966; A. keyrei Strimple and Moore, 1973; A. multiramus (Strimple, 1961); A. meadowensis (Strimple, 1961); A. supplantus Pabian and Strimple, 1974.

Range: Pennsylvanian (Desmoinesian–Virgilian). USA: Texas, Oklahoma, Kansas, Nebraska, Iowa, and Colorado.

Aglaocrinus pustulosus (Moore and Plummer, 1940)
Strimple, 1961

Fig. 4D–F

Synonym:
Parulocrinus pustulosus Moore and Plummer, 1940

Description

This species is reported on the basis of a somewhat damaged cup that shows all of the characters of the holotype. Dorsal cup broad, low. Infrabasal circlet made up of 5 kite-shaped plates and confined to a shallow concavity. Columnar cicatrix round, deeply impressed, about one-half the diameter of the infrabasal circlet with about 35 crenellae and pentalobate lumen. Basals 5 AB, DE, and EA nearly regular pentagons; BC and CD irregular hexagons that accommodate anal plates; most proximal tip only in basal concavity; most of proximal portions of basals make up the basal plane of cup; basals rise upward in a circular arc to about two-thirds the cup height. Radials 5, epaulette-shaped; proximal tips reach halfway to cup base. Cross-section of radials parabolic, curving strongly inward near cup summit. Radialan quadrangular; anal $X$ irregularly pentagonal, resting on truncated CD basal. Cup plates ornamented with irregularly spaced pustules. Plate sutures deeply impressed.

Radial articular facets plenary, long A blunt, outer marginal-ridge is separated from outer ligament-ridge by wide,
FIGURE 4. Photographs of Nebraska and Iowa Argentine Limestone crinoids. A-C. *Parethelocrinus expansus* (Strimple); summit, posterior, and basal views; hypotype, SUI 38179, X3. D-F. *Aglaocrinus pustulosus* (Moore and Plummer); summit, posterior, and basal views; hypotype, SUI 38175, X2.5. G-I. *Parethelocrinus expansus* (Stirn pie); posterior, summit, and basal views; hypotype, UNSM 16916, X4. J-K. *Haerotocrinus missouriensis* Moore and Plummer; anterior and posterior views; hypotype, UNSM 16943, X2. L-M. *Stellarocrinus exsulcatus* (Strimple); basal and posterior views; hypotype, SUI 38178, X2.
shallow outer ligament-furrow. Ligament-pit furrow wide, hollow, separated by a very deep ligament-pit. Transverse ridge low, denticulate. Lateral ridge low and adustral slope is about 45°. Lateral lobes parabolic, merging into deep intramuscular notch that connects to a small central pit by a short intramuscular furrow. Muscle areas gently concave.

Material studied: Hypotype: SUI 38175, Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

Genus Parethelocrinus Strimple, 1961

Type species: Parethelocrinus ellipticus Strimple, 1961.

Diagnosis

Cup broad, rather low with shallow or no basal concavity and broad, subhorizontal infrabasal disk; 2 anal plates in cup; 10 or more arms bifurcating in proximal portions; surface smooth to granular; sutures not deeply impressed.

Other species included: Parethelocrinus millsapensis (Moore and Plummer, 1940); P. plattsburgensis (Strimple, 1938); P. varibilis (Strimple, 1949); P. watkinsi (Strimple, 1949).

Range: Pennsylvanian (Morrowan-Virgilian) and "Permian" (Wolfcampian). USA: Nevada, Texas, Oklahoma, Kansas, Missouri, Nebraska, and Iowa.

Parethelocrinus expansus (Strimple, 1938)

Fig. 4A-C, G-I

Description

Cup low and nearly discoid with an almost flat base. Infrabasal circllet has 5 kite-shaped plates separated by distinct sutures. The columnar cactrix is deeply impressed, crenulated, with a pentalobate lumen. AB, DE, and EA basals pentagonal; BC and CD basals hexagonal, to accommodate rectangular radianal and anal X plates. Proximal portions of basals nearly flat but basals recurve in midsection, rising upward in a parabolic arc to about one-half the cup height. Five epaulette-shaped radials reach nearly to basal plane of cup and recurve inward near cup summit. C and D radials separated by narrow anal X plate, which is followed by small triangular right tube-plate.

PBrl plates axillary, pentagonal. A trapezoidal SBrl plate is preserved on the B ray.

Remarks

Parethelocrinus expansus may have a fairly short range zone. Our collections include specimens from the Westerville Limestone of Nebraska and Iowa, but our collections contain no specimens of P. expansus from units younger than the Argentine Limestone. The holotype was collected from the crinoidal horizon of the Wann Formation exposed at the Mound, SE¼ Sec. 3, T. 26 N., R. 12 E., just west of Bartlesville, Osage County, Oklahoma.

Material studied: Hypotypes: SUI 38179, Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. UNSM 16916, abandoned quarry, SW¼ SW¼ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

Family Ulocrinidae Moore and Strimple, 1973

Genus Ulocrinus Miller and Gurley, 1890

Type species: Ulocrinus buttsi Miller and Gurley, 1890.

Diagnosis

(Modified after Strimple and Watkins, 1969:165.) Dorsal cup medium, irregularly bowl-shaped with prominent up-flared infrabasals; 3 anal plates in older species, but typically only 2 anal plates; 10 biserial arms, outer surfaces smooth or ornate, stem round.


Range: Pennsylvanian (Atokan, Desmoinesian, Missourian, and Virgilian) and "Lower Permian." USA: Nebraska, Iowa, Missouri, Kansas, Oklahoma, Texas, Colorado, and Illinois. Upper Permian. Also: USSR, Indonesia (Timor), and Pakistan.

Remarks

Ulocrinus is known largely from infrabasal circllets and dissociated plates since the cup is normally large and loosely fitted together. It is well known throughout the Missourian of the Midcontinent.
**Ulocrinus kansasensis** Miller and Gurley, 1890

Fig. 5L–N

**Synonym:**
*Cromyocrinus kansasensis* Keyes, 1894

**Description**

This species is reported here from 2 hemispherical cups. The 5 infrabasals are kite-shaped and form an outwardly convex, saucerlike disk with a deeply impressed, crenulated columnar cicatrix with a pentalobate lumen. Basals large, forming about one-half the cup height; AB, DE, and EA six-sided; CD six-sided but modified; and BC heptagonal to accommodate radianal and anal X plates. Radianal is long, rectangular. Anal X tiny, barely separating C and D radials. A, B, D, and E radials epaulette-shaped, bulbous in middle and strongly recurved near cup summit; C radial is irregularly trapezoidal. Cup plates bulbous but inornate, sutures impressed.

Radial articular facets plenary, flat-lying, somewhat narrow. Outer ligament-area forms a shelf that abuts a sharp outer ligament-ridge that is separated from the finely denticulate transverse ridge by a deep ligament-pit furrow and ligament-pit. Lateral ridges and adsutural slopes of low relief. Muscle areas broad, slopes gently into a shallow central pit. The intermuscular notch and furrow are poorly defined. Facets wide, constricting summit opening to visceral cavity of cup.

**Remarks**

*Ulocrinus kansasensis* differs from *U. buttsi* in having a very large radianal plate, a diminished anal X plate, and a constricted summit opening to the cup cavity. The hemispherical cup cross-section and the constricted summit suggest affinities to *Ulocrinis sangamonensis*, and the evenly flared infrabasal circlet suggests affinities to *U. convexus*.

*Ulocrinus kansasensis* appears related most closely to *U. sangamonensis* (Meek and Worten, 1861), from which it differs largely in the nature of the anal X plate, that being diminutive and nearly expelled in the former and still prominent in the latter. The holotype of *U. kansasensis* was collected from the Argentine Limestone near Kansas City, Missouri. Our collections indicate that this species ranges as high as the basal Stoner limestone Member of the Stanton Formation.

**Material studied:** Hypotypes: SUI 38171, Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa, UNSM 13330, Kiewitz Shale Bed, Stoner Limestone Member, Stanton Formation, Ash Grove Cement Company Quarry, NE¼ NE¼ Sec. 14, T. 12 N., R. 11 E., Cass County, Nebraska.

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**Ulocrinus buttsi** Miller and Gurley, 1890

Fig. 5K

**Description**

This species is reported on the basis of a single, semi-ellipsoidal, badly crushed cup. Five infrabasals form a flaring cone—the proximal ends sloping at about 60° and the distal at about 30°. There is a somewhat impressed, crenulated columnar cicatrix. AB, BC, EA basal hexagonal; CD and DE basals heptagonal to accommodate rectangular radianal and pentagonal anal X plate. Five radials are epaulette-shaped, C being slightly smaller to accommodate radianal. Cup appears somewhat bulged near middle of basal circlet and to recurve inward in the radial circlet. Anal X five-sided, followed by a spear-shaped left tube-plate and having a facet for a right tube-plate. Cup plates smooth.

Radial articular facets plenary, probably flat-lying. Outer marginal-ridge is sharp, well defined, bordering a shallow but distinct outer ligament-furrow. Outer ligament-ridge denticulate, sharp, and separated from denticulated transverse ridge by a ligament-pit furrow and deep ligament-pit. Lateral ridge and adsutural slope small but lateral lobe tiny and extending to a deeply incised intermuscular notch. Muscle areas nearly flat. Central pit elevated and partially impressed on interior of transverse ridge.

**Remarks**

Current collections from Iowa, Nebraska, and Kansas suggest that the range zone of *Ulocrinus buttsi* is from the Winterset Limestone through the Argentine Limestone. *U. buttsi* occurs in the Hogshooter and Wann formations of Oklahoma. In Oklahoma the stratigraphic position as well as associated fauna suggest that the crinoidal zone in the Wann is of about Argentine age. Pabian and Strimple (1979:430) have indicated that the higher Wann crinoid zone near Ochelata, Oklahoma, is probably of Plattsburg age.

*Ulocrinus buttsi* occurs with several other species of *Ulocrinus*. *U. fistulosus* from the LaSalle of Illinois has a cuplike infrabasal circlet rather than flared. *U. convexus* has an evenly flared infrabasal circlet. *U. sangamonensis* has a low cup. *U. fistulosus* has bulbous plates that appear "stitched together," whereas *U. buttsi* has non-bulbous plates. *Ulocrinus kansasensis* has a diminished anal X plate.
FIGURE 5. Photographs of Nebraska and Iowa Argentine Limestone crinoids. **A-C. Retusoerinus laxus** (Strimple); summit, posterior, and basal views; hypotype, UNSM 16948, X2. **D-E. Sciadioerinus confertus** Moore and Plummer; summit and basal views; hypotype, UNSM 16969, X2. **F-H. Stenopecrinus impressus** Moore and Plummer; posterior, summit, and basal views; hypotype, UNSM 16919, X2. **I-J. Stenopecrinus hexagonus** Strimple; basal and summit views; hypotype, SUI 47101, X2. **K. Ulocrinus buttsi** Miller and Gurley; right lateral view; hypotype, SUI 38167, X1. **L-N. Ulocrinus kansasensis** Miller and Gurley; summit, basal, and posterior views; hypotype, SUI 38171, X2.
A large, crushed cup at hand (SUI 38167) adds no significant morphologic data regarding plate arrangement, cross-section, etc. It does have a large, six-sided anal X plate with 2 facets for receiving tube-plates. One five-sided left tube-plate is still intact and a thin, dislodged trapezoidal plate between the E and A radials may be tegminal in origin.

Material studied: Hypotype: SUI 38167, Schildberg Construction Company Quarry, SE 1/4 SW 1/4 Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

Superfamily Scytalocrinacea Moore and Laudon, 1943
Family Scytalocrinidae Moore and Laudon, 1943
Genus Haeretocrinus Moore and Plummer, 1940
Type species: Haeretocrinus missouriensis Moore and Plummer, 1940.

Diagnosis
(After Stimple and Moore, 1971a:23). Dorsal cup conical, truncate at point of stem attachment. Five infrabasals rise evenly, readily visible in side view; interradial sutures located in furrows, articular facets slope gently outward; 3 anal plates commonly Primitive Type B or Extreme Type (1) arrangement (see Strimple, 1960:250 and 251). Arms uni­serial, first bifurcation on primibrach 1 in all rays; thereafter they may branch exotomously two or more times. Anal sac large, long, recurved, with large anus about midway down on anterior side (e.g., H. wagneri Strimple and Moore, 1971). Stem round.

Other species included: Haeretocrinus magnus Moore and Plummer, 1940; H. depressus Strimple, 1962; H. turbinatus Strimple, 1962; H. washburni (Beede, 1899); H. macoupinensis (Worthen, 1873); H. wagneri Strimple and Moore, 1971.

Range: Pennsylvanian (Desmoinesian-Virgilian). USA: Illinois, Missouri, Oklahoma, Kansas, Texas, and Nebraska.

Haeretocrinus missouriensis Moore and Plummer, 1940

Description
This species is recorded from Nebraska on the basis of a single, compacted, medium cone-shaped dorsal cup with attached primibrachials. The infrabasal circlet is made up of 5 kite-shaped plates, the distal ends of which slope upwards at about 60°. The columnar cicatrix is subpentagonal, covering the middle half of the infrabasal circlet. Basals 5, slightly protruded, sloping upward at about 60°; AB, DC, DE, and EA hexagonal; BC heptagonal to accommodate six-sided radial plate. Radials 5, A, B, D, and E tapered pentagon-shaped; C six-sided, smaller to accommodate pentagonal anal X plate and right tube-plate.

Primibrachials pentagonal, axillary. SBrl irregularly trapezoidal, followed by parallelogram-shaped SBr2 through SBr5. Brachials crescentic in cross-section.

Remarks
The holotype of Haeretocrinus missouriensis was probably collected from the Lane Shale near Kansas City, Missouri. The species appears to be rather short-ranged, but it is, perhaps, too rare to have significant value as an index fossil.


Genus Hydriocrinus Trautschold, 1867
Type species: Hydriocrinus pusillus Trautschold, 1867.

Range: Middle Pennsylvanian–Pennsylvanian. USA and USSR.

Hydriocrinus turbinatus Strimple, 1971

Description
Dorsal cup is a high truncated cone. The columnar cicatrix is crenulated, flat-lying, and has a rounded lumen. The 5
infrabasals slope upward at about 70°. The basals are shield-shaped and slope at about 70°. The radials are sub-pentagonal and flare outward as they approach the cup summit, giving the cup a trumpetlike cross-section. The posterior interradius is damaged, and its exact configuration cannot be determined. Sutures between cup plates are mildly impressed. Radial articular facets plenary, outer marginal-ridge very sharp; outer ligament-furrow deep, merging with deep ligament-pit. Transverse ridge non-denticulate, very strong. Adsutural slopes steep, merging into semi-circular lateral lobes. Muscle areas slope steeply into a large central pit that converges into an intermuscular notch via a short, distinct furrow.

**Remarks**

The C and D radials and the posterior interradius have been damaged on the specimen studied. The extant cup sculpture is sufficiently well preserved to allow comparison with *Hydriocrinus turbinatus*. The holotype of *H. turbinatus* was collected from the Wann Formation, at the Mound west of Bartlesville, Oklahoma.

**Material studied:** Hypotypes: SUI 38168 (one cup and one infrabasal circlet), Schildberg Construction Company Quarry, SE § SW § Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. Collected by Ed Spiller.

**Superfamily Lophocrinacea Bather, 1899**

**Family Pachylocrinidae Kirk, 1942**

**Genus Plummericrinus Moore and Laudon, 1943**

**Type species:** *Pachylocrinus mcquirei* Moore, 1939.

**Diagnosis**

(After Moore and Strimple, 1973:50.) 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.
**Remarks**

*Plummericrinus* *pittsburghensis* Burke is retained in this genus with some reservation. Examination by the senior author of the holotype, a somewhat compressed cup, leads to *Glaikosocrinus* as the probable generic affinity. Burke (1968: 15) indicated that it was difficult to determine the original outlines of the cup. The primibrachials appear to be somewhat stout, and the cup contour appears to be more hemispherical than truncate-bowl-shaped. The radial articular facets could not definitely be discerned, but they may be plenary, as compared to most pachylocrinids which have peneplenary facets.


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**Plummericrinus nettingi** Burke, 1968

**Description**

This species is represented by a single, medium truncated bowl-shaped cup. Infrabasal disk about one-fifth diameter of cup, made up of 5 kite-shaped plates. Columnar cicatrix about one-half the diameter of the infrabasal disk; contains one or more round columnals, has about 35 crenellae, and a pentalobate lunule. Basals 5, bulbous, AB, DE, and EA pentagonal; BC and CD six-sided to accommodate anal plates; BC truncated diagonally, and CD truncated distally. Proximal tips of basals confined to shallow concavity; basals recurve in proximal area to form basal plane; distal two-thirds rise parabolically to a maximum slope of about 60°. Radials 5, A, B, C, and E tapered pentagons; C six-sided; slightly bulbous; radicals slope upward at about 45° and proximal tip reaches up to two-thirds the distance to the basal plane. Radial an irregular pentagon; anal X six-sided; distal end bears 2 tube-plate facets; slot available for right tube-plate. Cup plates have a slightly wrinkled finish.

Radial articular facets peneplenary, sloping outward at about 45°. Outer marginal-furrow broad, shallow, abutted by low, denticulate outer ligament-ridge. Ligament-pit furrow broad, shallow; ligament-pit deep and wide. Transverse ridge blunt, non-denticulate. Muscle areas slope gently toward a “V-shaped” intermuscular furrow. Arms unknown.

**Remarks**

The specimen at hand is relegated to *Plummericrinus nettingi* Burke because of its affinity to the holotype, which was collected from the Cambridge Limestone in Allegheny County, Pennsylvania. The Cambridge is somewhat older than the Argentine Limestone of the Midcontinent, probably being age-equivalent to the Winterset Limestone.

**Material studied**: Holotype: CM 29857, a dorsal cup from the Cambridge Limestone, Allegheny County, Pennsylvania. Hypotype: SUI 38177, Schildberg Construction Company Quarry, SE 1/4 SW 1/4 Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

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**Family Laudonocrinidae Moore and Strimple, 1973**

**Genus Laudonocrinus** Moore and Plummer, 1940

**Type species**: *Hydreionocrinus subsinuatus* Miller and Gurley, 1894.

**Diagnosis**

(After Strimple and Moore, 1971a:20.) The type of the type species is a low, modified bowl-shaped dorsal cup without any arms preserved. The infrabasals are subhorizontal but with their distal tips appearing in side view of the cup; basals curve very gently outward and then upward to join the radials in forming the sides of the cup; CD interray and adjoining areas are confluent and form a gentle concavity. Three anal plates are in normal (primitive) arrangement within the cup.

**Other species included**: *Laudonocrinus? catillus* Moore and Plummer, 1940; *L. ? cecullus* Moore and Plummer, 1940; *L. arrectus* Moore and Plummer, 1940.

**Remarks**

Strimple and Moore (1971a:20) suggested that *Laudonocrinus catillus* and *L. cecullus* may belong to another [undescribed] genus. Pabian and Strimple (1974b:11) proposed affinity with *Metaperimestocrinus* Strimple, based strictly on the nature of the cup bases. *Laudonocrinus* most closely resembles *Bathronymocrinus* Strimple, but the latter typically has more steeply upflared infrabasals.

**Range**: Pennsylvanian (?Desmoinesian-Missourian). USA: Texas, Oklahoma, Nebraska, Iowa, and Illinois.
Laudonocrinus subsinuatus (Miller and Gurley, 1894)
Moore and Plummer
Fig. 7D-F

Synonym:
Hydreionocrinus subsinuatus Miller and Gurley, 1894

Remarks
Laudonocrinus subsinuatus appears to be most common in Lower Missourian strata, although it occurs as high as the Basal Stoner Limestone in Nebraska. The exact horizon from which the holotype was collected has never been established. This fact both limits the stratigraphic value of L. subsinuatus and complicates interpretation and construction of any phylogeny of the genus Laudonocrinus, but Strimple and Moore (1971a:20) suggested close affinities to Anchicrinus or Metaperimestocrinus.

A small dorsal cup (SUI 38190) shows no appreciable change in cup outline from the larger cups studied. The largest cups observed suggest that L. subsinuatus may have a maximum cup diameter not much greater than 15 mm. All of the described species of Laudonocrinus have rather small cups. We suggest that adults of any species of Laudonocrinus probably did not become nearly as large as other related genera, e.g., Bathronocrinus.

Material studied: Hypotypes: UNSM 16892, SW¼ SW¼ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska, and SUI 31890 (2 specimens), Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

Genus Bathronocrinus Strimple, 1962

Type species: Bathronocrinus turioformis Strimple, 1962.

Diagnosis
Cup low, bowl-shaped, with sides flaring; base flat to slightly up-flared; basal and radial plates flare upward; plates not tumid; sutures not impressed; facets slope outward slightly; stem round.

Other species included: Bathronocrinus magnospinosus (Arendt, 1968); B. wolfreverensis Pabian and Strimple, 1974; B. deweyensis (Strimple, 1939); B. madisonensis n. sp.

Range: Middle Pennsylvanian-“Lower Permian.” USA and USSR.

Bathronocrinus madisonensis n. sp.

Figs. 7A-C and 8M-O

Description
This species is based on 2 cups that are low bowl-shaped. Infrabasals 5, kite-shaped, confined to a flat or slightly up-flared circle that is almost covered by a round, crenulated columnar cicatrix. Basals 5, up-flared in circular cross-section; AB, BC, DE, and EA pentagonal; CD truncated to accommodate anal. Radials 5, epaulette-shaped, sloping upward in parabolic cross-section; C and D separated by radianal and/or anal X. Sutures not impressed.

Radial articular facets plenary, without notches between them, and nearly flat-lying. Outer marginal-ridge sharp and separated from ligament-pit by wide furrow; transverse ridge faint, non-denticulate; lateral ridges high, and ad sutural slopes about 45°. Lobate muscle areas slope inward to a shallow central pit that connects to the intermuscular notch by a short furrow.

Remarks
Bathronocrinus madisonensis differs from B. turioformis by lacking notches between the radial articular facets. B. madisonensis may exhibit a strong tendency to reduce the anal plates as the radianal has moved into the anal position on the holotype, and the radianal is reduced considerably in the paratype. Bathronocrinus turioformis lacks intersutural notches but has an ornamented surface. Cup outline and cross-section suggest that B. madisonensis and B. deweyensis may have been derived from a common ancestor.

Measurements: See Table III.


Family Stellarocrinidae Strimple, 1961

Genus Stellarocrinus Strimple, 1940

Type species: Stellarocrinus stillativus (White, 1879).

Diagnosis
Crown widely expanded to mid-height, then contracted, arms not apposed. Cup low, truncated bowl with broad, concave base. Infrabasals 5, small, subhorizontal. Basals 5, forming
FIGURE 7. Photographs of Nebraska and Iowa Argentine Limestone crinoids. A-C. *Bathronocrinus madisonensis* n. sp. basal, summit, and posterior views; paratype, UNSM 16891, X3. D-F. *Laudonocrinus subsinuatus* (Miller and Gurley); basal, summit, and posterior views; hypotype, UNSM 16892, X3. G-I. *Plaxocrinus crassidiscus* (Miller and Gurley); posterior, summit, and basal views; hypotype, UNSM 16945, X2. J-K. *P. crassidiscus*; summit and basal views; hypotype, UNSM 16893, X2. L-N. *Perimestocrinus nodulifer* (Miller and Gurley); summit, posterior, and basal views; hypotype, UNSM 16917, X3. O. *Vertigoocrinus paridis* (Moore and Plummer); basal view; hypotype, SUE 46114, X2. P-R. *Stenopecrinus planus* (Strimple); posterior, summit, and basal views; hypotype, UNSM 16947, X2.
walls of basal concavity, base of cup and lower portion of cup walls. Radials 5, low, penepenial facets sloping outward to vertically. Single radianal in cup. Arms biserial.

**Other species included:** Stellaeoerillus exclilptus (Strimple, 1939); S. texani Strimple, 1951; S. virgilellsis Strimple, 1951; S. petalosus Strimple, 1961; S. florealis (Moore and Plummer, 1940); S. geometricus (Moore and Plummer, 1940); S. bulbous Strimple and Watkins, 1969; S. bilineatus Strimple and Moore, 1971.

**Range:** Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Virgilian) and "Lower Permian" (Wolfcampian). USA: Texas, Oklahoma, Kansas, Nebraska, Iowa, Missouri, and Illinois.

*S. exculpus* (Strimple, 1939)
Strimple and Moore, 1971

Figs. 4L-M and 9A-B

Synonyms:
Whiteoerinus excelpus Strimple, 1939
Apollocrinus exculpus (Strimple) Moore and Plummer, 1940

Remarks

*Stellarocinus exculpus* is an important component of the crinoid fauna found in the Wann Shale exposed at the Mound, west of Bartlesville, in Osage County, Oklahoma.

A topotype at hand (Fig. 9A) has most of a long, stout anal sac intact as well as tapered pentagonal, axial PBr plates. The PBr plate is followed by 2, biserial SBr plates.

**Material studied:** Topotypes: UNSM 13891, Wann Formation, Ochelata Group, Airport Road-cut, approximately NW¼ SW¼ Sec. 5, T. 26 N., R. 12 E., Osage County, Oklahoma. Hypotypes: SUI 38164 (2 specimens) and SUI 38178, Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

**Superfamily Agassizocrinacea S. A. Miller, 1890**

**Family Anobasicrinidae Strimple, 1961**

**Genus Terpnocrinus Strimple and Moore, 1971**

*Type species:* Terpnocrinus occytensis Strimple and Moore.

**Diagnosis**

Crown tall. Cup moderately high bowl, evenly expanded, well rounded; infrabasals 5, up-flared; basals 5; radials 5; anal 3 in normal (primitive) arrangement. Arms stout, more than 20, uniserial.

**Other species included:** Terpnocrinus ellipticus Pabian and Strimple, 1974.

**Range:** Pennsylvanian (Missourian). USA: Oklahoma, Texas, Kansas, Nebraska, Iowa, and Illinois.

*Terpnocrinus ellipticus* Pabian and Strimple, 1974

Fig. 6G-I

Remarks

*Terpnocrinus ellipticus* probably ranges throughout the Missourian Series. The holotype was collected from the Kiewitz Shale Bed (see Pabian and Strimple, 1979:421) of the Stoner Limestone Member, Stanton Formation. Our collections include specimens from the Winterset Limestone in Kansas and Nebraska and from the South Bend Limestone of Nebraska. No specimen of *Terpnocrinus* is currently known from Virgilian-age strata.

**Material studied:** Hypotypes: SUI 38183 (2 specimens), Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

**Superfamily Erisocrinacea Wachsmuth and Springer, 1886**

**Family Catacrinidae Knapp, 1969**

**Genus Delocrinus Miller and Gurley, 1890**

*Type species:* Delocrinus hemisphericus (Shumard, 1958) (= Delocrinus subhemisphericus Moore and Plummer, 1940).

**Diagnosis**

Cup low, bowl-shaped, with deep basal concavity. Infrabasals 5, down-flared, basals 5, down-flared in proximal portions, recurving so that medial areas form base of cup, and distal tips rise about one-half the cup height. Radials 5, pentagonal. Anal, one in cup; sac weak. Facets plenary, flat-lying. Arms 10, biserial.

**Other species included:** Delocrinus craigii (Worthen, 1875); D. inflexus (Geinitz, 1866); D. pendens Moore and Plummer, 1938; D. versus Moore and Plummer, 1940; D. vulgatus Moore and Plummer, 1940; D. wewokaensis Strimple, 1940; D. extraneous Strimple, 1949; D. ponderosus Strimple, 1949.

Delocrinus hemisphericus (Shumard, 1858)
Miller and Gurley, 1890

Fig. 10A–G

Synonyms:
Poteriocrinus hemisphericus Shumard, 1858
Scaphiocrinus hemisphericus (Shumard) Meek, 1872
Ceriocrinus hemisphericus (Shumard) Wachsmuth and Springer, 1886
Delocrinus subhemisphericus Moore and Plummer, 1940

Remarks

Delocrinus hemisphericus is perhaps the most abundant crinoid in the Iowa–Nebraska region. However, D. hemisphericus is a relatively unimportant constituent in the LaSalle limestone of Illinois, where it seems to be replaced in numbers by various species of Stellarocrinus, a genus which is quite unimportant in the Nebraska-Iowa region. Pabian and Strimple (1977) indicated that the distribution of Stellarocrinus and Delocrinus was of provincial importance. In all instances, Pabian and Strimple (1977) referred to D. hemisphericus as representing that genus.

Delocrinus hemisphericus shows considerable intraspecific variation. The most conspicuous feature is a tendency to expel the anal plate from the cup, and this is shown by specimen SUI 38163 (Fig. 10D–F). There may be some variation in the cup height to diameter ratio and in the tumidity of plates, especially in juvenile forms. Some specimens with very bulbous plates are here assigned to Endelocrinus; however, these individuals have very broad, shelflike forefaceral areas, unlike D. hemisphericus.

Material studied: Hypotypes: SUI 38174 (8 specimens), SUI 38173 (25 specimens), and SUI 38163, Schildberg Construction Company Quarry, SE 1/4 SW 1/4 Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. UNSM 16898–UNSM 16899, UNSM 16904–UNSM 16911, UNSM 16913, UNSM 16914, abandoned quarry, SW 1/4 SW 1/4 Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

Genus Endelocrinus Moore and Plummer, 1940

Type species: Endelocrinus fayettensis (Worthen, 1873).

Endelocrinus kieri Burke, 1966

Fig. 10H–J

Synonym:
Delocrinus allegheniensis Burke, 1932 (partim)

Remarks

The holotype of Endelocrinus kieri was collected from the Ames Limestone in Guernsey County, Ohio. This species may serve as an important index fossil in correlating Appalachian and Midcontinent stratigraphic units. Although the lower extent of E. kieri has not been established, our collections indicate that it ranges no higher than the South Bend Limestone Member of the Stanton Formation in Nebraska.

Material studied: Hypotypes: SUI 38172 (4 specimens), Schildberg Construction Company Quarry, SE 1/4 SW 1/4 Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. UNSM 16896 and UNSM 16897, abandoned quarry, SW 1/4 SW 1/4 Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

Family Erisocrinidae Wachsmuth and Springer, 1886

Diagnosis

Dicyclic, cup truncated cone or truncated bowl with
crinoids, the present authors consider this unlikely. Knapp's Paradelocrinidae have cups with a basal concavity; 5, down-flared infrabasals; 5, small basals visible in side view of cup; anal plates typically absent, but one may be present; and 10 uniserial arms. Paradelocrinus and Pontotocrinus were included in this family by Knapp. The typical uniserial arms of this family were based on those of Delocrinus matheri Moore and Plummer, which was subsequently (Strimple, 1960:151) assigned to Endocrinus on the basis of uniserial arms and depressions at plate angles. Knapp contended that presence or absence of an anal plate was a negligible character, but no known specimen of Moore and Plummer's type species, Paradelocrinus aequabilis, shows more than a rudimentary anal plate for this genus, whereas Endocrinus matheri has a well developed anal plate in contact with the C-D basal below. Knapp indicated that the paradelocrinids (both Paradelocrinus aequabilis and Endocrinus matheri) developed from the phanocrinids, and that contention is not disputed.

Paradelocrinus wapanucka Strimple, 1961, was proposed on the basis of a monotype from the Wapanucka Formation (Morrowan) and additional specimens have not been observed to date. Knapp (1969:352), proposed Pontotocrinus with Paradelocrinus wapanucka as the type species, and assigned the genus to the Paradelocrinidae Knapp, 1969. The type species of Paradelocrinus Moore and Plummer, 1938, is P. aequabilis Moore and Plummer, 1938, from the Brentwood Limestone, Boyd Formation (Morrowan). There are significant differences between the two species under discussion which are adequate for generic differentiation. P. aequabilis has a decided basal concavity, a low cup with proximal ends of radials entering the basal plane, whereas Pontotocrinus has a flat base (except for the sharply impressed stem attachment area), and more erect lateral sides of cup, with only the tips of radials reaching the basal plane. Pontotocrinus has a more primitive cup shape than Paradelocrinus and is probably not so closely related.

The only other species listed (Knapp, 1969:352) under Paradelocrinus was Delocrinus matheri Moore and Plummer, 1938. The species had previously (Strimple, 1960:151) been assigned to Endocrinus on the basis of the uniserial arms and the slight depressions at the angles of the cup plates. At this point there does not seem to be any justification for assigning it to Paradelocrinus. Contrary to Knapp's contention that the presence or absence of an anal plate is so variable as to be a negligible character, the fact is that Paradelocrinus aequabilis never has more than a rudimentary anal plate notching the summit of the cup, whereas in Endocrinus matheri a well developed anal plate is in firm contact with the posterior (C-D) basal in almost all of the numerous specimens examined. The two forms apparently had a common ancestor, probably Phanocrinus.

In the Atokan, direct derivatives of Paradelocrinus appear to be represented by the genus Protocrinus Jaekel, 1918.
The only appreciable change appears to be the reduction in size of basal plates which is reciprocated by the elongation of radials and in some instances by the infrabasals. *Protencrinus moscowiensis* Jaekel, 1918, is more primitive than American species in that the arms of the Russian species are cuneiform, much like the arms of *Diphiuscrinus*. A specimen with thick plates from the Barnett Hill Member, Atoka Formation (Atokan) of Oklahoma, considered conspécific with *Protencrinus mutabilis* Knapp, 1969, has biserial arms. Another species from the same formation, *P. atoka* Strimple, 1961, has thinner plates, a slightly lower cup, and biserial arms.

Desmoinesian species referred by Knapp (1969) to *Neo-protencrinus* include both the thick-plated forms, e.g. *Paradelocrinus brachiatius* Moore and Plummer, 1940, and thin-plated forms, e.g. *Paradelocrinus discitus* Strimple, 1949, with shortened interbasal sutures. With the lowering of cup height, the capacity of the body cavity is reduced, and to compensate for the loss of living space the basal concavity may be reduced or eliminated. Externally this change is reflected by a shallowly concave or flat base.

*Erisocrinus mediator* Strimple, 1962, is a rather common element of a large population of comparable forms in the Oologah Formation of Oklahoma. There is considerable variability within the group. Shortening of the interbasal sutures occurs in at least one ray in many specimens, and radials actually make contact with infrabasals in some. The flat base, except for the sharply impressed columnar attachment area, proximal ends of radials above basal plane, and articular facets having the transverse ridge near the periphery of the cup are characters held in common with *Pontotocrinus*. In that the basal plates are not appreciably reduced in size and the interbasal sutures sporadically shortened in *E. mediator*, it is not likely to have evolved from *Protencrinus* in which the basal plates are already small, and all interbasal sutures shortened. *Erisocrinus* is a relatively stable form common in Missourian (Pennsylvanian) to “Lower Permain” rocks. The base is typically shallowly concave, the basals are large, the interbasal sutures are long, the proximal ends of radials are above the basal plane; articular facets have the transverse ridge near the periphery of the cup, and there are 10 long, biserial arms. The older *E. mediator* is apparently not in the direct lineage leading to *Erisocrinus*, and it has been designated (Knapp, 1969: 354) the type species of *Libratoocrinus*.

**Genus Erisocrinus** Meek and Worthen, 1865

*Type species:* *Erisocrinus typus* Meek and Worthen, 1865.

**Diagnosis**

(After Strimple and Moore, 1971a:10.) Dorsal cup truncated cone-shaped, flattened base, with little or no concavity, circular stem impression. Cup outline is pentagonal when viewed from above or below. Five, small infrabasals, confined to basal area together with proximal portions of 5 large basal plates. Five radial plates form most of the lateral walls of the dorsal cup. Anal plate is typically a rudimentary piece interposed between upper articular surfaces of 2 (posterior) radials and not visible when the arms are in place. Arms 10, biserial, branching on short first primibrach in all rays. Branchials have flattened outer surfaces, sharply delineated from sides.

The stem is moderately large and composed of alternatingly expanded columnals.

**Other species included:** *Erisocrinus araxensis* Yakovlev, 1933; *E. elevatus* Moore and Plummer, 1940; *E. georgeae* Strimple and Watkins, 1969; *E. granulatus* Wanner, 1916; *E. healdae* Pabian and Strimple, 1974; *E. knoxvillensis* Strimple, 1975; *E. lozeyi* Lane and Webster, 1966; *E. lustrum* Strimple, 1951; *E. pentangulatus* Yakovlev, 1938; *E. propinquus* Weller, 1969; *E. stefannii* Yakovlev, 1934.

**Range:** Mississippian—“Upper Permain.” USA: Illinois, Iowa, Missouri, Nebraska, Kansas, Oklahoma, Texas, Colorado, and Nevada. USSR: Transcaucaus Region, Moscow Basin. Also: Brazil, Scotland, Sicily, and Timor.

*Erisocrinus typus* Meek and Worthen, 1865

Figs. 8D-F and 10N-Q

**Synonymy:**

*Erisocrinus nebrascensis* Meek and Worthen, 1865  
*Erisocrinus pelvis* (Meek and Worthen, 1865)

**Remarks**

*Erisocrinus typus* is a long-ranging species that spans the Missourian strata in the Midcontinent. *E. typus* seems to become abundant in the Winterset Limestone; it persists in large numbers through the South Bend Limestone. By Lower Virgilian time the species seems to have become relatively unimportant, and it is not known to occur in large numbers in units above the Haskell Limestone Member of the Cass Formation in the Iowa–Nebraska region. Pabian and Strimple (unpublished manuscript) reported several specimens of *E. typus* from the Stull Shale Member, Kanwaka Formation.

At least one lineage aligned with *Erisocrinus typus* showed a tendency to develop shorter sutures between basal plates, and thus have collapsed bases. In some extreme examples, the proximal tip of the radials actually contacted the infrabasals.
circlet. This tendency is shown by several species of *Erisocrinus* in Late Desmoinesian time (Strimple, 1962). It is demonstrated by many cups of *E. typus* from the Wann Formation exposed at the Mound west of Bartlesville, Oklahoma, and the same degree of evolutionary change in the unstable bases is shown in specimens of *E. typus* from Nebraska and Iowa.

One aberrant lineage of *Erisocrinus typus* shows a much flattened anterior region (Fig. 8J-L). Most of the flattening appears to be due to shortening of the A radial and the adjacent sutural areas in the B and E radials. The reason for this aberrancy is not understood as it does not seem to show up in populations of *E. typus* from the coeval Wann Formation of Oklahoma or from other stratigraphic units in the Missourian.

**Material studied:** Hypotypes: SUI 38188, SUI 38161, SUI 38162 (31 specimens), Schildberg Construction Company Quarry, SE1/4 SW1/4 Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. UNSM 16894 and UNSM 16895, SW1/4 SW1/4 Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

**Erisocrinus obovatus** (Moore and Plummer, 1940)  
Strimple and Watkins, 1969

*Fig. 8A-C*

**Synonyms:**  
*Paradelocrinus obovatus* Moore and Plummer, 1940  
*Pareresocrinus obovatus* (Moore and Plummer) Knapp, 1969

**Remarks**

The discovery of *Erisocrinus obovatus* from the Argentine Limestone extends the known range of this species considerably. The range zone now extends from the Winterset Limestone through the Argentine Limestone. The numbers of specimens in the collection indicate that *E. obovatus* is more abundant in the lower part of its range zone than in the higher part.

**Material studied:** Hypotype: UNSM 16918, abandoned quarry, SW1/4 SW1/4 Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

**Genus Eperisocrinus** Burke, 1977

**Type species:** *Delocrinus missouriensis* Miller and Gurley, 1890.

**Diagnosis**

(After Burke, 1977:174.) Dorsal cup with radial plates having articular facets and obtuse proximal angles essentially as in *Erisocrinus*, but differing in having: (1) a considerably higher basal impression; (2) infrabasal plates much more reduced, and steeper walled adjacent to the stem; (3) large basal plates; (4) interbasal and interradial sutures nearly equal in length; and (5) anal X represented an outer wall of the cup.

**Other species included:** None.

**Remarks**

Burke (1977:176) erected *Eperisocrinus* largely on the proximal obtuse radial plate angles and the *Erisocrinus*-like radial articular facets. The authors have examined the holotype of the type species (Fig. 10K-M), and its gross morphology suggests possible affinities to several genera, namely: *Cathetocrinus* Knapp, 1969; *Pyndaxocrinus* Knapp, 1969; and *Sublobalocrinus* Knapp, 1969. Arms have been found and described for the species *Sublobalocrinus kaseri* Pabian and Strimple; their morphology suggests affinities to the Catacrinidae. A specimen of *Cathetocrinus stullensis* (Strimple) from the Stull Shale of Nebraska has arms suggesting affinities to the catacrinids or diphuicrinids. The arms of *Pyndaxocrinus* are not known.

Our additional specimens provide a greater degree of uncertainty regarding the affinities of *Eperisocrinus*; however, we do accept the generic concept as outlined by Burke.

**Material studied:** Holotype: UC 6233a, Argentine Limestone Member, Wyandotte Formation, Kansas City, Missouri.

**Family Paradelocrinidae** Knapp, 1969

**Genus Neocatacrinus** Knapp, 1969

**Type species:** *Neocatacrinus protensus* (Moore and Plummer, 1940).

**Diagnosis**

(After Knapp, 1969:366, Text-fig. 22.) Basal concavity narrow and moderately deep; infrabasals down-flared, basals medium-sized, anal X notched at interior between posterior radial facets; pentagonal in dorso-ventral outline; arms unknown.

**Range:** Pennsylvanian (Missourian). USA: Iowa, Nebraska, Kansas, Oklahoma, and Texas.
Neocatacrinus protensus (Moore and Plummer, 1940) Knapp, 1969

Fig. 8P-Q

Synonyms:
Paradelocrinus protensus Moore and Plummer, 1940
Eriscocrinus protensus (Moore and Plummer) Strimple and Watkins, 1969

Remarks

Neocatacrinus protensus does not appear to be established until Late Missourian time. Collections under study indicate that this species ranges as high as the Ervine Creek Limestone Member of the Deer Creek Formation. N. protensus is uncommon and, for that reason, has limited stratigraphic value.

Material studied: Hypotypes: SUI 38161 (3 specimens), Schildberg Construction Company Quarry, SE NW Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

Family Protencrinidae Knapp, 1969
Genus Neoprotencrinus Knapp, 1969

Type species: Neoprotencrinus subplanus (Moore and Plummer, 1940).

Diagnosis

Infrabasals 5 in shallow, broad concavity. Basals 5, with proximal tips in basal concavity, medial portions forming basal plane of cup, and distal tips rising one-half the cup height. Radials 5, nearly reaching basal plane. Anal X small, wedge-shaped or absent, not reaching outer cup-wall. Facets plenary. Stem round. Arms unknown.

Other species included: Neoprotencrinus cranei (Strimple, 1949); N. regulatus (Strimple, 1949).

Range: Middle–Upper Pennsylvanian (Desmoinesian–Missourian). USA: Iowa and Oklahoma.

Neoprotencrinus sp. cf. N. subplanus Moore and Plummer

Fig. 8G-I

Synonyms:
Paradelocrinus subplanus Moore and Plummer, 1940
Neoprotencrinus subplanus (Moore and Plummer) Knapp

Remarks

The specimen at hand closely resembles the holotype of Neoprotencrinus subplanus with the exception of having developed somewhat larger basal plates. It might prove to be a distinct species if additional comparative material becomes available.

Material studied: Hypotype: SUI 38166, Schildberg Construction Company Quarry, SE NW Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

Family Graphiocrinidae Wachsmuth and Springer, 1886

Contocrinus Knapp, 1969

Type s: Contocrinus stantonensis (Strimple, 1939).

Diagnosis

Base concave; infrabasals 5, subhorizontal or down-flared; proximal tip of radial plates above basal plane. Articular facets subhorizontal or sloping inward. Arms 10, uniserial. Anal X short, followed by one tube-plate.

Other species included: Contocrinus bridgeportensis (Strimple, 1951); C. deflectus (Strimple, 1962); C. lineatus (Strimple, 1963); C. kingi (Moore and Plummer, 1940); C. invaginatus Pabian and Strimple, 1980; C. coupi Strimple and Moore, 1971; C. scopulus Lane and Webster, 1966.

Range: Middle–Upper Pennsylvanian (Desmoinesian–Virgilian)–“Lower Permian” (Wolfcampian). USA: Nevada, Texas, Oklahoma, Nebraska, Kansas, Missouri, Iowa, and Illinois.

Contocrinus kingi (Moore and Plummer, 1940)

Fig. 9D-F, J

Synonym:
Graphiocrinus kingi Moore and Plummer, 1940

Remarks

Moore and Plummer (1940:55) erected a Graphiocrinus kingi zone which lies in the upper part of the Mineral Wells Formation in the Keechi Creek Shale of the Missourian. They indicated that the zone was slightly above the Desmoinesian-Missourian boundary, based on evidence supplied by fusulinids. Moore and Plummer recognized eight crinoid species in this zone, three of which, Eriscocrinus typus, Peristemencrinus...
impressus (= Stenopecrinus impressus), and Graphiocrinus kingi (= Contocrinus kingi), have been recognized in the Argentine Limestone of Iowa and Nebraska. In addition, parulocrinus pustulosus was recognized from localities that Moore and Plummer correlated with the Mineral Wells Formation. These units in Texas correlate approximately with the Bethany Falls-Winterset interval (Lower Missourian) of Nebraska and Iowa.

Material studied: Hypotypes: SUI 38186 (2 specimens), SUI 38184 (9 specimens), and SUI 38189 (11 specimens), Schildberg Construction Company Quarry SE$rac{1}{4}$ SW$rac{1}{4}$, Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. UNSM 16901-UNSM 16903 and UNSM 16912-UNSM 16914, abandoned quarry, SW$rac{1}{4}$ SW$rac{3}{4}$ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

Superfamily Apographiocrinacea Moore and Laudon, 1943
Family Apographiocrinidae Moore and Laudon, 1943
Genus Apographiocrinus Moore and Plummer, 1940

Type species: Apographiocrinus typicalis Moore and Plummer, 1940.


Diagnosis

The dorsal cup is low, bowl-shaped, and has gently tumid plates separated by impressed sutures. The base is flat or shallowly concave, and infrabasals are down-flared or sub-horizontal. There is a single anal plate with 2 facets.

Range: Desmoinesian through Virgilian (Pennsylvanian) and Wolfcampian “Permian.” USA: Texas, Oklahoma, Kansas, Nebraska, Missouri, Iowa, Illinois, and Michigan. Also Upper Permian, Timor.

Apographiocrinus typicalis Moore and Plummer, 1940

Fig. 9H-I

Synonym:
Graphiocrinus carbonarius (Meek and Worthen) Strimple, 1938

Remarks

Our collections indicate that Apographiocrinus typicalis does not range any higher than the South Bend Limestone Member of the Stanton Formation. Pabian and Strimple (1974b) reported A. typicalis from several Missourian units, the oldest of which was the P.W.A. Limestone Member of the Drum Formation.

Material studied: Hypotypes: SUI 38185, SUI 38169 (2 specimens), and SUI 38191 (6 specimens), Schildberg Construction Company Quarry, SE$rac{1}{4}$ SW$rac{3}{4}$ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. UNSM 16900, abandoned quarry, SW$rac{1}{4}$ SW$rac{3}{4}$ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

Superfamily Pirasocrinacea Moore and Laudon, 1943
Family Pirasocrinidae Moore and Laudon, 1943
Genus Plaxocrinus Moore and Plummer, 1938

Type species: Plaxocrinus crassidiscus (Miller and Gurley, 1894).

Diagnosis

Basal concavity shallow to nearly indistinguishable. Infrabasals 5, in basal concavity; basals 5, distal tips visible in side view of cup. Radials 5, with facets sloping outward. Notches between facets may be broad giving cup a circular outline. Sutures between plates impressed. Arms not known.

Other species included: Plaxocrinus discus (Meek and Worthen, 1860); P. virginarius Moore, 1939; P. macrorniferus Pabian and Strimple, 1974.

Range: Upper Pennsylvanian (Missourian-Virgilian). USA: Texas, Oklahoma, Kansas, Nebraska, Missouri, and Iowa.

Plaxocrinus crassidiscus (Miller and Gurley, 1894)
Moore and Plummer, 1938

Fig. 7G-K

Synonym:
Hydreionocrinus crassidiscus Miller and Gurley, 1894

Remarks

Plaxocrinus crassidiscus is possibly the most abundant and long-ranging pirasocrinid in Nebraska and Iowa. Moore and Plummer (1938:278) indicated that the holotype was
most likely collected from the Wyandotte Limestone in the Kansas City Group near Kansas City. Our collections show this species ranges into the Kanwaka Formation (Virgilian) but the lower extent of *P. crassidiscus* has not been determined.

*Plaxocrinus crassidiscus* occurs with *P. discus* (Meek and Worthen), from which it differs by having somewhat more tumid plates and impressed sutures. *P. crassidiscus* has a lower facet-angle and shallower cup than described by Moore (1939) for *P. virginarius*. *P. macrospiniferus* Pabian and Strimple, 1974, has a cup similar to *P. virginarius* except the sutures are much more deeply impressed in the latter.

**Material studied:** Hypotypes: UNSM 16893, abandoned quarry in SW¼ SW¼ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska, UNSM 16944, Farley Limestone, Lone Star Cement Company Quarry, northeast of Bonner Springs, Kansas.

*Plaxocrinus discus* (Meek and Worthen, 1860)

Moore and Plummer, 1938

**Synonym:** *Zacrinus discus* Meek and Worthen, 1860

**Remarks**

The holotype of *Plaxocrinus discus* was collected from Illinois. The collections at hand show that *P. discus* also occurs in southern Kansas and northeastern Oklahoma. It is especially common in the Wann Formation at the Mound west of Bartlesville, Oklahoma, where the strata are thought to be of about Argentine age.

**Material studied:** Hypotypes: SUI 38180 (2 specimens), Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa, UNSM 16945, Iola Limestone, Cement Plant Quarry, NE¼ Sec. 2, T. 25 S., R. 18 E., Allen County, Kansas.

**Genus Stenopecrinus** Strimple, 1961

**Type species:** *Stenopecrinus planus* (Strimple, 1952).

**Diagnosis**

(After Knapp, 1969:379.) Basal concavity restricted and deep; proximal parts of the basal plates overhang the bottom of the concavity; notches between facets narrow giving the cup a hexagonal outline; plates tumid; sutures impressed; arms uniserial, endotomous.

*Other species included:* *Stenopecrinus formosus* (Moore and Plummer, 1940); *S. calyculus* (Moore and Plummer, 1940); *S. hexagonus* (Strimple, 1962); *S. papillatus* (Strimple, 1962); *S. impressus* (Moore and Plummer, 1940); *S. moseleyi* (Strimple, 1951); *S. ornatus* Moore and Strimple, 1973; *Stenopecrinus sp.* Moore and Strimple, 1973.

**Range:** Lower Pennsylvanian (Morrowan) and Upper Pennsylvanian (Virgilian). USA: Oklahoma, Kansas, Texas, Nebraska, Iowa, Illinois, and Utah. “Lower Permian” (Wolfcampian). USA: Nevada.

*Stenopecrinus hexagonus* (Strimple, 1952)

Strimple, 1961

**Fig. 51-J**

**Synonyms:**

*Perimestocrinus hexagonus* Strimple, 1952

*Aatocrinus hexagonus* (Strimple) Knapp, 1969

*Stenopecrinus hexagonarius* Strimple and Boardman, 1971 (lapsus)

**Remarks**

Knapp (1969:372) removed *Stenopecrinus hexagonus* to *Aatocrinus*, probably on the basis of the broad basal concavity shown by the type of *Aatocrinus robustus* Beede, 1900. Strimple and Boardman (1971:30) retained *Stenopecrinus hexagonus*. *Aatocrinus* may be closely related to *Stenopecrinus*, the latter having a much more specialized, constricted basal concavity. Strimple (1952:785) indicated that the proximal portions of the basals curved strongly into the basal concavity and recurred before contacting the infrabasals. The recurve of the infrabasals causes an “overhang” of these plates, which is characteristic of the type species. For this reason, we favor identification as *Stenopecrinus hexagonus*.

*Stenopecrinus hexagonus* occurs with several closely related species. The fine ornamentation of *S. hexagonus* separates it from the smooth, inornate *S. planus* (Strimple, 1952). *S. moseleyi* (Strimple, 1951) has a very coarsely granular surface as does *S. impressus* (Moore and Plummer, 1940). *S. formosus* (Moore and Plummer, 1940) has distinctly sculptured radial plates with arcuate, nodose ridges (see Moore and Plummer, 1940:205). *S. calyculus* (Moore and Plummer, 1940) has highly convex plates, and *S. papillatus* (Strimple, 1962) has very bulbous basals. *S. ornatus* Moore and Strimple, 1963, has very large nodes. *S. xerophilus* Lane and Webster, 1967, was assigned to *Stenopecrinus* with reservation since its base is flat, but all other features are similar to those of the type species.
Stenopeerinus hexagonus appears to have a rather short range. The holotype was collected from the Wann Formation at the Mound west of Bartlesville, Oklahoma. Our collections show no specimen of S. hexagonus from beds younger than the Argentine Limestone, but the lower range of this species has not yet been determined.

**Material studied:** Hypotypes: SUI 47101, Schildberg Construction Company Quarry, SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa, UNSM 16946, Iola Limestone, Cement Pant Quarry, NE¼ Sec. 2, T. 25 S., R. 18 E., Allen County, Kansas.

**Stenopecrinus planus** (Strimple, 1952) Strimple, 1961

*Fig. 7P-R*

**Synonym:**

*Perimestocrinus planus* Strimple, 1952

**Remarks**

Our collections indicate that *Stenopecrinus planus* ranges throughout most of the Missourian (cf. Pabian and Strimple, 1974b:9). The holotype was collected from a shale bed now mapped as part of the Barnsdall Formation (Virgilian), exposed at the abandoned tank dike in the hill some 4 km northeast of Copan, Oklahoma. The crinoidal horizon is well above a sandstone identified as the "Torpedo" Sandstone. Most of the crinoids in this exposure are strikingly similar to those found in the Basal Stoner Limestone of Nebraska and Kansas. Thus, we believe that the beds at the Copan locality should be critically re-examined in light of new biostratigraphic evidence to ascertain their exact age.

**Material studied:** Hypotypes: UNSM 16947, abandoned quarry, SW¼ SW¼ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

**Stenopecrinus impressus** (Moore and Plummer, 1940) Knapp, 1969

*Fig. 5F-H*

**Synonym:**

*Perimestocrinus impressus* Moore and Plummer, 1940

**Remarks**

*Stenopecrinus impressus* was described on the basis of a holotype from the Keechi Creek Limestone and a paratype from the East Mountain Shale, Mineral Wells Formation. The Keechi Creek Limestone is of about the same age as the Bethany Falls-Winterset interval of Iowa and Nebraska. The East Mountain Shale is of Late Desmoinesian age. Our collections suggest a range as high as the Argentine Limestone.

**Material studied:** Hypotype: UNSM 16919, abandoned quarry, SW¼ SW¼ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

**Genus Retusocrinus** Knapp, 1969

**Type species:** *Retusocrinus lobatus* (Moore and Plummer, 1940).

**Diagnosis**

(Modified after Knapp, 1969:373.) Cup low, bowl-shaped, having narrow, distinct to shallow basal concavity; infrabasals subhorizontal, basals with distal tips visible in side view of cup; plate sutures slightly impressed; outline of cup hexagonal to sub-circular, due to wide notches between radials and wide posterior interradius. Arms unknown.

**Other species included:** *Retusocrinus laxus* (Strimple, 1951).

**Range:** Middle and Upper Pennsylvanian (Desmoinesian-Missourian). USA: Texas, Kansas, Missouri, Iowa, and Nebraska.

**Retusocrinus laxus** (Strimple, 1951) Knapp, 1969

*Fig. 5A-C*

**Synonym:**

*Plaxoerinus laxus* Strimple, 1951

**Remarks**

*Retusocrinus laxus* was described from the Lake Bridgeport Shale at Bridgeport, Texas. These beds are thought to be equivalent to the Upper Missourian Stanton beds of Kansas and Nebraska. Our collections include specimens of *R. laxus* from the Basal Stanton of Nebraska. Pabian and Strimple (1980:17-18) reported *R. laxus* from the Ervine Creek Limestone (Middle Virgilian) of Iowa. The oldest known occurrence is in the Iola Limestone (Middle Missourian), which suggests a very long range for *R. laxus.*

Genus *Perimestocrinus* Moore and Plummer, 1938

Type species: *Perimestocrinus nodulifer* (Miller and Gurley, 1890).

Diagnosis

(Modified after Moore and Plummer, 1938:281.) Dorsal cup bowl-shaped with flaring sides; base with sharply im­pressed concavity; infrabasals 5, small, partly covered colum­nar cicatrix at bottom of concavity; basals 5, proximal parts included in basal concavity, but main part forming lower slope of cup, subequal; radials 5 with peneplenary facets sloping outward; anals 3, anal X and right tube-plates projecting above summit of radials. Arms uniserial; PBrI axillary; SBri quadrangular; anal tube long with 2 respiratory slits on each side; and stem round.

Other species included: *Perimestocrinus granuliferus* (Miller and Gurley, 1894); *P. ibexensis* Strimple and Board­man, 1971; *P. nevadaensis* Lane and Webster, 1966; *P. oasis* Lane and Webster, 1966; *P. parvus* (Miller and Gurley, 1894); *P. teneris* Moore and Plummer, 1938.

Remarks

The genus *Perimestocrinus* has been poorly understood by past workers, the problems arising from specimens that do not show the characters of the type species having been placed in the genus. After re-examining *Perimestocrinus* while docu­menting crinoids from the Stull Shale of Nebraska and Kansas, we include only those species that have all the characters of the type species.

Range: Pennsylvanian (Morrowan–Virgilian) and “Lower Permian” (Wolfcampian). USA: Nevada, Texas, Oklahoma, Kansas, Missouri, and Nebraska.

*Perimestocrinus nodulifer* (Miller and Gurley, 1894) Moore and Plummer, 1938

Fig. 7L–N

Synonyms:

*Hydreinocrinus noduliferus* Miller and Gurley, 1894

*Perimestocrinus noduliferus* (Miller and Gurley) Moore and Laudon, 1944

Remarks

Moore and Plummer (1938:281) indicated that the holotype of *Perimestocrinus nodulifer* was collected from the Argentine Limestone Member of the Wyandotte Formation. Our collections show that *P. nodulifer* probably ranges as high as the Basal Stoner Limestone Member of the Stanton Formation. Our collections include no specimen of *P. nodulifer* from a bed older than the Argentine Limestone, but *P. teneris* Moore and Plummer, 1938, indicates the genus to be as old as Morrowan. *P. teneris* closely resembles *P. nodulifer* except for a nodose development on the plate surfaces of the latter. Moore and Strimple (1973:76) believe that *P. teneris* may have given rise to the type species of *Perimestocrinus* as well as to the typical *Stenopecrinus*.

Material studied: Hypotype: UNSM 16917, abandoned Cedar Creek Quarry, SW¼ SW¼ Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

Genus *Vertigocrinus* Knapp, 1969

Type species: *Vertigocrinus subtilis* (Moore, 1939).

Diagnosis


Other species included: *Vertigocrinus politus* (Moore, 1939); *V. calyculus* (Moore and Plummer, 1940); *V. parilis* (Moore and Plummer, 1940); *V. gloukosensis* (Strimple, 1951).

Range: Upper Pennsylvanian (Missourian–Virgilian). USA: Texas, Oklahoma, Kansas, Nebraska, and Iowa.

*Vertigocrinus parilis* (Moore and Plummer, 1940) Knapp, 1969

Fig. 7O

Synonym:

*Plaxocrinus parilis* Moore and Plummer, 1940

Remarks

*Vertigocrinus parilis* is most likely to be confused with *Vertigocrinus gloukosensis* (Strimple, 1951), but the latter
species has much more bulbous basals. *Vertigocrinlls subtilis* (Moore, 1939) has a relatively higher cup and a flattened posterior interradius. *V. calculus* (Moore and Plummer, 1940) has more deeply impressed sutures, and *V. politus* (Moore, 1939) has a very constricted, narrow posterior interradius.

A paratype of *Vertigocrinlls parilis* was collected from the Argentine Limestone at Lake of the Forest in Wyandotte County, Kansas. Our collections suggest that *V. parilis* has a fairly long range. Pabian and Strimple (1974a:283) identified *V. parilis* in the Plattsburg Formation of Nebraska and it may occur in strata as old as the Winterset Limestone in southeastern Kansas.

**Material studied:** Hypotypes: SUI 38181 (4 specimens), Schildberg Construction Company Quarry, SE 1/4 SW 1/4 Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa. UNSM 16915, SW 1/4 SW 1/4 Sec. 7, T. 12 N., R. 12 E., Cass County, Nebraska.

**Genus Sciadiocrinus** Moore and Plummer, 1938

*Type species:* Sciadiocrinus (*Hydreionocrinus*) acanthophorus (Meek and Worthen, 1870).

**Diagnosis**

(From Strimple and Moore, 1973:75.) Cup low, with broad, shallow-to-deep basal concavity; infrabasals subhorizontal to gently down-flaring; basals down-flaring to subhorizontal, not visible in side view of cup (except elongated CD basal); radial plates bulging, reaching to basal plane; posterior interray narrow. Arms uniserial, branching isomotously more than once.

*Other species included:* Sciadiocrinus cascus Moore and Strimple, 1973; *S. confertus* (Moore and Plummer, 1940); *S. crassacanthus* Moore and Plummer, 1938; *S. disculus* Moore and Plummer, 1940; *S. harrisae* Moore and Plummer, 1940; *S. humilis* Strimple, 1951; *S. invaginatus* (Strimple, 1951); *S. llanoensis* Strimple and Watkins, 1969; *S. obesus* (Moore and Plummer, 1940); *S. platybasis* (White, 1876); *S. plautus* Strimple, 1975.

**Range:** Pennsylvanian ( Morrowan–Virgilian). USA: Texas, Oklahoma, Kansas, Missouri, Nebraska, Iowa, and Illinois.

**Sciadiocrinus confertus** (Moore and Plummer, 1940)

*Strimple, 1961*

**Fig. 5D-E**

**Synonym:**

*Schistocrinus confertus* Moore and Plummer, 1940

**Remarks**

*Sciadiocrinus confertus* is easily recognized by its shallow basal concavity. This species is fairly long-ranging, the holotype having been collected from the Brannon Bridge Limestone Member of the Millsap Lake Formation (Desmoinesian) in Parker County, Texas. Because of thin plates, cups of this species are uncommon, but it appears to be represented by numerous loose plates. *S. confertus* may range as high as the Stoner Limestone Member of the Stanton Formation in Nebraska.

**Material studied:** Hypotype: UNSM 16949, Farley Limestone Member, Wyandotte Formation, Lone Star Cement Company Quarry, Bonner Springs, Kansas.

**Superfamily Zeacrinitacea** Bassler and Moodey, 1943

**Family Exocrinidae** Strimple and Watkins, 1969

**Genus Exocrinus** Strimple, 1949

*Type species:* Exocrinus multiramis Strimple, 1949.

**Diagnosis**

Cup shallow, commonly cone-shaped with infrabasals subhorizontal or down-flared. Radials dominate cup plates, 3 analss in specialized arrangement i.e., radial in CD position followed by anal X to the left, and right tube-plate to right, with superior surfaces forming a horizontal plane. Fusion of brachials (hypepinnulation) common.

*Other species included:* Exocrinus desmoinesensis Strimple, 1949; *E. pallium* Strimple, 1949; *E. virgilensis* Strimple, 1949; *E. wanni* Strimple, 1949; *E. moorei* (Lane and Webster, 1966).

**Remarks**

Strimple placed *Exocrinus* with the Ampelocrinidae in his original description of the genus and indicated *Cymbiocerinus* Kirk and *Ampelocrinus* as possible ancestors, with the evolution to *Exocrinus* occurring by fusion of 2 primibrachials *Stellarocrinus* was also considered, but it was less favored because of marked differences in the radial articular facets. Strimple and Watkins (1969:184) indicated that *Oxynocrinus* Strimple and Watkins, 1969, had arms somewhat comparable to *Ampelocrinus*, except that the former has no syzygial pairs and the latter has paired primibrachials.
**R. K. Pabian and H. L. Strimple**

**Range**: Pennsylvanian (Desmoinesian-Virgilian)—"Lower Permian" (Wolfcampian). USA: Oklahoma, Kansas, Texas, Nebraska, Illinois, Iowa, and Nevada.

**Exocrinus multirami** Strimple, 1949

Fig. 8R

*Synonym:* Exocrinus sp., cf. *E. multirami* of Strimple and Moore, 1971

**Remarks**

The holotype of *Exocrinus multirami* was collected from somewhat younger rocks than the specimen presently under study (SUI 38170). The holotype has keel-like ridges medially situated along the length of the primibrachials. These features are not as distinct on the specimen under study but are nonetheless present. As in the holotype, the A primibrachial is largest and B and E are shortest. Several hypotypes from the Frances Shale (Kansas City, Missourian) of Oklahoma (OU 4487 and OU 6164) also have strongly keeled brachials (see Strimple and Moore, 1971b: Figs. 4-3 and 9-2), but in all other respects they appear to be identical to the specimen under study.

**Exocrinus wanni** Strimple, 1949, has a cup with more erect sides and an oblique radianal-posterior basal suture. *E. desmoinensis* Strimple, 1949, has a very shallow cup, an elongated posterior basal, and reduced radianal. *E. virgilensis* Strimple has an elongated radianal with a single facet for succeeding plates. *E. moorei* (Lane and Webster, 1966) has shorter primibrachials and shows a stronger tendency toward a reduction in number of secundibrachials.

A topotype of *E. multirami* (UNSM 11859) shows 3 secundibrachials in the A, B, and E rays. *E. desmoinensis* Strimple (1971b: Figs. 9-2) indicated that the hypotype of *E. multirami* had 3 secundibrachials in all but the outer half-ray of the C arm. Lane and Webster (1966: Fig. 10) showed the B and C arms of the holotype of *E. moorei* to have only 2 secundibrachials. A hypotype of *Exocrinus wanni* (IGS 42P92D) (see Strimple and Moore, 1971a; Plate 8, Fig. 2) appears to have only 2 secundibrachials in the other half of the D arm.

**Material studied**: Hypotype: SUI 38170, collected by Arnel Priest from the Argentine Umestone Member, Wyandotte Formation, Kansas City Group, Missourian (Upper Pennsylvanian), Schildberg Construction Company Quarry, SE¼, SW¼, Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

**Order Disparida Moore and Laudon, 1943**

**Superfamily Allagecrinacea Carpenter and Etheridge, 1881**

**Family Allagecrinidae Carpenter and Etheridge, 1881**

**Genus Isoallagecrinus Strimple, 1966**

*Isoallagecrinus* sp.

Fig. 9C

**Remarks**

This species is represented by two specimens, the larger of which is a partial cup with an estimated width of 4.3 mm and height of 2 mm. The smaller specimen (average width 3.6 mm, height 1.5 mm) is a complete cup with some primibrachs attached, which, however, has been distorted by lateral compaction. The anal notch has not been observed, but distribution of arm facets appears to be C-1, D-3, E-1, A-2, and B-2. The large facet of A radial adjoins the E ray and the small facet is adjacent to B ray. This distribution is comparable to that of *I. lasallensis* reported by Strimple and Moore (1971a) except that species typically bears 2 arms on D radial rather than 3 although it is conceivable another arm might appear on a gerontic specimen. However, in such a development the last would probably be smaller than the other two. *I. bassleri* has 9 arms at a much younger (smaller) stage and dramatically displays plate porosity as well as a more stellate-appearing cup outline in plan view.

*I. copani* Strimple has a cup which is larger and proportionately taller than that of *Isoallagecrinus* sp. and supports 7 arms. The presently considered species apparently represents a stage within a lineage which found it advantageous to curtail the number of very small arms in A, B, and D rays.

**Material studied**: SUI 38182, 2 dorsal cups, Argentine Limestone Member, Wyandotte Formation, Missourian, Schildberg Construction Company Quarry, north side of Iowa State Highway 92, center east line SE¼ SW¼ Sec. 5, T. 25 N., R. 29 W., Madison County, Iowa.

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