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Some Late Pennsylvanian (Virgilian) Crinoids from Southeastern Nebraska and Southwestern Iowa

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Virgilian age rocks of Iowa and Nebraska contain important crinoid faunas and current collections help to establish distributions and tentative ranges of numerous species. A middle limestone-core shale fauna from the Cass Formation of Nebraska provides small, usually inornate species with close Missourian affinities. Other crinoids studied are from outside shales and upper limestones of the cyclothem and these are usually large, ornate species. Biserial arms are reported for the first time for *Sublobalocrinus* Knapp. The first report of flexible crinoids from Virgilian strata of the Iowa-Nebraska area is made here. Current collections of crinoids contain 40 species and 31 genera representing 19 families: new species or subspecies are; *Isoallagecrinus bassleri intermedius, Graffhamierinus gratesquus, Arrectocrinus iowensis, Pyndoxocrinus inornatus, Sublobacrinus kaseri, Contocrinus invaginatus, Apographiocrinus platybasis*. The species *Aesiocrinus luxuris* is referred to the genus *Moundocrinus*.

INDEX DESCRIPTORS: Crinoids; Pennsylvanian, Missourian, Virgilian; Shoemaker Limestone, Haskell Limestone, Cass Formation; Plattsmouth Limestone, Oread Formation; Jackson Park Shale, Stull Shale, Kanwaka Formation; Doniphan Shale, Beil Limestone, Avoca Limestone, Lecompton Formation; Ost Limestone, Tecumseh Formation; Ervine Creek Limestone, Deer Creek Formation; Calhoun Shale. Cass County, Nebraska, Mills, Montgomery, Fremont Counties, Iowa.

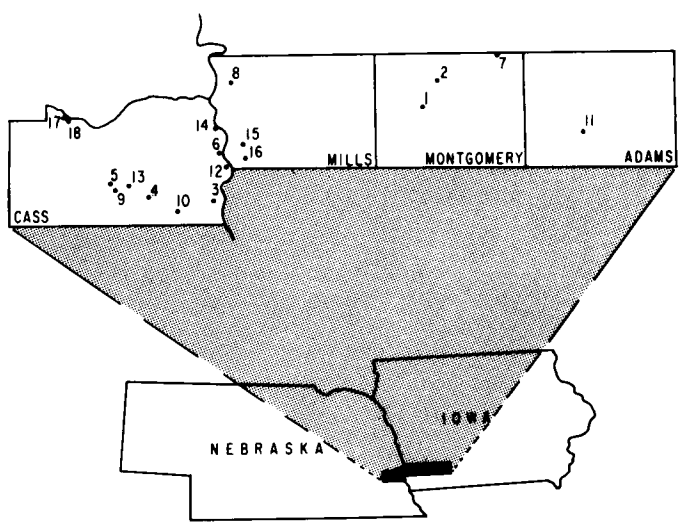
A large number of Virgilian crinoid species have been described from the North American midcontinent region by Moore (1939, 1940), Moore and Plummer (1940) and Strimple (1947, 1948, 1949a and b, 1951b and c, 1952, 1963) but practically all of these species were reported from Kansas, Oklahoma, or Texas. Very few crinoids of Virgilian age have been reported from extensive exposures in Iowa and Nebraska. Geinitz (1866) described *Delocrinus (Cyathocrinus) inflexus* from Nebraska. Strimple and Priest (1969) described *Graffhamicrinus (Tholiacrinus) decapodos* from the Stull Shale of Nebraska, and Pabian and Strimple (1974a, 1974b, 1977b) described Virgilian crinoids from the Beil, Ervine Creek, and Coal Creek Limestones, and the Stull Shale of Nebraska and Iowa, as well as three species of *Arrectocrinus* Knapp from Nebraska and Iowa. Neither the geographic nor stratigraphic distribution of these fossils is well documented in Iowa and Nebraska. This study embraces nearly 200 specimens that have been collected mainly from upper limestones and outside shales of cyclothems as defined by Heckel and Baesemann (1975) and Heckel (1977). As is the case with Missourian crinoid faunas studied by Pabian and Strimple (unpublished manuscript), Virgilian crinoids tend to show the greatest abundance and diversity near the cores of cyclothems. These crinoids are normally small, inornate species. Such a fauna occurs in the transgressive facies of the Cass Formation. Virgilian crinoids from the outside shales and regressive, upper limestones are usually large, ornate species as are their Missourian predecessors.

The crinoids described or reported in this study were collected from the locations shown in Text-fig. 1 and given in Appendix I. Stratigraphic horizons were determined from data of Hershey *et al* (1960), Burchett and Reed (1967), Schrott (1966), and unpublished sections of Burchett, Burchett and Prichard, Dixon and Erdenberger, and Wood.

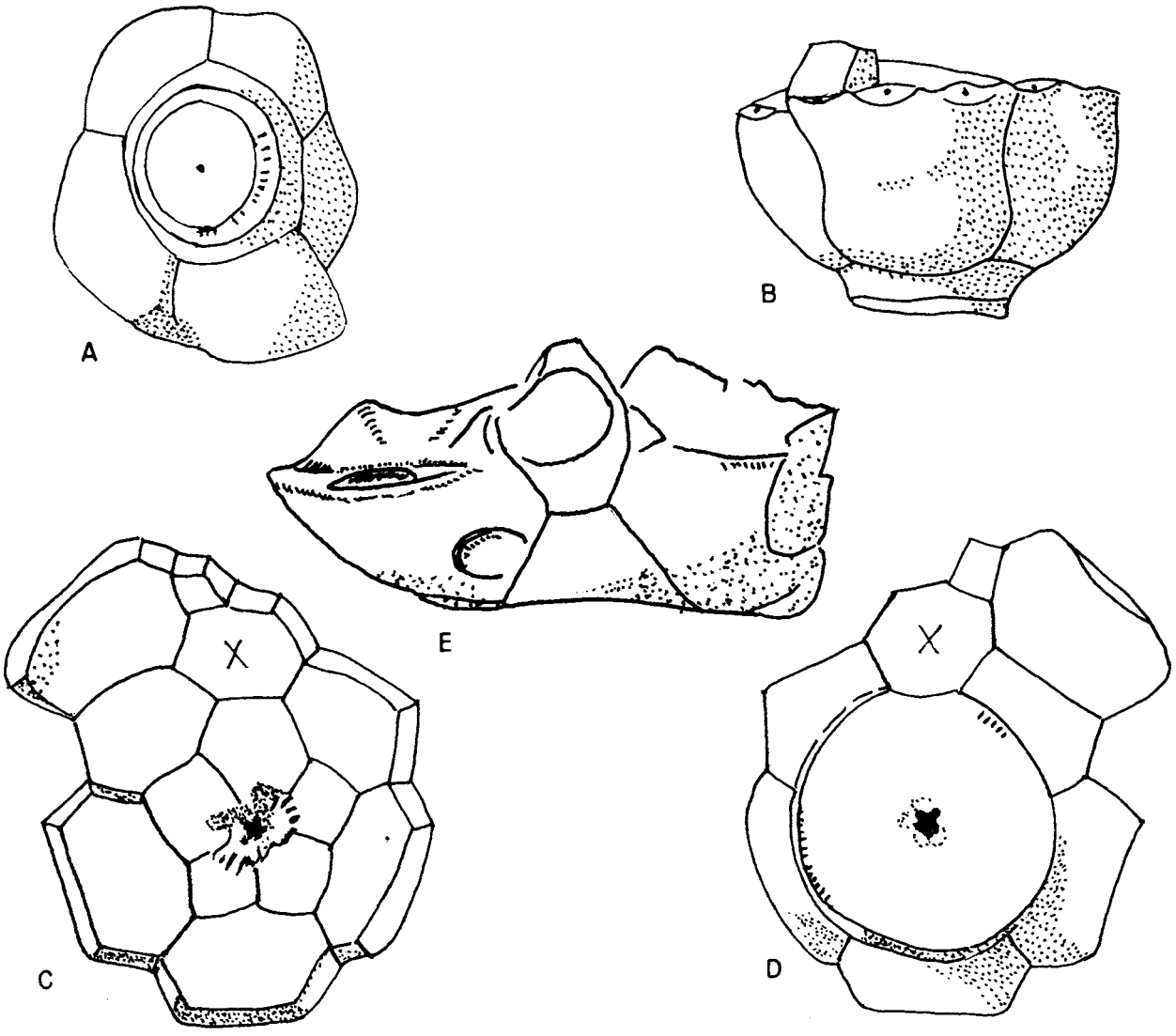
The transgressive facies of the Cass Formation (Shoemaker Limestone, Little Pawnee Shale, and lower Cass Limestone) seems to mark an important crisis point in crinoid evolution. Pabian and Strimple (1978) indicated that crinoids in the lower part of the South Bend Limestone of Nebraska showed Missourian affinities. The crinoids from the core of the Cass cyclothem consists of species that were present in Missourian strata. None of the Cass crinoid species have been found in younger strata. The data on hand suggests that crinoids began their transition from Missourian to Virgilian forms in South Bend time and completed the transition in Cass time. Sedimentologic factors complicate the picture. The lower South Bend crinoids are of a transgressive assemblage normally associated with middle limestone, core shale, and basal upper limestones whereas those of the upper South Bend are a regressive assemblage that is normally associated with the upper limestone. We believe that the transition of Missourian to Virgilian crinoids is not well understood partly because the South Bend Limestone of Nebraska may have been misinterpreted by earlier workers. The cyclothem model put forth by Heckel and Baesemann (1975) and Heckel (1977) appears to hold throughout deposition of Douglas and Shawnee sediments. We have examined the evolution of crinoids in both the transgressive and regressive facies of the cyclothem as separate entities. We suggest that evolution of transgressive crinoid faunas may have shown somewhat different trends, because there is greater stability of physical factors found at maximum transgression (depth) than for crinoids found in the outside shales or upper limestones where physical factors are usually more variable.

Measurements for holotype specimens of new cladid inadunate species are given in Appendix II.

Ranges of Pennsylvanian crinoids are often difficult to establish because of sporadic distribution and provincialism of these fossils.



Text-fig. 1. *Index map showing locations from which fossil crinoids were collected.*



Text-fig. 2. *Virgilian crinoids from Iowa and Nebraska. A, B.* Isoallagecrinus bassleri intermedius *Strimple and Pabian new subspecies, basal and E ray views of holotype, UNSM-16775, X12.5. C, D.* Paramphicrinus *sp. cf.* P. oklahomaensis *Strimple, summit and basal views, X6. E.* Vertigocrinus gloukosensis *(Strimple), posterior interray of hypotype, SUI-45861, X6.*

Pabian and Strimple (1979, in press) have shown that some of these problems can be overcome by observing systematic changes in populations. Increased volume of specimens in our collections have provided more insight into the matter. Tentative ranges are given in the discussion of most species.

SYSTEMATIC PALEONTOLOGY

Phylum ECHINODERMATA Leske, 1778
Subphylum CRINOZOA Matsumoto, 1929
Class CRINOIDEA Miller, 1821
Subclass FLEXIBILIA Zittel, 1895
Order SAGENOCRINIDA Springer, 1913
[*nom. correct.* Moore *in* Moore, Lalicker & Fischer, 1952]
Superfamily SAGENOCRINITACEA Bassler, 1938
[*nom. trans.* Moore & Strimple, 1973]
Family EURYOCRINIDAE Moore & Strimple, 1973
Genus PARAMPHICRINUS Strimple & Moore, 1971
PARAMPHICRINUS sp. cf. P. OKLAHOMAENSIS Strimple, 1939
Text-figs. 2 c-d

DISCUSSION

A single dorsal cup with a few proximal brachials and two plates in the posterior interray is available for study. The specimen appears to have close affinity with *Paramphicrinus oklahomaensis* which species has been fully documented by Strimple (1939) from the Wann Formation (Missourian) of Oklahoma and by Strimple and Moore (1971) from the Bond Formation (Missourian) of Illinois.

Externally the entire infrabasal and basal circlets, as well as proximal portions of the basals, are covered by the broad columnar cicatrix. Internally there is no evidence of infrabasals which have apparently been completely fused with and/or absorbed by the basals. A depressed area, which is roughly in the form of five lobes, together with a complex of radiating grooves (nerve channels?) occupy the area. Posterior (CD) basal is larger and considerably longer than the other four basals. Anal X is rather large with facets above for reception of two subequal anal plates.

MATERIAL STUDIED

Hypotype, UNSM-16668, Calhoun Shale, Location 11.

Subclass INADUNATA Wachsmuth & Springer, 1885
Order DISPARIDA Moore & Laudon, 1943
[*nom. correct.* Moore *in* Moore, Lalicker & Fischer, 1952]
Superfamily ALLAGECRINACEA Carpenter & Etheridge, 1881
[*nom. trans.* Moore & Strimple, 1973]
Family ALLAGECRINIDAE Carpenter & Etheridge, 1881
Genus ISOALLAGECRINUS Strimple, 1966
Type species. Isoallagecrinus bassleri (Strimple, 1938)

DISCUSSION

Isoallagecrinus bassleri, type species of the genus, is relatively distinctive and common in upper Missourian rocks of northeastern Oklahoma and southeastern Kansas. Strimple, 1951, reported *Isoallagecrinus bassleri* var. [sub. sp.] *nodosus* from the Lake Bridgeport Shale (= Wolf Mountain Shale, Graford Formation) of Wise County, Texas, and also described a coexisting form as *I. bassleri status.* Strimple, 1966, elevated the subspecies *status* to the specific level. The only readily apparent difference between mature specimens of *status* and *nodosus* is the nodose exterior of the radial plates in the latter.

The inornate species *I. graffhami* (Strimple) occurs in the Stull Shale (Virgilian) of Kansas and *I. eaglei* Strimple in the Red Eagle Formation (Oklahoma) and Bird Spring Formation (Nevada) of Wolfcampian (Lower Permian) age. Mature specimens of *I. graffhami* are smaller than those of *I. bassleri* or *I. status* whereas *I. eaglei* is much larger than any of the other three species.

With the discovery of another form which has surface ornamentation, in this instance coalesced nodes, it appears desirable to propose a subspecific division pending a better understanding of the interrelationships. The name *I. bassleri intermedius* new subspecies is described below.

RANGE

Upper Carboniferous-Permian; U.S.A., U.S.S.R., Indonesia.

ISOALLAGECRINUS BASSLERI INTERMEDIUS Strimple & Pabian, new subspecies.
Text-figs. 2 a-b

DIAGNOSIS

Like *Isoallagecrinus bassleri* s.s except radials do not project below summit of basals, nodes on radials are coalesced, and there may be one or two less arms than found in specimens of the basic species of comparable size (i.e. 10 as compared to normal compliment of 11 or 12 arms).

DESCRIPTION

Cup moderately low, asymmetrical with shortest diameter from posterior to anterior. Basals three, smallest in BC interradius, circlet broad-based with short lateral sides; columnar attachment area of proximal columnal is smooth except for short crenulations just inside a rim marking the perimeter of the segment; lumen quinquelobate with lobes in radial positions; lateral sides of basal circlet expand slightly and are readily visible in side view of cup. Proximal ends of five radials are subhorizontal with a sharp demarcation between basals and radials; pronounced curvature of radials take place as the maximum width of cup is approached which, together with sharply incised interradial sutures and decided increase in distal width of multiple arm bearing plates, creates an almost spherical contour to those elements in their lower portions. Multiplicity of arms requires expansion of the distal portions of involved radials with additions apparently taking place from right to left, the most bizarre being E radial with three arm facets and which enroaches strongly on A radial which has only one large arm. Mid-portions of radials bear nodes which have coalesced; the transverse ridges on the articular surfaces are accentuated by outer ligament pits and each ridge bears a pore (nerve canal?) in mid-length. The left shoulder of C radial bears a diagonal facet for reception of the anal plate and the right side of D radial is also slightly affected; a wedge-shaped gap, termed a parabolic notch by Kirk (1936) extends toward the interior. Arm facet distribution is; A ray-1, B ray-3, C ray-1 plus anal, D ray-2, E ray-3. The right arm facet on E ray is larger than other arms of the ray.

DISCUSSION

Only two specimens of the new subspecies are available. One is too poorly preserved to be more than supportive and has been designated a paratype. Plates of the posterior side of the other specimen, the holotype, are partially dislocated but in other respects it is well preserved. They are of comparable size and are judged to be adult. The specimens are in the size range of young adults of *I. bassleri* or *I. status,* however, both of those species have one or two more arms at a comparable size (stage of development).

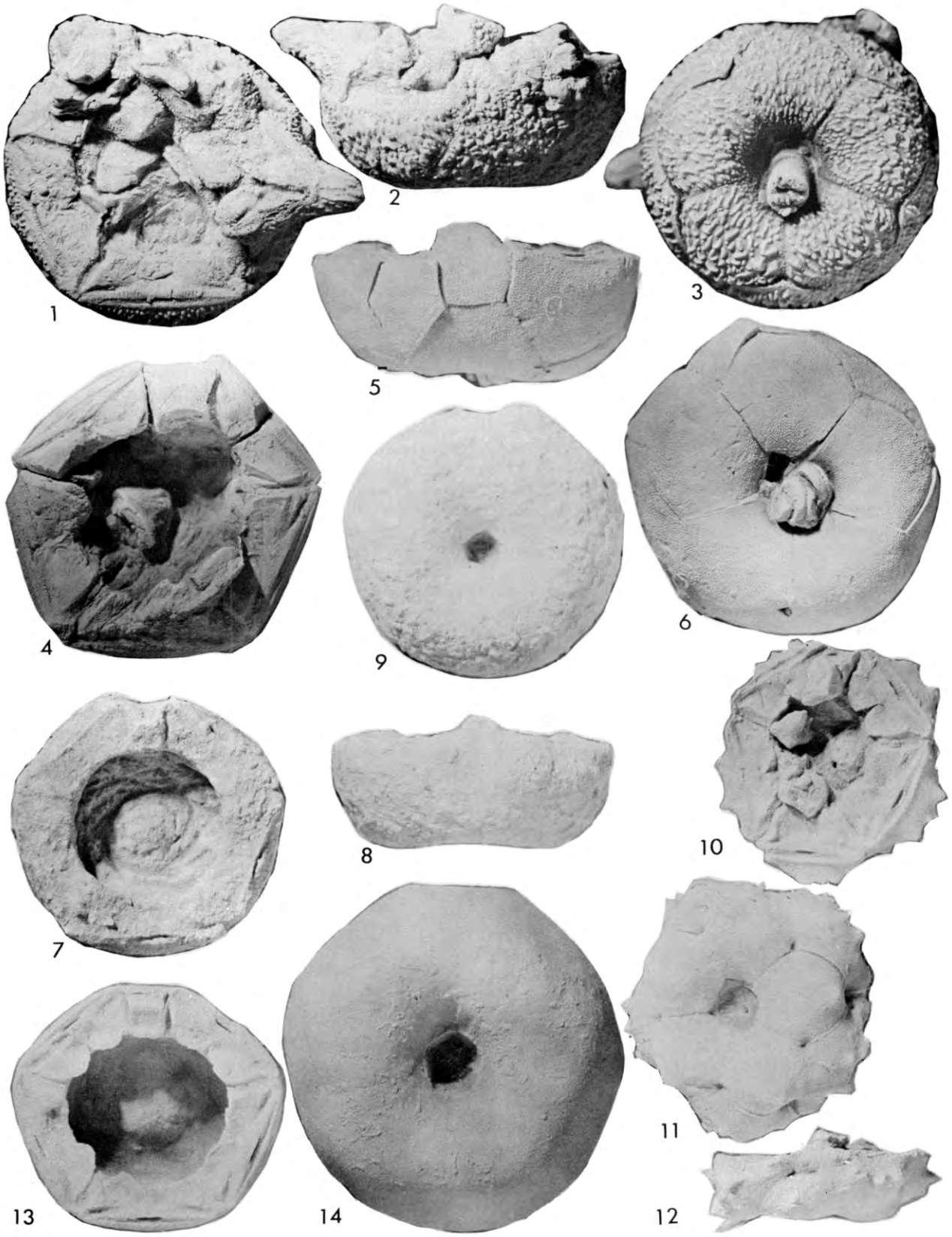
Measurements of holotype in millimeters; maximum width of cup 5.7, height of cup 3.1, height of basal circlet 0.4, diameter of proximal columnal 2.3.

MATERIAL STUDIED

Holotype, UNSM-16775 and paratype, UNSM-16676, Curzon Limestone Member, Topeka Formation, Location 3.

Order CLADIDA Moore & Laudon, 1943
Suborder POTERIOCRININA Jaekel, 1918
Superfamily ERISOCRINACEA Wachsmuth & Springer, 1886
Family DIPHUICRINIDAE Strimple & Knapp, 1966

Plate 1. *Virgilian crinoids from Iowa and Nebraska. 1-3.* Graffhamicrinus magnificus *(Strimple), summit, posterior, and basal views of hypotype, UNSM-15719, X3. 4-6.* Graffhamicrinus subcoronatus *(Moore & Plummer), summit, posterior, and basal views of hypotype, UNSM-16676, X2. 7-9.* Graffhamicrinus paucinodus *(Moore & Plummer), summit, basal, and posterior views of hypotype, UNSM-16796, X3. 10-12.* Graffhamicrinus grotesquus *Pabian and Strimple, new species, summit, basal, and posterior views of holotype, UNSM-16748, X3. 13-14.* Arrectocrinus iowensis *Pabian and Strimple new species. 13. Hypotype, UNSM-16696, summit view, X3. 14. Hypotype, UNSM-16938, basal view. X2.*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Genus GRAFFHAMICRINUS Strimple, 1961
GRAFFHAMICRINUS MAGNIFICUS Strimple, 1947
Plate 1, figs. 1-3

DISCUSSION

Graffhamicrinus magnificus is one of the most widespread, long-ranging species in the Virgilian. The present study embraces 17 cups. It is known to occur in rocks as old as Late Missourian age (Stanton Formation) of Nebraska and in rocks as young as Middle Virgilian (Deer Creek Formation). *Graffhamicrinus magnificus* is a large, ornate species that is normally restricted to the outside shales or upper limestones of the Midcontinent cyclothems. All samples of *G. magnificus* studied to date show individuals that have a tendency to eliminate or expel the anal X plate from the CD interradius. This tendency is not exhibited in *G. subcoronatus,* the other *Graffhamicrinus* species in Virgil age rocks of Nebraska and Iowa.

MATERIAL STUDIED

Hypotypes UNSM-16702 — UNSM-16704, Plattsmouth Limestone, Oread Formation, Location 1. Hypotypes UNSM-16594 — UNSM-16598, Beil Limestone, Lecompton Formation, Location 2. Hypotypes UNSM-16635 — UNSM-16637, Doniphan Shale, Lecompton Formation, Location 2. Hypotype, UNSM-16718, Doniphan Shale, Lecompton Formation, Location 4. Hypotypes, UNSM-15706, UNSM-15713, Beil Limestone, Lecompton Formation, Location 5. Hypotype, UNSM-16759, Ervine Creek Limestone, Deer Creek Formation, Location 9. Hypotypes, UNSM-15719 — UNSM-15720, Haskell Limestone, Cass Formation, Location 18.

GRAFFHAMICRINUS SUBCORONATUS (Moore & Plummer) 1940
Plate 1, figs. 4-6

DISCUSSION

This species is represented by 28 cups, and, as is the case in most other Virgilian age units, *Graffhamicrinus subcoronatus* is more prolific than *G. magnificus*. Like *G. magnificus, G. subcoronatus* is essentially confined to the outside shales and upper limestones of the midcontinent cyclothems as defined by Heckel and Baesemann (1975) and Heckel (1977). This species appears to have a more widespread geographic distribution than does *G. magnificus;* the holotype of *G. subcoronatus* was collected from the lower Missourian Keechi Creek Member of the Mineral Wells Formation of Palo Pinto County, Texas. Both *G. magnificus* and *G. subcoronatus* are successful, long-ranging species that are most commonly found in the early, transgressive and late, regressive facies of the Nebraska-Iowa cyclothem.

MATERIAL STUDIED

Hypotypes UNSM-16705 — UNSM-16709, SUI-45838-SUI-45840, Plattsmouth Limestone Member, Oread Formation, Location 1. UNSM-16599, UNSM-16600, Beil Limestone Member, Lecompton Formation, Location 2. UNSM-16653-UNSM-16660, Doniphan Shale Member, Lecompton Formation, Location 2. UNSM-16716, UNSM-16717, Doniphan Shale Member, Lecompton Formation; Location 4. UNSM-16719 — UNSM-16721, Spring Branch Limestone Member, Lecompton Formation, Location 4. UNSM-15705, Beil Limestone Member, Lecompton Formation, Location 5. UNSM-15714, UNSM-15715, Kanwaka Shale Formation, Location 5; UNSM-16676 — UNSM-16677, Doniphan Shale Member, Lecompton Formation, Location 8. UNSM-16746, UNSM-16747, Ervine Creek Limestone, Deer Creek Formation, Location 10. UNSM-16672, Plattsmouth Limestone Member, Oread Formation, Location 16. UNSM-15717, Shoemaker Limestone, Cass Formation, Location 18.

GRAFFHAMICRINUS PAUCINODUS (Moore & Plummer) 1940
Plate 1, figs. 7-9

DISCUSSION

Current collections reveal that this species does not range above the Heumader Shale Member, Oread Formation, in the midcontinent (See Pabian and Strimple, 1974a, p. 265). The holotype was collected from the Palo Pinto Limestone (Middle Missourian) in Wise County, Texas. *Graffhamicrinus paucinodus* may be in the lineage including *G. subcoronatus,* the latter differing by having a deeper, more roughened cup.

MATERIAL STUDIED

Hypotype, UNSM-16796, Haskell Limestone, Cass Formation, Location 17.

GRAFFHAMICRINUS DECAPODOS (Strimple & Priest), 1969

DISCUSSION

Current collections indicate that *Graffhamicrinus decapodos* ranges from late Missourian age (Stanton) units through early Virgilian (Kanwaka) age units. The species is well documented in Nebraska and Kansas but is unknown from the Iowa section.

MATERIAL STUDIED

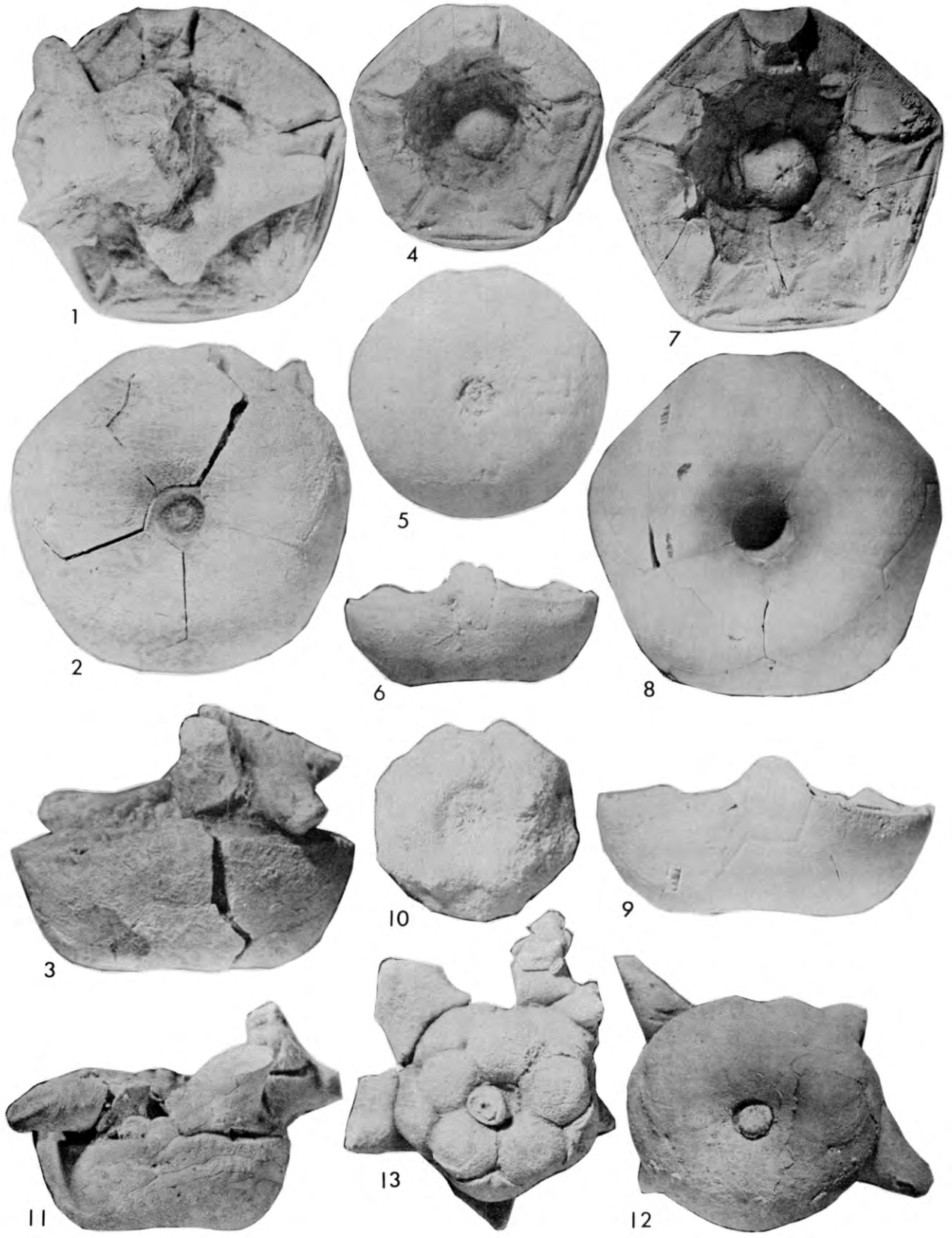
Hypotype, UNSM-16797, Haskell Limestone Member, Cass Formation, Location 17.

GRAFFHAMICRINUS GROTESQUUS Pabian & Strimple, new species
Plate 1, figs. 10-12

DESCRIPTION

This species is based on a single cup with a deep, broad, funnel-like basal concavity. Five infrabasals form a hemispherical circlet with a pentagonal outline that is confined to the upper third of the concavity.

Plate 2. *Virgilian crinoids from Iowa and Nebraska. 1-3.* Arrectocrinus iowensis *Pabian and Strimple new species, summit, basal, and posterior views of holotype, UNSM-16698, X3. 4-6.* Pyndaxocrinus inornatus *Pabian and Strimple new species, summit, basal, and posterior views of holotype, UNSM-16749, X3. 7-9.* Delocrinus vulgatus *Moore & Plummer, summit, basal, and posterior views of hypotype, UNSM-16649, X2. 10.* Perimestocrinus nodulifer *(Miller & Gurley), basal view of hypotype, UNSM-16784, X4. 11, 12.* Endelocrinus alleghaniensis *(Burke), posterior and basal views of hypotype, UNSM-16651, X3. 13.* Endelocrinus tumidus *(Strimple), basal view of hypotype, UNSM-16729, X3.*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The proximal quarter of each of the five basals is confined to the basal concavity; the medial half of the basals are nearly flat-lying and extend outward to form nearly horizontal, spinose projections. The distal quarter of the basals recurve sharply to form deep dimples at the basal-interradial confluence. Such a dimple also occurs at the radial-interbasal confluence. The CD basal is hexagonal and truncated to receive the rectangular anal X plate; all others are pentagonal. The five radials are tapered pentagons; their proximal tips reach almost to the basal plane of the cup; the medial portions are bulbous and have 3 or 4 horizontally extended nodes, C and D are separated by anal X.

The radial articular facets are plenary. The outer marginal ridge is sharp and separated from a well-defined, denticulate transverse ridge by a deep, narrow, ligament pit furrow. The articular facets are level, but impressed below the cup summit. There is a deep lateral furrow that is bounded by a short oblique ridge. The lateral ridge is well-defined and the adsutural slope is about 45 degrees. Lateral lobes are parabolic and create a deeply incised, V-shaped intermuscular notch that connects directly to a divided central pit.

In addition to the coarse projections, the cup surface is covered with minute granules. The stem impression is round and bears a lumen that appears to be round.

DISCUSSION

This species appears to be derived from an undescribed species of Missourian age from Nebraska which has the horizontal projections confined to the basal plates only. *G. grotesquus* is the only described species of *Graffhamicrinus* to have pronounced horizontal projections of basal and radial plates.

MATERIAL STUDIED

Holotype, UNSM-16748, Ervine Creek Limestone Member, Deer Creek Formation, Location 9.

Family CATACRINIDAE Knapp, 1969
Genus ARRECTOCRINUS Knapp, 1969
ARRECTOCRINUS STANLEYI Pabian & Strimple, 1977b

DISCUSSION

The specimens at hand show that the dorsal cup of *A. stanleyi* may reach a maximum diameter of about 25 mm. This is nearly twice as large as the holotype. The known range of the species is from the Doniphan Shale through the Beil Limestone.

MATERIAL STUDIED

Hypotypes, UNSM-16618 — UNSM-16622, Doniphan Shale Member, Lecompton Formation, Location 2.

ARRECTOCRINUS HOPPERI Pabian & Strimple, 1977

DISCUSSION

The known range for this species is from the Ervine Creek Limestone through the Curzon Limestone; *Arrectocrinus hopperi* differs from *A. stanleyi* in having a low cup.

MATERIAL STUDIED

Hypotypes, UNSM-16736 — UNSM-16739, Curzon Limestone Member, Topeka Formation, Location 3.

ARRECTOCRINUS COMMINUTUS Pabian & Strimple, 1974a

DISCUSSION

Tentative range zone of *Arrectocrinus comminutus* is from the Plattsmouth Limestone, Oread Formation, through the Curzon Limestone, Topeka Formation.

MATERIAL STUDIED

Hypotypes, SUI-45858 — SUI-45859, Plattsmouth Limestone Member, Oread Formation, Location 1.

ARRECTOCRINUS IOWENSIS Pabian & Strimple, new species
Plate 1, figs. 13-14; Plate 2, figs. 1-3

DESCRIPTION

This species is based on ten dorsal cups. The infrabasal circlet contains five, kite-shaped plates that are confined to a broad, but shallow, basal concavity. The round stem impression is crenulated and forms a nearly vertical well in the infrabasal circlet. AB, BC, DE, and EA basals are pentagonal; CD is hexagonal, to receive a barrel-shaped anal X plate; the proximal third of the basals slopes gently out of the basal concavity, the medial third forms the basal plane of the cup, and the distal third rises upward in a parabolic arc to about half the height of the cup. The five radials are epaulette shaped; they extend to about ¾ the distance to the cup base; the proximal part slopes upward at about 80 degrees and the medial area is nearly vertical; they recurve inward near the cup summit. C and D radials are separated by a barrel-shaped anal X plate.

Radial articular facets are level and plenary. Outer marginal ridge is well defined and is separated from a sharp, denticulate transverse ridge by a deep ligament pit furrow and ligament pit; the lateral furrow is well impressed and bounded by an oblique ridge. The lateral ridge is sharp and the adsutural slope is quarter-round in cross section. Muscle area grades into a semi-circular lateral lobe and slopes inward gently to a broad, shallow central pit that connects to a short intramuscular notch by a short furrow.

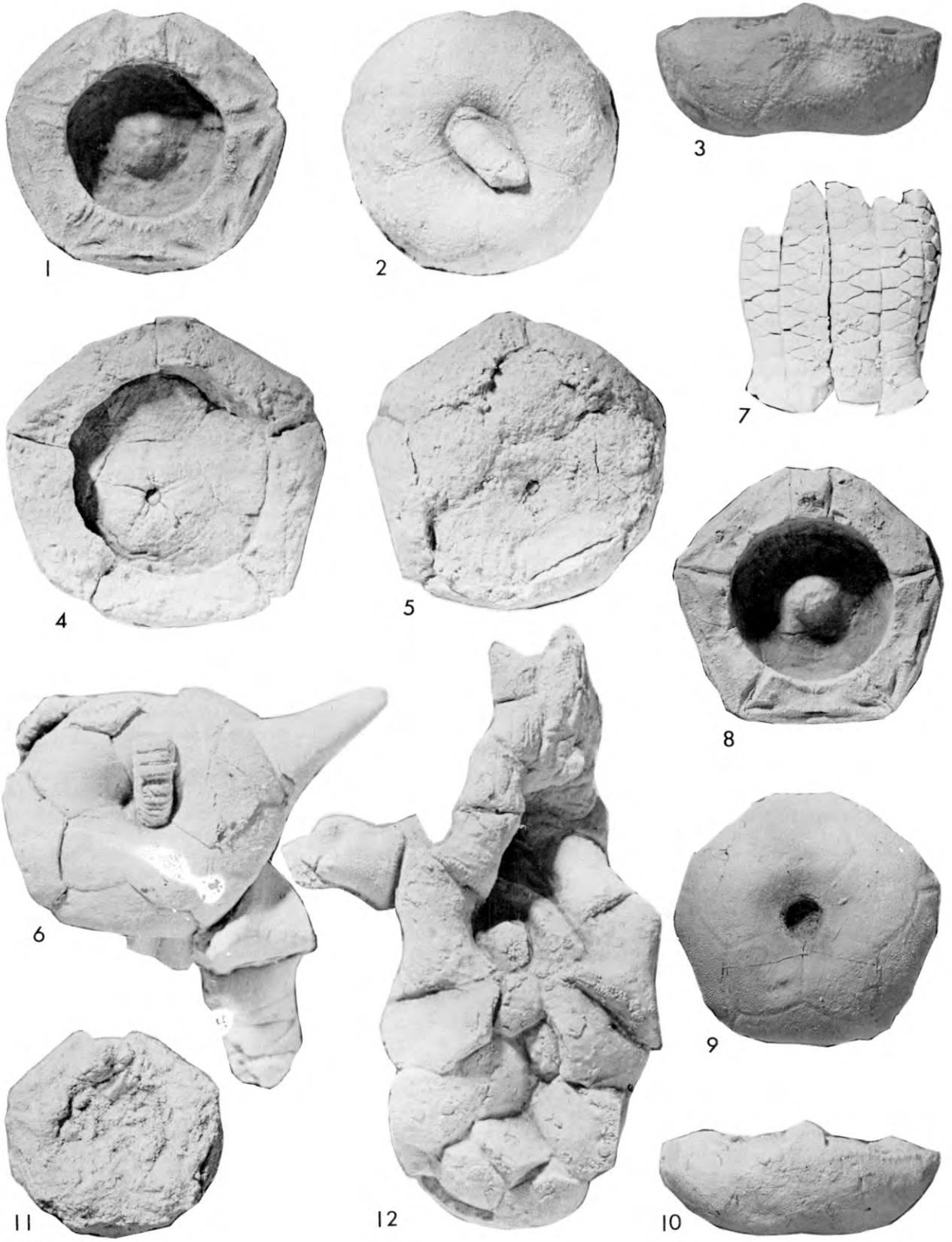
PBrl axillary, spinose. SBrl trapezoidal, followed by unknown number of cuneiform SBrBr plates.

Cup plates are smooth with but a few fine granules of ornamentation; stem round, crenulated, with pentalobate lumen.

DISCUSSION

Arrectocrinus iowensis appears to be most closely related to *A.*

Plate 3. *Virgilian crinoids from Iowa and Nebraska. 1-3.* Delocrinus hemisphericus *(Shumard), summit, basal, and posterior views of hypotype, UNSM-16787, X3. 4, 5.* Neocatacrinus *sp. cf.* N. protensus *(Moore & Plummer), summit and basal views of hypotype, UNSM-16760, X3. 6-10.* Sublobalocrinus kaseri *Pabian & Strimple new species. 6. Holotype, UNSM-16680, basal view, X3. 7. Arms associated with hypotype, UNSM-16623, X2. 8-10. Paratype, UNSM-16685, summit, basal, and posterior views, X3. 11.* Perimestocrinus nodulifer *(Miller & Gurley), summit, view of hypotype, UNSM-16784, X4. 12.* Gloukosocrinus *sp., hypotype, UNSM-16795, posterior view, X3.*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comminutus from which it differs in having smooth plates rather than being finely granulose; *A. hopperi* has a very low profile and *A. stanleyi* has non-spinose primibrachials.

MATERIAL STUDIED

Holotype, UNSM-16698; paratypes, UNSM-16692 — UNSM16697, UNSM-16699 — UNSM-16701, SUI-45841 — SUI45849, Plattsmouth Limestone Member, Oread Formation, Location 1. Hypotype, UNSM-16789, Haskell Limestone Member, Cass Formation, Location 17.

Genus PYNDAXOCRINUS Knapp, 1969
PYNDAXOCRINAS INORNATUS Pabian & Strimple, new species
Plate 2, figs. 4-6

DESCRIPTION

This species is based on a flat-based dorsal cup. The infrabasal circlet is pentagonal and nearly covered by a round columnar cicatrix with a pentalobate lumen. AB, BC, DE and EA basals are pentagonal, CD being truncated to receive a six-sided anal X plate. The proximal area of the basals is confined to a very shallow, broad concavity; the medial areas form the cup base, and the distal areas rise about 2/5 the height of the cup in a circular arc. Five radials are epaulette shaped; the proximal tip reaches the basal plane; they rise upward in a circular cross section about ¾ the cup height and then recurve near the summit. C and D radials are separated by anal X. Cup plates smooth.

Radial articular facets plenary, nearly level. Wide, outer ligament ridge separated from transverse ridge by ligament pit and furrow. Oblique ridge and lateral ridge form a prominent swelling that is bounded by adsutural slope and lateral furrow, and blunt lateral lobe that grades into a broad muscle area that slopes to a central pit leading to the intramuscular notch through a narrow furrow.

DISCUSSION

Pyndaxocrinus inornatus has a cup of low profile compared to *P. gerdesi*, which is also covered by many fine granules. *P. separatus* is covered with fine granules and has a shallowly impressed base.

MATERIAL STUDIED

Holotype, UNSM-16749, Ervine Creek Limestone, Deer Creek Formation, Location 10.

Genus ENDELOCRINUS Moore & Plummer, 1940
ENDELOCRINUS TUMIDUS (Strimple), 1939
Plate 2, fig. 13

DISCUSSION

Endelocrinus tumidus appears to be a rather long ranging species. In the midcontinent it first appears in the lower Missourian age Winterset Limestone, and ranges upward to at least the Church Member, Howard Limestone, of Virgilian age. *Endelocrinus tumidus* occurs with *E. allegheniensis* (Burke) in Virgil strata; the former has more tumid plates than the latter, and only slightly protruded primibrachials as compared to spinose PBrl in *E. allegheniensis*.

MATERIAL STUDIED

Hypotypes, SUI-45874 — SUI-45875, Plattsmouth Limestone Member, Oread Formation, Location 1. UNSM-16729, Beil Limestone, Lecompton Formation, Location 3. UNSM-16791 — UNSM-16792, Haskell Limestone Member, Cass Formation, Location 17.

ENDELOCRINUS sp. cf. E. ALLEGHENIENSIS (Burke) 1932
Plate 2, figs. 11-12

DISCUSSION

Endelocrinus allegheniensis is not common in the midcontinent but has a tentative range from the Doniphan Shale Member, Lecompton Formation, through Ervine Creek Limestone, Deer Creek Formation. The range of *E. allegheniensis* may be sufficiently short to be fairly effective in correlation between the midcontinent and Appalachian region. It may occur with *Delocrinus vulgatus* Moore & Plummer but *E. allegheniensis* is easily differentiated by having spinose primibrachials and dimples at plate junctions, compared to non-spinose primibrachials and smooth plate junctions in *D. vulgatus*.

MATERIAL STUDIED

Hypotypes; SUI-45876 — SUI-45879, Plattsmouth Limestone Member, Oread Formation, Location 1; UNSM-16650 — UNSM-16652; Doniphan Shale, Lecompton Formation, Location 2.

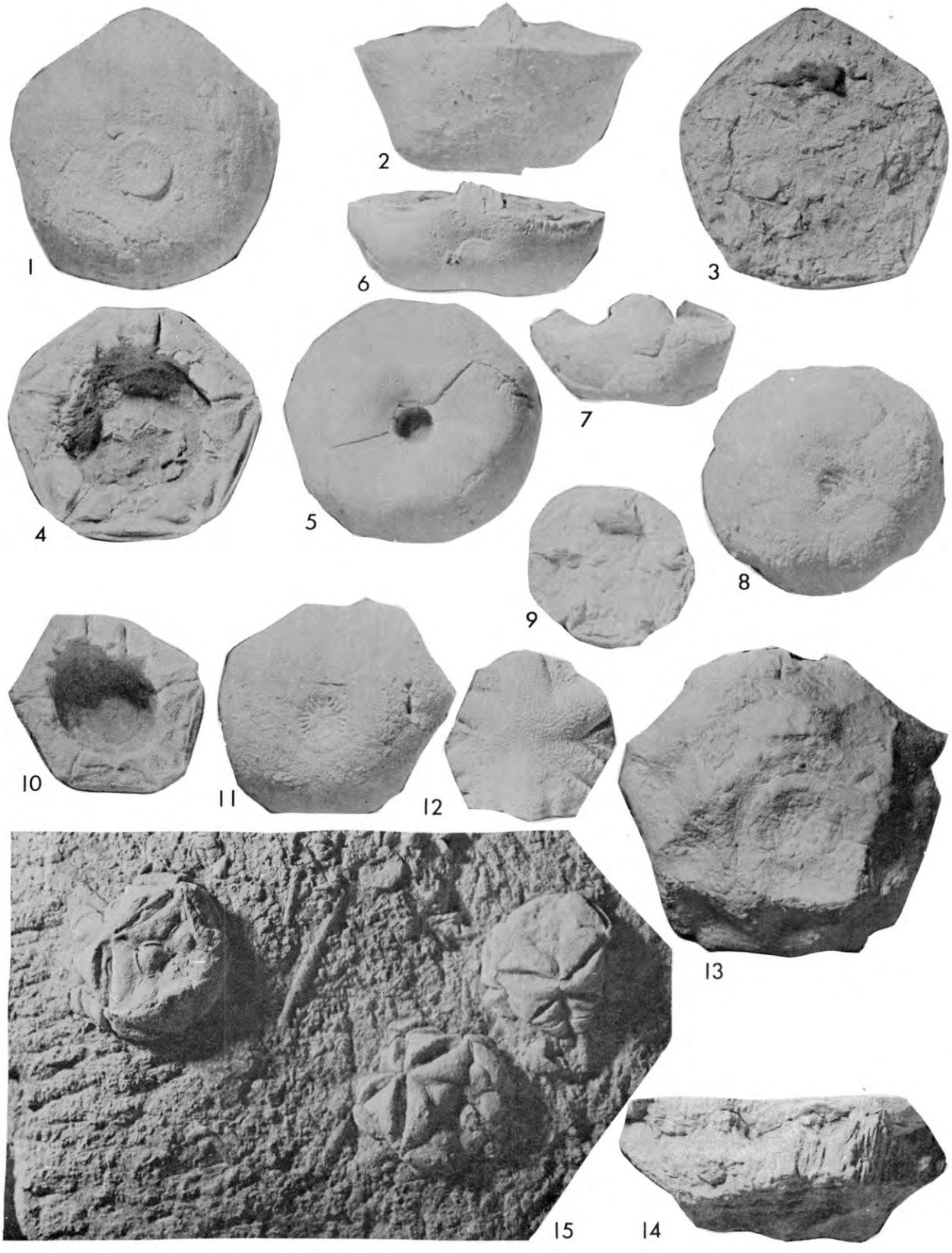
Genus DELOCRINUS Miller & Gurley, 1890
DELOCRINUS VULGATUS (Moore & Plummer) 1940
Plate 2, figs. 7-9

DISCUSSION

Delocrinus vulgatus has the widest range of any species of *Delocrinus* found in rocks of Virgilian age. Current collections indicate that it ranges through almost the entire Virgilian sequence; the lowest occurrence is probably in the Haskell Limestone Member of the Cass Formation and it occurs as high as the Brownville Limestone Member of the Wood Siding Formation. Although *D. hemisphericus* (Shumard) occurs in rocks as young as the Coal Creek Limestone Member, Topeka Formation, it appears to have given way to *D. vulgatus* in very early Virgilian time. *Delocrinus vulgatus* seems to have developed from *D. hemisphericus* by reducing the protrusion and height of the primibrachials and growing a much larger cup in fully mature individuals.

Throughout its range, *D. vulgatus* shows a tendency to expel the anal X plate but this appears to have been fortuitous as no descendant

Plate 4. *Virgilian crinoids from Iowa and Nebraska. 1-3.* Erisocrinus typus *Meek & Worthen, basal, posterior, and summit views of hypotype, UNSM-16790, X3. 4-6.* Contocrinus invaginatus *Pabian and Strimple new species, summit, basal, and posterior views of holotype, UNSM-16590, X3. 7-9.* Apographiocrinus platybasis *Pabian and Strimple new species. 7, 9. Posterior and summit views of holotype, UNSM-16774, X-3. 8. Basal view of holotype, UNSM-16774, X4. 10, 11.* Laudonocrinus *sp. cf.* L. subsinuatus *(Miller & Gurley), hypotype, SUI-45870. 10. Summit view, X3. 11. Basal view, X4. 12.* Exoriocrinus *sp., radianal plate only of hypotype, UNSM-16617, X3. 13, 14.* Stellarocrinus *sp. cf.* S. geometricus *(Moore & Plummer), basal and summit views of hypotype, UNSM-15718, X3. 15.* Oklahomocrinus supinus *Moore & Plummer, three crowns on slab, hypotype, UNSM-16762, X1.*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lineages entirely lacking anal X plates are known.

MATERIAL STUDIED

Hypotypes: UNSM-16710 — UNSM-16712, SUI-45865 — SUI-45869, Plattsmouth Limestone Member, Oread Formation, Location 1. UNSM-16638 — UNSM-16649, Doniphan Shale Member, Lecompton Formation, Horizon 9, Location 2. UNSM-16601 — UNSM-16606, Beil Limestone Member, Lecompton Formation, Location 3. UNSM-16732, Beil Limestone Member, Lecompton Formation, Location 4. UNSM-16722 — UNSM-16724, Spring Branch Limestone Member, Lecompton Formation, Location 4. UNSM-16714 — UNSM-16715, Doniphan Shale Member, Lecompton Formation, Location 5. UNSM-15703 — UNSM-15704, Beil Limestone Member, Lecompton Formation, Location 6. UNSM-16767 — UNSM-16770, Stull Shale Member, Kanwaka Formation, Location 8. UNSM-16678, Doniphan Shale Member, Lecompton Formation, Location 9. UNSM-16756, Ervine Creek Limestone Member, Deer Creek Formation, Location 10. UNSM-16750, Ervine Creek Limestone Member, Deer Creek Formation, Location 13. UNSM-16674, Plattsmouth Limestone Member, Oread Formation, Location 13.

DELOCRINUS HEMISPHERICUS (Shumard), 1858
Plate 3, figs. 1-3

DISCUSSION

Delocrinus hemisphericus appears to be a very long-ranging, successful form that survived through much of the Desmoinesian, all of the Missourian, and the lower half of the Virgilian. The success of *D. hemisphericus* may lie in the fact that the species does not seem to have been environmentally controlled; it is found in practically all depositional environments of the cyclothem. It is interesting to note that adults of *D. hemisphericus* from upper limestone and outside shales become significantly larger than adults from cyclothem cores.

MATERIAL STUDIED

Hypotypes; UNSM-16785 — UNSM-16787, Haskell Limestone Member, Cass Formation, Location 17.

Family PARADELOCRINIDAE Knapp, 1969
Genus NEOCATACRINUS Knapp, 1969
NEOCATACRINUS sp. cf. N. PROTENSUS (Moore & Plummer), 1940
Plate 3, figs, 4-5

DESCRIPTION

Dorsal cup low bowl-shaped. Infrabasals five, confined to broad and fairly shallow concavity. Basals five, pentagonal; proximal end in basal concavity, medial area makes up basal plane of cup, distal half rises in circular arc about half the cup height. Radials five, epaulette-shaped, with tips reaching almost to basal plane; they raise upward at about 60 degrees and recurve inward near cup summit. Cup plates probably originally smooth though as preserved roughened due to weathering. Stem round. Anal X not observed.

Radial articular facets poorly defined, plenary, nearly level. Outer marginal ridge, ligament pit furrow, ligament pit, and transverse ridge faint. Lateral ridges blunt, but adsutural slopes large and deep.

DISCUSSION

This species differs from *Neocatacrinus protensus* (Moore & Plummer) in having a comparatively broad and shallow basal concavity rather than the deep constricted one of the latter species. Because of poor preservation we hesitate to assign it to *N. protensus* or to propose a new species.

MATERIAL STUDIED

Hypotypes, UNSM-15707, Beil Limestone, Lecompton Formation, Location 5; UNSM-16760, Ervine Creek Limestone Member, Deer Creek Formation, Location 9; UNSM-15716, Shoemaker Limestone Member, Cass Formation, Location 18.

Genus SUBLOBALOCRINUS Knapp, 1969
SUBLOBALOCRINUS KASERI Pabian & Strimple, new species
Plate 3, figs. 6-10

DESCRIPTION

This species is represented by 38 low, discoid, and decidedly pentagonal dorsal cups with a deep, narrow, funnel-like basal concavity. The five infrabasals are small and are almost entirely covered by the round columnar cicatrix. Lumen is pentalobate. The stem impression is deep and forms a vertical cylinder. The proximal third of the five basals is within the basal concavity, the medial third forms the basal plane of the cup and the distal third rises in a circular arc about half the height of the cup. AB, BC, DE, and EA basals are pentagonal. CD basal is truncated to receive anal X. Five radials are epaulette shaped and rise in a circular arc nearly to the cup summit before recurving inward. C and D radials separated by anal X which may or may not be seen in posterior view of cup; anal X is hexagonal in the former case, and wedge shaped in the latter. Cup plates are smooth to finely granulose.

Radial articular facets are plenary and flat to sloping outward at up to 20 degrees. Outer marginal ridge is sharp and separated from denticulate transverse ridge by a deep, narrow ligament pit and ligament pit furrow. Lateral furrow is deeply impressed and bounds a high oblique ridge that joins with the lateral ridge. Adsutural slope about 45 degrees but not deep. Lateral lobes round and slope into broad central pit that connects to a deep intramuscular notch by a short furrow.

PBrl plates spinose, axillary. SBrl is trapezoidal and SBr2 is cuneiform. Biserial branching is attained by SBr3 in A ray of holotype.

DISCUSSION

This species is easily distinguished by its discoid, pentagonal cup. Arms found associated with a hypotype, UNSM-16623, are biserial and they swell midway, indicating a pyriform crown for *S. kaseri*. The

Plate 5. *Virgilian crinoids from Iowa and Nebraska. 1-3.* Moundocrinus luxuris *(Strimple), summit, posterior, and basal views of hypotype, UNSM-16730, X3. 4-6.* Polusocrinus rosa *Strimple, summit, posterior, and basal views of hypotype, UNSM-16727, X3. 7-9.* Anobasicrinus brevis *Strimple & Moore, summit, basal, and posterior views of hypotype, UNSM-16794, X3. 10.* Aglaocrinus compactus *(Moore & Plummer), posterior view of hypotype, UNSM-16614, X2. 11, 12.* Ulocrinus *sp. basal and summit views of infrabasal circlet only, hypotype, UNSM-16591, X3. 13.* Parulocrinus *sp. cf.* P. blairi *Miller & Gurley, left posterior view of hypotype, UNSM-16689, X2.*


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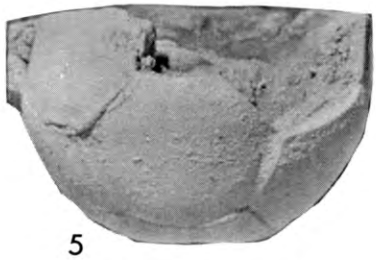
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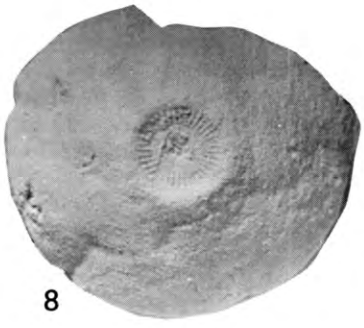
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specimen also indicates full biseriality was attained by SBr5. The arm structure may indicate a close relationship to *Lobalocrinus* Knapp.

Some of the specimens show a strong tendency to expel the anal X plate. This tendency is illustrated by the holotype of the type species of *Sublobalocrinus (Paradelocrinus iolaensis* Strimple). *Sublobalocrinus kaseri* differs from *S. iolaensis* in having more distinct plate sutures and from *S. planus* (White) by having a decidedly pentagonal outline.

The species is named for Kaser Construction Company which firm has allowed the authors access to their quarries.

MATERIAL STUDIED

Holotype, UNSM-16680, and paratypes, UNSM-16681 — UNSM-16688, Jackson Park Shale, Kanwaka Formation, Location 7. Hypotypes, SUI-45850 — SUI-45857, Plattsmouth Limestone Member, Oread Formation, Location 1. UNSM-16690 — UNSM-16691, Stull Shale, Kanwaka Formation, Location 1. UNSM-16623 — UNSM-16634, Doniphan Shale, Lecompton Formation, Location 2. UNSM-16607 — UNSM-16613, Beil Limestone, Lecompton Formation, Location 2. UNSM-16725, Avoca Limestone, Lecompton Formation, Location 3. UNSM-16713, Doniphan Shale, Lecompton Formation, Location 4. UNSM-16673, Spring Branch Limestone, Lecompton Formation, Location 8. UNSM-16679, Doniphan Shale, Lecompton Formation, Location 8. UNSM-16751 — UNSM-16752, Ervine Creek Limestone, Deer Creek Formation, Location 10. UNSM-16669 — UNSM-16671, Doniphan Shale, Location 14. UNSM-16788, Haskell Limestone Member, Cass Formation, Location 17.

Family DECADOCRINIDAE Bather, 1890
Genus GLAUKOSOCRINUS Strimple, 1951
GLAUKOSOCRINUS sp.
Plate 3, fig. 12

DISCUSSION

Because of poor preservation, we refrain from assigning this specimen to a species of *Glaukosocrinus*. This same species occurs in the Stoner Limestone (Missourian) or Nebraska and we will withhold the specific name for a subsequent study. The species is characterized by a smooth cup and heavy arms with an axillary PBrl followed by 6 or more zig-zag arranged SBr plates.

MATERIAL STUDIED

Hypotype, UNSM-16795, Haskell Limestone, Cass Formation, Location 17.

Family ERISOCRINIDAE Wachsmuth & Springer, 1886
Genus ERISOCRINUS Meek & Worthen, 1865
ERISOCRINUS TYPUS Meek & Worthen, 1865
Plate 4, figs. 1-3

DISCUSSION

Erisocrinus typus is a very long ranging form of doubtful stratigraphic value. Some middle Missourian forms such as those from the Wann Formation of Oklahoma and the Argentine Limestone of Nebraska and Iowa show a tendency to have collapsed bases but this condition appears to have become corrected by the end of the Missourian. *Erisocrinus typus* is not known to occur above the Haskell Limestone Member of the Cass Limestone (Lower Virgilian) in the midcontinent.

MATERIAL STUDIED

Hypotype, UNSM-16790, Haskell Limestone Member, Cass Formation, Location 17.

Family GRAPHIOCRINIDAE Wachsmuth & Springer, 1886
Genus CONTOCRINUS Knapp, 1969
CONTOCRINUS INVAGINATUS Pabian & Strimple, new species
Plate 4, figs. 4-6

DESCRIPTION

This species is based on 8 cups having mildly invaginated, fairly broad basal concavities. Five infrabasals are confined to the basal concavity and form a pentagonal circlet that is nearly covered by a deeply impressed, round columnar cicatrix with a pentalobate lumen. The distal ends of the infrabasals are mildly downflared. Basals five, AB, BC, DE, and EA pentagonal, CD truncated to receive barrel-shaped anal X plate. Proximal ends of basals included in basal concavity; medial portion forms a broad basal plane; distal half rises in a circular cross section about half the cup height. Proximal tips of all five radials reach to basal plane of cup from where the plates curve upward in a parabolic arc and are nearly vertical at cup summit. C and D radials separated by anal X, which rises above cup summit. Cup sutures mildly impressed; plates smooth, inornate.

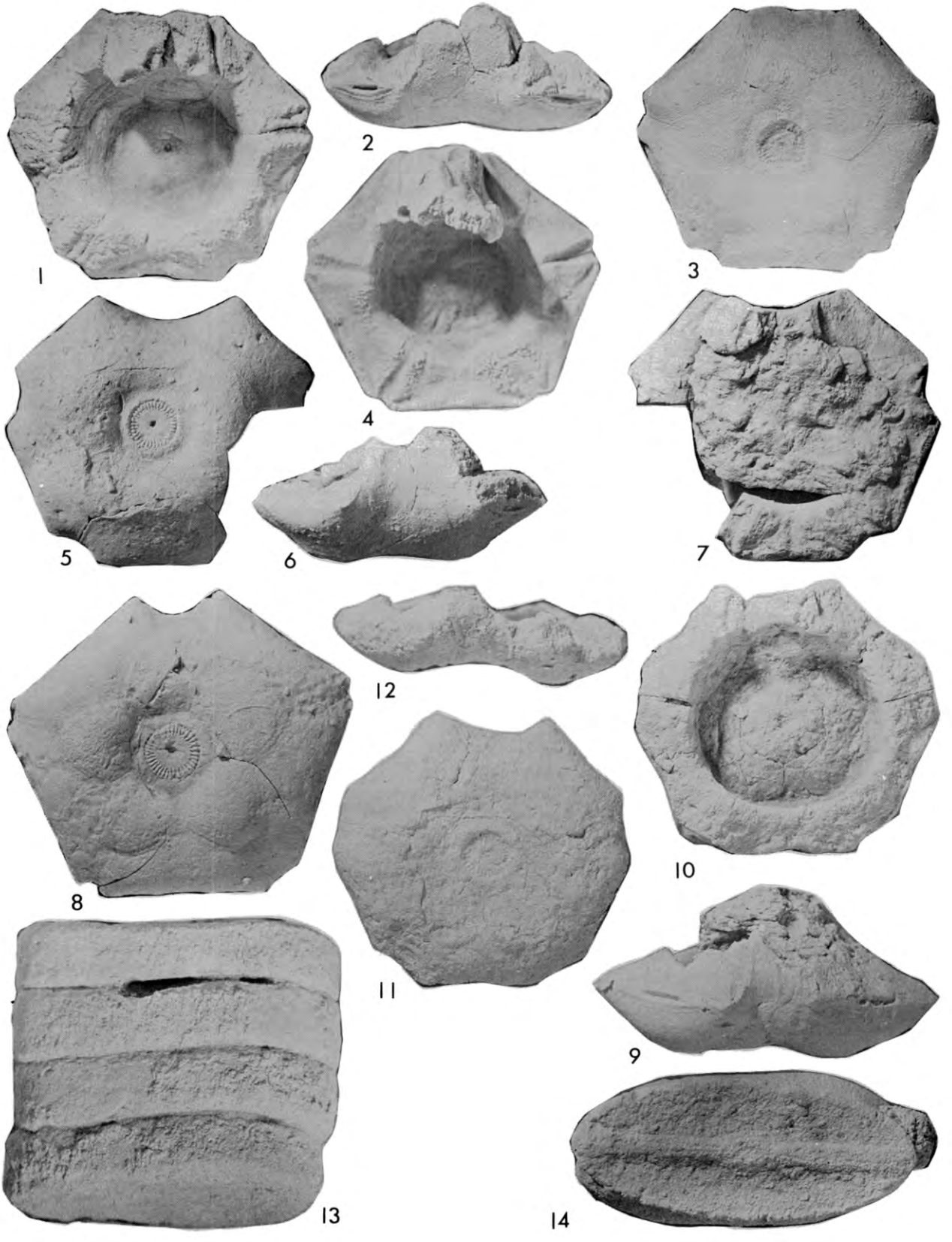
Radial articular facets plenary; outer-marginal ridge separated from transverse ridge by deep ligament pit and ligament pit furrow. Lateral furrows deep; oblique and lateral ridges high; adsutural slopes quarter-round in cross section. Muscle areas slope into deep, central pit that connects to a large intramuscular notch via a short furrow.

DISCUSSION

Contocrinus invaginatus is typified by its inornate, non-tumid plates and concave base with a deeply impressed columnar cicatrix; *C. stantonensis* (Strimple), *C. deflectus* (Strimple) and *C. kingi* (Moore & Plummer) all have planate or slightly concave bases and are delicately ornamented; *C. lineatus* (Strimple) has very tumid cup plates and fine ornamentation.

Some specimens of *C. invaginatus* display a tendency to form small pits at the meeting of angles between plates of the basal and radial circlets. This feature, together with the cup shape, indicates a tendency toward convergence of *Contocrinus* on *Endelocrinus* in so far as the cup form is concerned. *Contocrinus invaginatus* is most readily distinguished from *Endelocrinus* by the wide and short distal surface of the single anal plate (X ?). In *Endelocrinus* the distal surface of the anal plate is either about as long as it is wide or is longer than wide, and in any event much smaller than found in *Contocrinus*. When arms are

Plate 6. *Virgilian crinoids from Iowa and Nebraska. 1-4.* Plaxocrinus crassidiscus *(Miller & Gurley), 1-3. Summit, posterior, and basal views of hypotype, UNSM-16616, X3. 4. Summit view of hypotype, UNSM-16781, X3. Note lower plates of anal sac. 5-9.* Retusocrinus laxus *(Strimple) 5-7. Basal, posterior and summit views of hypotype, UNSM-15697, X2. 8, 9. Basal and posterior views of hypotype, UNSM-16937, X2. Note narrowed CD interray. 10-12.* Sciadiocrinus humilis *Strimple, summit, basal, and posterior views of hypotype, UNSM-15708, X2. 13, 14.* Platycrinites texanum *(Moore & Jeffords), lateral and end views, hypotype, SUI-45862, X3.*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present the two genera are readily separable because *Contocrinus* retains uniserial (cuneate secundibrachs) arms and *Endelocrinus* has biserial arms.

MATERIAL STUDIED

Holotype, UNSM-16590, paratypes, UNSM-16587 — UNSM-16589, Beil Limestone Member, Lecompton Formation. UNSM-16666, Doniphan Shale, Lecompton Formation, Location 2: hypotypes, SUI-45860, Plattsmouth Limestone Member, Oread Formation, Location 1. UNSM-15712, Beil Limestone Member, Lecompton Formation, Location 5. UNSM-16764 — UNSM-16765, Beil Limestone Member, Lecompton Formation, Location 6.

Superfamily APOGRAPHIOCRINACEA Moore & Laudon, 1943
Family APOGRAPHIOCRINIDAE Moore & Laudon, 1943
Genus APOGRAPHIOCRINUS Moore & Plummer, 1940
APOGRAPHIOCRINUS TYPICALIS Moore & Plummer, 1940

DISCUSSION

This species is long-ranging and appears to be of little value in making refined correlations. *Apographiocrinus typicalis* may prove to be of some paleoecological importance as it normally occurs in association with large, diverse echinoderm and other invertebrate faunas which are associated with a time of maximum transgression.

MATERIAL STUDIED

Hypotype, UNSM-16799, Ervine Creek Limestone, Deer Creek Formation, Location 10. Hypotype, UNSM-16766, Avoca Limestone, Lecompton Formation, Location 6. Hypotype, UNSM-16675, Avoca Limestone, Lecompton Formation, Location 12. Hypotype, UNSM-16793, Haskell Limestone Member, Cass Formation, Location 17.

APOGRAPHIOCRINUS PLATYBASIS Pabian & Strimple, new species
Plate 4, figs. 7-9

DESCRIPTION

This species is based on a single cup with a broad, nearly flat base. The infrabasal disk is a large, flat element composed of five, kite-shaped plates; the stem impression is about half the diameter of the disk and is deeply impressed. The lumen is round. The stem impression is coarsely crenulated. The surface of the infrabasal disk is somewhat rugose. The proximal third of the five basals are confined to a very shallowly concave to nearly flat base; the medial third of the basals is rounded; the distal third is nearly vertical, giving the basals a quarter-round appearance in cross section. The AB, BC, DE, and EA basals are pentagonal, and rise about ½ the height of the cup, CD is hexagonal, larger, and rises to about 2/3 the height of the cup, and is truncated for reception of a seven-sided anal X plate. The five radials are epaulette-shaped; their proximal tip extends nearly to the cup base; the radials rise upwards very steeply and recurve inward near the cup summit. At the AB, BC, DE, and EA interradi, the radials are extended into inwardly projecting prongs; C and D are separated by anal X. With the exception of the infrabasal circlet, cup plates are smooth.

Radial articular facets are well defined. Outer marginal ridge is sharp but small. Outer ligament furrow is deep, grading into deep, wide ligament pit. Muscle areas are broad, sloping inward to large central pit.

DISCUSSION

Apographiocrinus platybasis is defined by the flat, broad base of the cup. This species appears most closely related to *A. facetus* Moore & Plummer, found in the Missourian of Texas, from which it differs by having a much flatter, broader base and in lacking ornamentation near the radial articular facets.

MATERIAL STUDIED

Holotype, UNSM-16774, Beil Limestone, Lecompton Formation, Location 3.

Superfamily LOPHOCRINACEA Bather, 1899
Family LAUDONOCRINIDAE Moore & Strimple, 1973
Genus LAUDONOCRINUS Moore & Plummer, 1940
LAUDONOCRINUS sp. cf. L. SUBSINUATUS (Miller & Gurley), 1890
Plate 4, figs. 10-11

DISCUSSION

Although *Laudonocrinus* is fairly common in Missourian age rocks of the midcontinent, it is not well-known from Virgilian age strata. The specimen at hand is immature but most closely resembles *L. subsinuatus*. It is of interest to note that the proximal ends of the anal X and right tube plate rest directly upon the radianal. The articular facet on the C radial is somewhat underdeveloped due to the large right tube plate.

MATERIAL STUDIED

Hypotype, SUI-45870, Plattsmouth Limestone Member, Oread Formation, Location 1.

Family STELLAROCRINIDAE Strimple, 1961
Genus STELLAROCRINUS Strimple, 1961
STELLAROCRINUS sp. cf. S. GEOMETRICUS (Moore & Plummer), 1940
Plate 4, figs. 13-14

DISCUSSION

Pabian and Strimple (1977a) indicated that *Stellarocrinus* was very rare in Pennsylvanian strata of much of the midcontinent region, but rather common in Oklahoma, and abundant in the Bond Formation of Illinois. They indicated this distribution was of provincial importance in Missourian age strata. Such provincialism appears to hold through at least lower Virgil age units. Pabian and Strimple (in press) have further indicated that such provincialism may have been due, in part, to duration of transgression.

MATERIAL STUDIED

Hypotype, UNSM-15718, Haskell Limestone, Cass Formation, Location 18.

Family PELECOCRINIDAE Kirk, 1941
Genus EXORIOCRINUS Strimple & Moore, 1971
EXORIOCRINUS sp.
Plate 4, fig. 12

DISCUSSION

This genus is quite rare in Virgilian age strata; it is represented here

by a single CD basal plate which bears a facet for a radianal plate.

MATERIAL STUDIED

Hypotype, UNSM-16617, Beil Limestone Member, Lecompton Formation, Location 2.

Superfamily TEXACRINACEA Strimple, 1961
Family CYMBIOCRINIDAE, Strimple & Watkins, 1969
Genus OKLAHOMACRINUS Moore, 1939
OKLAHOMACRINUS SUPINUS Moore, 1939
Plate 4, fig. 15

DESCRIPTION

This species is represented by three partial crowns on a single slab. Infrabasals five, forming flat circlet. Basals five, bulbous, forming basal plane of cup; proximal portion in slight basal concavity, distal ends rising about half the cup height; CD basal truncated to receive rectangular anal X. Radials five, tapered pentagons, nearly flat lying with proximal tips reaching to basal plane of cup. C and D radials separated by anal X.

Radial articular facets slope at about 75 degrees outward. Facets indistinct in specimens at hand. PBr1 and PBr2 irregularly fused into single, wedge-shaped, axillary plates. SBr1, SBr2, SBr3, and SBr4 irregularly shaped trapezoids which decrease in size until SBr5. These are followed by at least 7 cuneiform SBr plates.

Cup surface smooth. Stem round.

DISCUSSION

Oklahomacrinus is not well-known from complete cups or crowns in Nebraska but numerous loose plates assignable to this genus occur throughout the Pennsylvanian-Permian section.

MATERIAL STUDIED

Holotype, NMNH-14106, Brownville Limestone, Wood Siding Formation, Osage County, Oklahoma. Hypotypes, UNSM-16762, Avoca Limestone, Lecompton Formation, Location 6. UNSM-16761, Ervine Creek Limestone Member, Deer Creek Formation, Location 9.

Genus MOUNDOCRINUS Strimple, 1939
MOUNDOCRINUS LUXURIS (Strimple, 1949a) new combination
Plate 5, figs. 1-3

DISCUSSION

Although originally described as *Aesiocrinus luxuris* the species is here referred to *Moundocrinus luxuris* (Strimple), new combination based on the short radial articular facets and the truncated distal end of anal X. *Aesiocrinus* is closely related to *Moundocrinus* but has longer radial articular facets and the distal end of anal X is faceted for the reception of two tube plates rather than one.

Moundocrinus luxuris appears to have a fairly long range. The holotype was collected from the Wann Formation exposed at the Mound west of Bartlesville, Oklahoma. Rocks here are probably equivalent in age to the Argentine Limestone Member of the Wyandotte Formation (Missourian). This species extends upward to at least the Curzon Member of the Topeka Formation (Virgilian).

MATERIAL STUDIED

Hypotypes, UNSM-16730, Beil Limestone, Lecompton Formation, Location 3. UNSM-16734 — UNSM-16735, Curzon Limestone Member, Topeka Formation, Location 3.

Family GALATEACRINIDAE Knapp, 1969
Genus GALATEACRINUS Moore, 1940
GALATEACRINUS sp. cf. G. GOSSAMERI Pabian & Strimple, 1974a

DISCUSSION

The specimen at hand is badly corroded and impossible to place in a described species. It is compared to *Galateacrinus gossameri* because of the narrow external ligament area. The holotype specimen (UNSM-7976) was collected from the Beil Limestone at Location 6. The collections at hand indicate that this species has an upward range into at least the basal Ervine Creek (Haynies) Limestone.

MATERIAL STUDIED

Holotype, UNSM-7976, Beil Limestone Member, Lecompton Formation, Location 6. Hypotype, UNSM-15710, Beil Limestone Member, Lecompton Formation, Location 5.

Superfamily AGASSIZOCRINACEA S.A. Miller, 1890
Family AMPELOCRINIDAE Kirk, 1942
Genus POLUSOCRINUS Strimple, 1951
POLUSOCRINUS ROSA Strimple, 1951
Plate 5, figs. 4-6

DISCUSSION

This species may prove to be of value in biostratigraphic correlation of Virgilian units between Iowa, Nebraska, and Oklahoma. It appears to have a fairly short range. The holotype was collected in a thin limestone in the shale about 35 feet below the Wildhorse Limestone Member of the Barnsdall Formation (Virgilian) exposed west of Skiatook, Osage County, Oklahoma.

MATERIAL STUDIED

Hypotype, UNSM-16727, Beil Limestone Member, Lecompton Formation, Location 3.

Family ANOBASICRINIDAE Strimple, 1961
Genus ANOBASICRINUS Strimple, 1961
ANOBASICRINUS BREVIS Strimple & Moore, 1971
Plate 5, figs. 7-9

DISCUSSION

The specimen of *Anobasicrinus brevis* at hand is the first recorded occurrence of this genus in Virgilian age strata. The holotype was described by Strimple & Moore (1971) from the LaSalle Limestone Member, Bond Formation, (Missourian), Livingston County, Illinois. The LaSalle Limestone is probably equivalent in age to the Iola Limestone of Oklahoma-Kansas.

MATERIAL STUDIED

Hypotype, UNSM-16794, Haskell Limestone Member, Cass Formation, Location 17.

Superfamily CROMYOCRINACEA Bather, 1890
Family CROMYOCRINIDAE Bather, May, 1890
Genus AGLAOCRINUS Strimple, 1961
AGLAOCRINUS COMPACTUS (Moore & Plummer), 1940
Plate 5, fig. 10

DISCUSSION

Aglaocrinus compactus is present throughout most of the Missourian and Virgilian rocks of the midcontinent. One specimen at hand (UNSM-16614) shows axillary PBrl and SBrl plates in the C and D rays, and axillary PBrl and non-axillary SBrl in the A and D rays.

MATERIAL STUDIED

Hyptoypes, UNSM-16614, Beil Limestone Member, Lecompton Formation, Location 2. UNSM-16755, Ervine Creek Limestone Member, Deer Creek Formation, Location 10.

Genus PARULOCRINUS Moore & Plummer, 1940
PARULOCRINUS sp. cf. P. BLAIRI (Miller & Gurley), 1890
Plate 5, fig. 13

DISCUSSION

Parulocrinus blairi is fairly common throughout the Missourian and Virgilian age units of Nebraska and Iowa. It is easily distinguished by large, smooth cups with unimpressed sutures in adult forms. The cup base is either flat or very slightly concave. Since all of the specimens at hand are damaged, we refrain from definite assignment to a species.

MATERIAL STUDIED

Hypotypes, UNSM-16664, Doniphan Shale Member, Lecompton Formation, Location 2. UNSM-16593, Beil Limestone Member, Lecompton Formation, Location 2. UNSM-15709, Beil Limestone Member, Lecompton Formation, Location 5. UNSM-16689, Jackson Park Shale, Kanwaka Formation, Location 7. UNSM-16753 — UNSM-16754, Ervine Creek Limestone Member, Deer Creek Formation, Location 10. UNSM-16668, Ervine Creek Limestone Member, Deer Creek Formation, Location 15.

Family ULOCRINIDAE Moore & Strimple, 1973
Genus ULOCRINUS Miller & Gurley, 1890
ULOCRINUS sp.
Plate 5, figs. 11, 12

DISCUSSION

Ulocrinus is represented only by infrabasal circlets in the collections at hand and cannot be identified to species.

MATERIAL STUDIED

Hypotypes, UNSM-16591 — UNSM-16592, Beil Limestone, Lecompton Formation, Location 2.

Superfamily PIRASOCRINACEA Moore & Laudon, 1943
Family PIRASOCRINIDAE Moore & Laudon, 1943
Genus PLAXOCRINUS Moore & Plummer, 1938
PLAXOCRINUS CRASSIDISCUS (Miller & Gurley), 1894
Plate 6, figs. 1-4

DISCUSSION

Plaxocrinus crassidiscus is probably the most abundant and longest ranging of the pirasocrinids in the midcontinent. It is known to range from at least lower Missourian through middle Virgilian strata. This species seems to have suffered no ill effects from changes in depositional environments; it occurs in shales and limestones and is found in both outside and near-core environments of the midcontinent cyclothems.

MATERIAL STUDIED

Hypotypes, UNSM-16692 — UNSM-16693, and SUI-45871 — SUI-45873, Plattsmouth Limestone Member, Oread Formation, Location 1. UNSM-16661 — UNSM-16663, Doniphan Shale Member, Lecompton Formation, Location 2. UNSM-16615 — UNSM-16616, Beil Limestone Member, Lecompton Formation, Location 2. UNSM-16728, Beil Limestone Member, Lecompton Formation, Location 3. UNSM-16731, Ervine Creek Limestone, Deer Creek Formation, Location 3. UNSM-16778 — UNSM-16782, Haskell Member, Cass Limestone, Location 17.

Genus PERIMESTOCRINUS Moore & Plummer, 1938
PERIMESTOCRINUS NODULIFER (Miller & Gurley), 1894
Plate 2, fig. 10; Plate 3, fig. 11

DISCUSSION

Perimestocrinus nodulifer is a fairly important component in late Missourian age crinoid faunas and its range is probably from the Argentine Limestone Member, Wyandotte Formation (Missourian) through the Haskell Limestone Member, Cass Formation (Lower Virgilian). The species is easily recognized by its flattened, impressed infrabasals and bulbous basals as well as the relatively small size of mature cups.

MATERIAL STUDIED

Hypotypes, UNSM-16783 — UNSM-16784, Haskell Limestone Member, Cass Formation, Location 17. UNSM-15718, Haskell Limestone Member, Cass Formation, Location 18.

Genus RETUSOCRINUS Knapp, 1969
RETUSOCRINUS LAXUS (Strimple), 1951a
Plate 6, figs. 5-9

DISCUSSION

Retusocrinus laxus is typically known from the Lake Bridgeport Shale of northcentral Texas. The species may range as high as the middle Virgilian Ervine Creek Limestone.

MATERIAL STUDIED

Hypotypes, UNSM-15697, Ervine Creek Limestone Member, Deer Creek Formation, Location 16. UNSM-16777, Haskell Limestone Member, Cass Formation, Location 17.

Genus VERTIGOCRINUS Knapp, 1969
VERTIGOCRINUS GLOUKOSENSIS (Strimple), 1951b
Text-fig. 2E

DISCUSSION

Next to *Plaxocrinus crassidiscus, Vertigocrinus gloukosensis* is

probably the most common and long-ranging pirasocrinid in the midcontinent. This species shows a strong tendency to expel the anal plates from the cup and one specimen (SUI-45861) has only a radianal plate in the anal X position (Text-fig. 2E). *Vertigocrinus gloukosensis* also does not appear to have suffered environmental restriction since its distribution parallels that of *Plaxocrinus crassidiscus*.

MATERIAL STUDIED

Hypotypes, SUI-45861, Plattsmouth Limestone Member, Oread Formation, Location 1. UNSM-16665, Doniphan Shale Member, Lecompton Formation, Location 2. UNSM-16733, Beil Limestone Member, Lecompton Formation, Location 3. UNSM-16740, Ervine Creek Member, Deer Creek Formation, Location 10.

Genus SCIADIOCRINUS Moore, 1938
SCIADIOCRINUS sp. cf. S. HUMILIS Strimple, 1951a
Plate 6, figs. 10-12

DISCUSSION

Sciadiocrinus humilis is known from a number of Virgilian age outcrops in the midcontinent. The holotype was collected from the Stull Shale Member, Kanwaka Formation, and it is also known to occur as high as the Ervine Creek Limestone Member, Deer Creek Formation.

MATERIAL STUDIED

Hypotypes, UNSM-15708, Beil Limestone Member, Lecompton Formation, Location 5. UNSM-16757 — UNSM-16758, Ervine Creek Limestone Member, Deer Creek Formation, Location 9.

Superfamily SCYTALOCRINACEA Moore & Laudon, 1943
Family BLOTHROCRINIDAE Moore, 1940
Genus ELIBATOCRINUS Moore, 1940
ELIBATOCRINUS sp.

DISCUSSION

Elibatocrinus was probably a rather common crinoid in Virgilian time; this is based on the abundance of infrabasal circlets that can be attributed confidentially to this genus. Because of thin cup plates, *Elibatocrinus* cups or crowns are rarely preserved intact.

MATERIAL STUDIED

Hypotypes (infrabasal circlets only) UNSM-16726, Avoca Limestone Member, Lecompton Formation, Location 3. UNSM-16763, Stull Shale Member, Kanwaka Formation, Location 6. UNSM-16741 — UNSM-16743, Ervine Creek Limestone Member, Deer Creek Formation, Location 15. UNSM-15721, Shoemaker Limestone Member, Cass Formation, Location 18.

Subclass CAMERATA Wachsmuth & Springer, 1885
Order MONOBATHRIDA Moore & Laudon, 1943
Family PLATYCRINITIDAE Bassler, 1938 (1942)
Genus PLATYCRINITES Miller, 1821
PLATYCRINITES sp.
Plate 6, figs. 13-14

DISCUSSION

Columnals of several species of *Platycrinites* occur throughout Pennsylvanian and Permian strata of the midcontinent. Such stems appear to be confined to the regressive facies of upper limestones in the cyclothem model of Heckel and Baesemann (1975).

MATERIAL STUDIED

Hypotypes, SUI-45862 — SUI-45864, Plattsmouth Limestone Member, Oread Formation, Location 1.

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APPENDIX 1

Register of Localities

Location No.	Legal Description
1	Quarry, NW¼ SW¼ sec. 17, T. 72 N., R. 38 W., Montgomery County, Iowa
2	Quarry, NE¼, sec. 27, T. 73 N., R. 38 W., Montgomery County, Iowa
3	Quarry, SE¼, sec. 17, T. 10 N., R. 14 E., Cass County, Nebraska
4	Quarry, SE¼, sec. 10 and NW¼ NE¼, sec. 15, T. 10 N., R. 12 E., Cass County, Nebraska
5	Quarry, SE¼ SE¼, sec. 34, SW¼ SW¼, sec. 35, T. 11 N., R. 11 E., Cass County, Nebraska
6	Quarry, NE¼ SW¼, sec. 9, T. 11 N., R. 14 E., Cass County, Nebraska
7	Quarry, NW¼ NE¼, sec. 5, T. 73 N., R. 36 W., Montgomery County, Iowa
8	Quarry, N½ SW¼ NW¼, sec. 29, T. 73 N., R. 43 W., Mills County, Iowa
9	Quarry, SE¼ NE¼ SE¼, sec. 2, T. 10 N., R. 11 E., Cass County, Nebraska
10	Quarry, SW¼ NE¼, sec. 29, T. 10 N., R. 13 E., Cass County, Nebraska
11	Quarry, SW¼, sec. 3, T. 71 N., R. 34 W., Adams County, Iowa
12	King Hill Quarry, E½ SW¼, sec. 22, T. 11 N., R. 14 E., Cass County, Nebraska
13	Quarry, SW¼ NE¼, sec. 6, T. 10 N., R. 12 E., Cass County, Nebraska
14	Quarry, W½ SE¼, sec. 20, T. 12 N., R. 14 E., Cass County, Nebraska
15	Quarry, C N½ NW¼, sec. 15, T. 71 N., R. 43 W., Mills County, Iowa
16	Quarry, SE¼ NW¼, sec. 27, T. 71 N., R. 43 W., Mills County, Iowa
17	Quarry, SW¼ SE¼, sec. 9, T. 12 N., R. 10 E., Cass County, Nebraska
18	Quarry, SW¼ NW¼, sec. 15, T. 12 N., R. 10 E., Cass County, Nebraska

APPENDIX 2

Measurements in MM of holotype specimens of cladid inadunate crinoids. All measurements are based on Pabian and Strimple (1974, p. 43, 44, Figure 20, Table 1)

	Measurements								
Species	**Dpa**	**Dibb**	**H_a**	**L_{ab}**	**W_{ab}**	**L_a**	**W_a**	**L_{ax}**	**W_{ax}**
Graffhamicrinus grotesquus	14.9	2.7	3.7	6.7	4.9	4.8	8.6	1.6	1.4
Arrectocrinus iowensis	18.6	3.2	7.4	9.1	10.4	6.3	10.8	4.2	3.2
Pyndaxocrinus inornatus	14.3	2.6	4.8	5.4	6.4	5.4	8.8	3.5	2.7
Sublobalocrinus kaseri	14.4	2.1	4.8	—	4.6	5.0	8.6	—	—
Contocrinus invaginatus	13.8	2.6	4.7	6.1	6.0	5.1	8.6	2.7	2.6
Apographiocrinus platybasis	9.4	3.0	4.0	3.4	4.4	3.7	6.3	2.8	2.5