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SOUTHWESTERN UNITED STATES

BY

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## CARBONIFEROUS ECHINODERMS FROM THE SOUTHWESTERN UNITED STATES

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**ABSTRACT**—Study of Late Mississippian into Middle Pennsylvania age crinoids and blastoids found in Nevada, Arizona, and Utah suggests that they occur in sufficient numbers to be of stratigraphic value in the western United States. One species, *Paragassizocrinus calyculooides* (Lane) is a good index fossil for upper Morrowan strata in the Great Basin.

Two species of the blastoid *Pentremites* are recognized, one, *P. aridus*, is new. Crinoids assignable to 19 genera are described with 14 new species recorded: *Kallimorphocrinus inaquosus*, *K. inhumectus*, *Plummericrinus torridus*, *Perimestocrinus quintorus*, *Metaperimestocrinus verrucosus*, *M. squarrosus*, *Stenopeocrinus pedersenorum*, *Sciadiocrinus brewi*, *Scytalocrinus reconditus*, *Aesiocrinus? inflatus*, *Endelocrinus solus*, *Paradelocrinus nederi*, *Synarmocrinus carrizoensis*, and *Poteriocrinus cavus*.

### INTRODUCTION

**R**ELATIVELY few crinoids or blastoids have been found or reported from west of the Rocky Mountains in the conterminous United States, despite large available areas of exposed marine Paleozoic rocks. The fact that few papers have been published on western Carboniferous echinoderms is due partly to a lack of paleontologists specifically interested in this area of study. The geographic sparseness of specimens may be attributable to geologists and paleontologists not searching expressly for fossil crinoids and blastoids. We hope this report may alert other paleontologists doing field work in the western United States to the possibility of finding Carboniferous echinoderms.

The best known western Carboniferous faunas are those of Early Mississippian age from New Mexico, Arizona, and Montana. Crinoids from the Lake Valley, New Mexico, area have been described by Miller (1881), Wachsmuth & Springer (1897), Bowsher (1955), and Strimple & Koenig (1956), and blastoids by Macurda (1964b, 1965). Echinoderms from the Redwall Limestone of Arizona include both crinoids and blastoids (Brower and Macurda, in press). The third well-known fauna is from the Lodgepole Member of the Madison Formation of Montana, described by Miller & Gurley (1897), Meek (1872) and Laudon & Severson (1953), among others. All three of these faunas have been judged to be of closely comparable age, upper Kinderhook to lower Osage, although there are some conspicuous differences in generic and species composition among the three faunas. Probable reasons for these faunal differences have not yet been investigated, and evaluation of the relative importance of biogeography, environmental control, and slight age

differences may depend on discovery of crinoids at geographically intermediate localities.

Isolated crinoid specimens of comparable Mississippian age have been reported by White (1877) from the Monte Cristo Limestone of southern Nevada. Mississippian echinoderms of lower Kinderhook, upper Osage, or Meramec age have not been described from west of the Rockies with the exception of blastoids from the Brazer Limestone of Utah (Peck, 1930). Chester echinoderms include a single blastoid species (Macurda, 1964a), and one crinoid (Lane, 1964), which was erroneously considered early Pennsylvanian in age.

Pennsylvanian echinoderms include isolated specimens from Utah (White, 1876), two species from southern Nevada (Lane, 1964), an unidentified dorsal cup from the Ely Limestone of east-central Nevada illustrated by Lane (1962), and Morrowan cups and crowns from the Bridal Veil Falls Member of the Oquirrh Formation near Provo, Utah (Washburn, 1968).

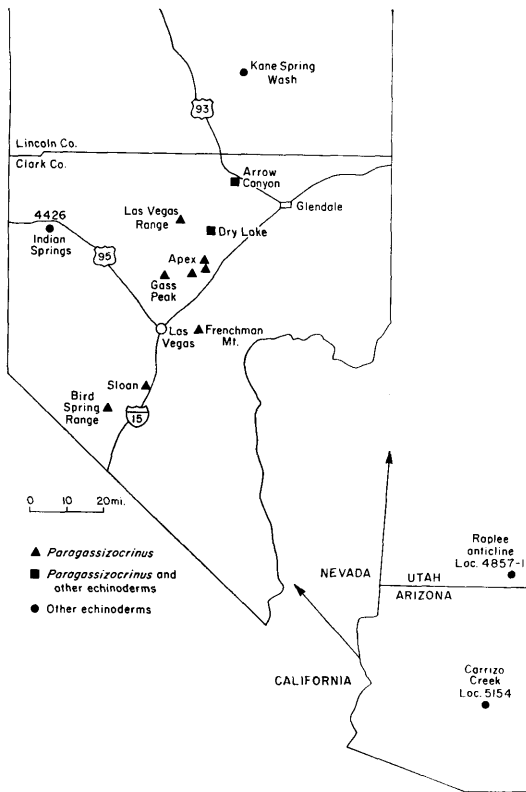
It is clear to us that Carboniferous echinoderms are much more abundant and geographically widespread than is indicated by published accounts. We have either seen collections of, or have collected, crinoids from the Monte Cristo Limestone of southern Nevada and southeastern California, the Joanna Limestone of Nevada and Utah, the Lodgepole of Wyoming, Chester rocks in Utah, the Desmoines of Colorado, and the Desmoines and Virgil of New Mexico.

### ECHINODERMS STUDIED

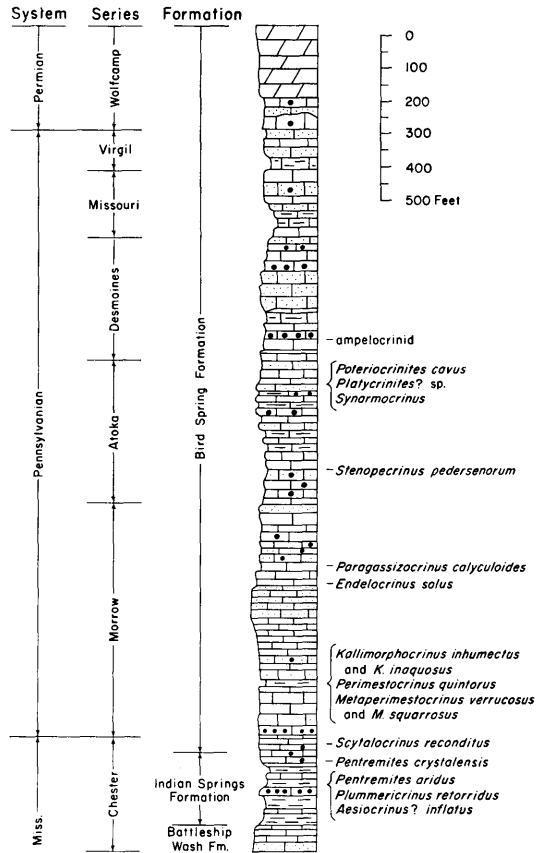
This report includes descriptions of specimens assignable to 19 genera of Carboniferous crinoids, and one blastoid, from southern Nevada, Arizona and Utah (Text-fig. 1). The preserva-



tion of the crinoids is adequate for assignment to 16 species, 14 of which are new. In addition, two specimens are assignable only to family, one a Pennsylvanian flexible crinoid (family Sagenocrinitidae), the other an ampelocrinid. Two disparid inadunates, both new species of the microcrinoid genus *Kallimorphocrinus*, are reported from Morrow rocks in southern Nevada (Text-fig. 2). Characteristic stem ossicles of the monobathrid camerate, *Platycrinites?*, are reported from Atoka rocks in southern Nevada. All of the other inadunate crinoids are advanced poteriocrinitid types typical of Late Mississippian and younger Paleozoic rocks elsewhere. Two of the crinoid genera are Chester in age, the other 17 are from lowest Morrow to Desmoines Pennsylvanian rocks. Two species of the blastoid *Pentremites*, one new, are reported from Chester rocks in southern Nevada. A summary of the echinoderms described and the areas and ages of rocks from which they were collected is as follows:



TEXT-FIG. 1—Locality map for Carboniferous echinoderms from southern Nevada, southern Utah, and eastern Arizona.



TEXT-FIG. 2—Stratigraphic column for southern Nevada, based on Arrow Canyon section, showing stratigraphic position of echinoderms from southern Nevada.

Southern Nevada, Bird Spring Formation

Desmoines: Family Ampelocrinidae, Species B  
 Atoka: *Poteriocrinites cavus* n. sp.; *Platycrinites* sp.; *Synarmocrinus brachiatus* Lane, 1964; *Stenoperocrinus pedersenorum* n. sp.

Morrow: *Paragassizocrinus calyculoides* (Lane), 1964; *Endelocrinus solus*, n. sp.; *Kallimorphocrinus inhumectus* n. sp.; *K. inaquosus* n. sp.; *Metaperimestocrinus verrucosus* n. sp.; *M. squarrosus* n. sp.; *Perimestocrinus quintorus* n. sp.; Family unknown, Species D.

Chester: *Scytalocrinus reconditus* n. sp.

Southern Nevada, Indian Springs Formation

Chester: *Pentremites crystalensis* Macurda, 1964; *P. aridus* n. sp.; *Plummericrinus retorridus* n. sp.; *Aesiocrinus? inflatus* n. sp.; *Parulocrinus vetulus* (Lane), 1964.

## Eastern Arizona, Naco Formation

Desmoines: *Paradelocrinus nederi* n. sp.; *Endelocrinus* sp.; *Delocrinus* sp.; *Sciadiocrinus brewi* n. sp.; *Synarmocrinus carrizoensis* n. sp.; *Parethelocrinus* sp.; Family Sagenocrinitidae, Species A; Family unknown, Species C.

## Southern Utah, Paradox Formation

Desmoines: *Erisocrinus typos* Meek & Worthen, 1873.

Too few crinoids are known as yet from an insufficient number of localities to attempt any zonation of western Carboniferous rocks. However, some generalities can be made concerning the relative abundance of different kinds of crinoids in stratigraphic sequence from the Chester through the Desmoines in the Southwest.

In addition to *Pentremites*, which has not been found in Lower Pennsylvanian rocks in the southwestern United States, Chester rocks contain *Scytalocrinus*, a genus reported by Laudon (1941) to be especially common in the upper Chester Pitkin Limestone of Oklahoma. The presence of *Plummericrinus* and *Aeisocrinus*? in Chester rocks is unexpected, neither of these genera having been reported previously from rocks older than the Morrow.

The Morrow rocks of southern Nevada contain three species assignable to the Pirasocrinidae. Although several representatives of this large family are known from Morrow rocks in the Midcontinent, the family is more abundant and diversified in younger Pennsylvanian strata.

*Paragassizocrinus calyculoides* has now been found at ten localities over an outcrop distance of 75 miles in southern Nevada. The distinctive cup ossicles, especially the infrabasal circlet of this species can be recognized in a disarticulated state in the field. Although complete cups or crowns are quite rare, silicified individual cup plates may be abundant in limestone beds, and readily released with acid. Washburn (1968) reported *P. calyculoides* (as *Globocrinus bulbosus*) from the late Morrowan part of the Oquirrh Formation in central Utah. This indicates that *P. calyculoides* is widespread in the Great Basin Morrowan rocks and therefore an important index fossil.

The Atokan crinoids so far known from this area are an unusual assemblage unlike any fauna of comparable age in the Midcontinent. *Platycrinites*? is rare, but sporadically represented by distinctive columnals in Pennsylvanian rocks elsewhere. *Synarmocrinus* has been reported only from the Middle Pennsylvanian of Arizona, Nevada, and Oklahoma and Lower Pennsylvanian of Utah. The species assigned

here to *Poteriocrinites* is unlike other Pennsylvanian crinoids and has great similarity to Lower Carboniferous crinoids of western Europe.

The Desmoines crinoids from Arizona and Utah are a typical assemblage of this age, consisting of species assignable to the Pirasocrinidae, Erisocrinidae and Ethelocrinidae. The dominance of erisocrinids is typical of many upper Middle and Upper Pennsylvanian crinoid faunas elsewhere.

## ACKNOWLEDGEMENTS

We thank the following: Mrs. Peter B. Kurtz and Miss Julie Guenther for drafting the line illustrations; Jay Inge and Mrs. Jerry Mathews for sketching the specimens of *Kallimorphocrinus*; Douglas Brew who discovered the Carrizo Creek locality and collected part of the material; and Irving Neder who helped in collecting.

Our field work has been supported by the Research Committee of the Academic Senate, University of California, Los Angeles. Part of the field work by Webster was supported by a fellowship from Standard Oil Company for 1962-63.

Photographs were made by us and negatives are on file in the Geology Department, University of California, Los Angeles.

## SYSTEMATIC PALEONTOLOGY

Morphologic terms used in the blastoid descriptions follow those of Fay (1961). Crinoid terminology and abbreviations follow Moore & Plummer (1940), with dimension terms such as length, width, and depth after Lane & Webster (1966). All specimen numbers refer to the UCLA Department of Geology invertebrate fossil collections except those preceded by NAM, which are specimens collected by Douglas Brew and deposited in the Northern Arizona Museum, Flagstaff, Arizona.

## Phylum ECHINODERMATA

Subphylum CRINOZOA Matsumoto, 1929

Class BLASTOIDEA Say, 1825

Order SPIRACULATA Jaekel, 1918

Family PENTREMITIDAE d'Orbigny, 1851

Genus PENTREMITES Say, 1820

Type species.—*cncrina Godonii* DeFrance, 1819, subsequent designation (Etheridge & Carpenter, 1886)

PENTREMITES CRYSTALENSIS Macurda, 1964a, Pl. 56, figs. 7,8

*Pentremites crystalensis* MACURDA, 1964a, p. 709-710, Pl. 116, figs. 8-11.

*Diagnosis.*—A *Pentremites* of the *P. sulcatus* group of Galloway & Kaska (1957, p. 63); calyx ovoid, moderate size, three small basal nodes on very broad pelvis, strongly convex vault, truncate at summit, pelvic angle averages 141 degrees, ambulacra concave, interambulacra slightly concave, five hydrospires per ambulacral side.

*Description.*—See Macurda (1964a, p. 709).

*Remarks.*—Specimens of *Pentremites crystallensis* were found to be locally abundant in all of the sections investigated by Webster (1969) in southern Nevada except at Arrowlime Quarry and Apex. Most specimens are crushed or fragmentary. The Kane Spring Wash section (UCLA locality 5243-22) yielded two partially silicified specimens, one of which is illustrated (Pl. 2, figs. 7-8). Specimens from this study compare closely to toptype material (UCLA 39413, three specimens) collected at Crystal Wash.

*Types.*—Hypotype, 34190.

PENTREMITES ARIDUS Webster & Lane, n. sp.  
Pl. 56, figs. 1-6

*Description.*—Calyx ovoid, greatest width at ambulacral tips, cross section pentagonal; pelvis moderately broad V-shaped; vault convex, probably subrounded up to truncate summit. The lengths of crushed specimens range from 13.0 to 14.5 mm; average maximum-minimum width varies from 8.1 to 10.5 mm; average height 13.5 mm, average width 8.9 mm, L/W 1.5. Vault to pelvis ratio varies from 3.7 to 5.1 mm, averaging 4.7 mm. Estimated pelvic angle ranges from 102 to 134°, average 115°. Ambulacra are flat to faintly convex; interambulacra slightly concave.

Three basals; azygous quadrate, two larger pentagonal; lack ornamentation; form approximately 2/3 of pelvis.

Five radials; extending adorally slightly over lower half of vault; radial sinus deep.

Five deltoids; dart-shaped, approximately twice as high as wide; adoral tips level with or extended slightly above summit, commonly broken off. Deltoid-radial suture V-shaped, approximately 60°. Five ambulacra; biconvex, long lanceolate, taper gradually; width at mid-vault height varies from 2.5 mm on small specimen to 4.1 mm on large specimen. Ambulacral rim faint at aboral tip, moderate at adoral end. Lancet plates occupy central half of ambulacral width, medial groove distinct. Side plates, one ambulacral pore each, three plates per mm. Lancet side plates suture indistinct except on weathered specimens. Transverse ridges medially grooved with small pit at lancet side plate suture.

Mouth central, surrounded by four spiracles and one anispiracle.

TABLE 1—MEASUREMENTS IN MM OF TYPE SPECIMENS OF *PENTREMITES ARIDUS*, N. SP.

	Holo- type 34186	Para- type 34187	Para- type 34188	Average
Length	14.5	13.0	13.1	13.1
Width-maximum	13.6	11.0	11.0	
-minimum	7.4	5.2	5.4	
-average	10.5	8.1	8.2	8.9
L/W	1.4	1.6	1.6	1.5
Vault	10.4	10.7	10.2	10.4
Pelvis	2.8	2.0	2.0	2.3
V/P	3.7	5.3	5.1	4.7
Pelvic Angle	108°	102°	134°	115°

*Measurements.*—See Table 1. All measurements are approximate, taken on crushed specimens. The values for length are undoubtedly large due to crushing; this would result in a larger than actual value for L/W.

*Remarks.*—All specimens of *Pentremites aridus* are either crushed or fragmentary and from the middle shales of the Indian Springs Formation (Chester) at the Dry Lake locality. *Pentremites aridus* belongs to the *P. godoni* group and is most closely related to *P. biconvexus*, a species reported from Lower Chester rocks (Galloway & Kaska, 1957, p. 47). *Pentremites aridus* differs from *P. biconvexus* in that the former has more concave interambulacra and the adoral tips of the deltoids extend to or slightly above the summit.

The specific name is from Latin, *aridus*, for dry, in allusion to the arid area where the specimens were found.

*Material.*—Three crushed calyces and 16 fragmentary plates or calyces.

*Types.*—Holotype, 34186; paratypes, 34187-34189.

Class CRINOIDEA J. S. Miller, 1821

Subclass CAMERATA Wachsmuth & Springer,  
1885

Order MONOBATHRIDA Moore & Laudon, 1943

Family PLATYCRINITIDAE Bassler, 1938

Genus PLATYCRINITES Miller, 1821

Type species.—*Platycrinites laevis* Miller, 1821,  
original designation

PLATYCRINITES sp.

Pl. 56, fig. 9

*Description.*—Columnals elongate-oval, 21 to 23 mm long, 7 to 9 mm wide, and 2 to 3 mm high; outer sides of columnals with an irregularly wavy median horizontal ridge; fulcral ridge narrow, prominent, with deeply concave surfaces on either side; lumen minute.

*Remarks.*—These Middle Pennsylvanian co-

lumnals are similar to other large, highly elongate Pennsylvanian and Permian platycrinoid columnals described from various parts of the world. The fulcral ridges on either side of a single columnal are parallel, rather than being set at an angle, as in most Mississippian *Platycrinites* with a corkscrew-type stem. Offset columnals, such as those described from the Lower Permian of Nevada (Webster & Lane 1967) and the Middle Carboniferous of Russia, with fulcral ridges set at a large angle, have not been found.

*Material*.—Eight columnals on a single slab of limestone are hypotype 47207.

*Locality*.—The columnals were found at UCLA locality 4426, southwest of Indian Springs, Nevada.

Subclass FLEXIBILIA Zittel, 1879  
Order SAGENOCRINIDA Springer, 1913  
Family SAGENOCRINITIDAE Bassler, 1938  
GENUS AND SPECIES UNKNOWN  
SPECIES A

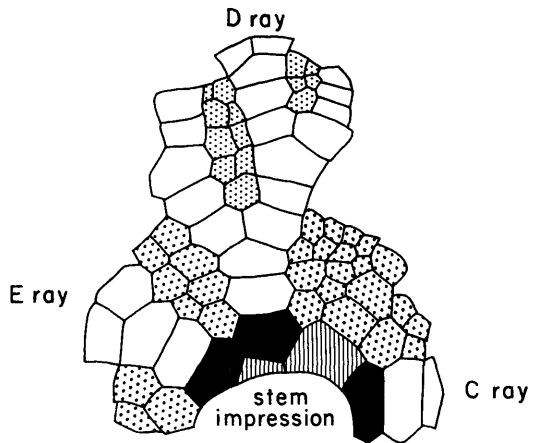
Pl. 56, fig. 16; Text-fig. 3

*Description*.—Crown large, incompletely preserved, interradial and interbranchial areas slightly depressed below rays, faint granulose ornament preserved in one small area, patelloid processes not evident, either poorly developed or poorly preserved; infrabasals completely under proximal columnal, not preserved; distal edge of DE basal projecting beyond stem impression; CD basal large, six-sided, completely separating C and D radials; supporting three anal plates above; radials wider than high, supporting two primibrachs in each ray, each of which is approximately as large as a radial; three secundibrachs on each side above primaxil, and three or four tertibrachs above each side of only preserved tertaxil; two quartibrachs are highest preserved brachs; secundibrachs separated by intersecundibrachs, one intersecundibrach notching upper edges of secundibrachs 1, and separating secundibrachs 2, followed by four ranges of two plates each, intertertibrachs preserved with one plate in the first range, and two plates in each of three succeeding rows; first regular interradial relatively small, notching upper edges of radials, followed by four ranges of two plates each, higher parts of interrays not preserved; posterior interray broad, with numerous plates; large anal (?radial) on right shoulder of CD basal in contact with C radial and first primibrach on right side and two large median anals on left; followed distally by one or two additional plates; a median series of three large anals is directly above the posterior basal; these plates gradually curve inward and

may have supported an anal tube; the left shoulder of the CD basal supports an anal plate that is smaller than the other two anals just above the basal, has six sides, is in contact with the D radial and first primibrach of the D ray, and supports two anal plates above; these two plates are followed by at least 13 plates that become progressively smaller distally and are in contact with secundibrachs on the left and the median series of anal plates on the right. The stem is not preserved.

*Measurements* (mm).—Greatest preserved length of ray 40; height and width, D radial, 4.6, 7.5; height and width, primibrach 1, 4, 8; height and width, primaxil, 4.5, 8; height and width, secundaxil, 4.2, 8; height and width, tertaxil, 3.1, 6.5; height and width, CD basal, 4.8, 7.7.

*Remarks*.—The single partial crown of a Pennsylvanian flexible crinoid on which this description is based probably represents a new genus. The specimen is judged, however, to be too incomplete to serve satisfactorily as the holotype of a type species. Among other Pennsylvanian and Permian flexibles with a generally similar configuration of plates, the Arizona specimen may be most closely related to *Trampidocrinus* from the Lower Permian of southern Nevada. It differs from *Amphicrinus* and *Synerocrinus* in having three anals next above the posterior basal rather than one, and in having many more plates in the posterior interray. In addition, these two named genera lack interbranchials above the secundaxils. *Trampidocrinus* has two, three, or four plates next above the posterior



TEXT-FIG. 3—Plate diagram of flexible crinoid, Family Sagenocrinitidae, Species A. Basals vertically ruled, radials black, interradials and anal plates coarse stipple, interbranchials fine stipple, ray plates white.

basal, numerous plates in the posterior interray, and interbranchials above the secundaxils and tertaxils. Diagnostic features of this Permian genus include a unique bent stem and development of an *E-BC* symmetry plane in the proximal part of the cup. The stem and much of the lower part of the cup of the specimen described here are not preserved and so close comparison with *Trapidocrinus* cannot be made.

*Material*.—A single incompletely preserved crown, NAM G2.8688, is from the Naco Formation along Carrizo Creek, Arizona, UCLA locality 5154.

Subclass INADUNATA Wachsmuth & Springer,  
1885

Order DISPARIDA Moore & Laudon, 1943

Family ALLAGECRINIDAE Carpenter & Etheridge,  
1881

Genus KALLIMORPHOCRINUS Weller, 1930

Type species.—*Kallimorphocrinus astrus* Weller,  
1930, original designator

KALLIMORPHOCRINUS INAQUOSUS Webster &  
Lane, n. sp.  
Pl. 58, figs. 1,2

*Description*.—Calyx small, pyriform, height equals width to slightly wider than high, flattened oral surface in side view, star-shaped in oral or aboral views, monocyclic. Three BB, sutures barely discernable, small, wider than high, quadrilateral, proximal half flat, forming stem facet; distal half flares upward and outward. Five hexagonal RR, flare upward, approximately twice as wide distally as proximally, height twice medial width, prominent medial longitudinal rounded angular ridge extends from proximal tip distally, truncated by beveled triangulation at distal extremity. Five rounded petalose OO, with a shallow spatulate depression on upper surface of each; OO overlap concavities between subjacent radial angulations; CD oral in contact with all other orals; BC and DE orals each in contact only with two adjacent orals; EA and AB orals in contact with two adjacent and CD oral; oral cirlet projects as a prominent cap above radial cirlet.

Anal plate not developed. Ornamentation fine irregular pits over all calyx plates and proximal columnal. Columnal round, crenellate, axial canal round.

*Measurements* (mm).—Holotype, 34194, height 1.2, maximum width 1.3; paratype, 34195, height 0.9, maximum width 0.9.

*Remarks*.—Study of growth stages (nine specimens) of *Kallimorphocrinus inaquosus* shows a decrease in the relative size of the orals to the calyx with continued growth as was shown for

*K. angulatus* by Strimple & Koenig (1956, p. 123, Text-fig. 2, 13–28). *Kallimorphocrinus inaquosus* most closely resembles *K. piasaensis* Weller, 1930, of Late Desmoines age, but differs in that the latter has articular facets and pits on the distal surface of the radials.

The specific name is from Latin, *inaquosus*, for lacking water, dry, in allusion to the climate where the specimens were found.

*Material*.—Nine specimens from the Lower Morrow part of the Bird Spring Formation, Arrow Canyon, Nevada.

*Types*.—Holotype, 34194; paratypes, 34195–34196.

KALLIMORPHOCRINUS INHUMECTUS Webster &  
Lane, n. sp.  
Pl. 58, fig. 3

*Description*.—Calyx small, subpyriform, slightly wider than high, star-shaped in oral or aboral views, monocyclic (?). Three quadrilateral BB, sutures faint, proximal part covered by column but appears flat for stem facet, distal half flaring upward. Five hexagonal RR, distal ends approximately one-fourth again as wide as proximal, height twice proximal width, prominent angular ridge extending from proximal end to beveled distal end; small shallow pit on distal end ventral to bevel. Five small OO, rounded petalose, restricted to ventral surface and do not overlap interradian concavities, faint depression on each oral surface; CD oral in contact with all other orals; BC and DE orals in contact only with two adjacent orals; EA and AB orals in contact with two adjacent and CD orals.

Rounded shallow anal pit shared by mutual distal shoulders of C and D radials. Ornamentation of fine irregular pits covering all calyx plates and preserved proximal columnal. Columnal round, crenellate, axial canal round.

*Measurements* (mm).—Height 1.3; width 2.0.

*Remarks*.—*Kallimorphocrinus inhumectus* differs from *K. inaquosus* in that the former has the orals restricted to the ventral part of the radial cirlet, possesses an anal pit, and appears more sharply angular. *Kallimorphocrinus inhumectus* resembles *K. indianensis* Weller, 1930, a species reported from rock of Middle Pennsylvanian age, but has less well-developed articular facets and pits, a smaller oral cirlet, and more angular interradian concavities.

The specific name is Latin, *inhumectus*, for not moist, dry, referring to the climate of southern Nevada.

*Material*.—One specimen from Lower Morrow part of Bird Spring Formation at Arrow Canyon, Nevada.

*Types*.—Holotype, 34197.

Order CLADIDA Moore & Laudon, 1943

Suborder POTERIOCRINITINA Jaekel, 1918

Family PACHYLOCRINIDAE Kirk, 1942

Genus PLUMMERICRINUS Moore & Laudon, 1943

Type species.—*Pachylocrinus mcquirei* Moore, 1939, original designation

PLUMMERICRINUS RETORRIDUS Webster & Lane,  
n. sp.

Pl. 55, figs. 20,21,26

*Description*.—Dorsal cup medium-low, truncate bowl-shaped, with a shallow basal concavity and slightly outflaring walls. Crushed IBB concealed by broad proximal columnal. Five hexagonal BB (BC basal heptagonal), wider than high, strongly convex longitudinally, gently convex transversely, extreme proximal tips in basal impression, distal tip nearly vertical, short interbasal sutures, all articular surfaces centrally depressed with denticulate rims. Facet occupies full width of radial, gently slopes outward; transverse ridge shorter, dorsal to maximum width of radial, denticulate; outer ligament area narrow, outer marginal ridge sharp, outer ligament furrow very narrow, outer ligament ridge denticulate, coalesces with transverse ridge laterally, ligament pit furrow grades into ligament pit with no apparent break, ligament pit moderately deep and only slightly inclined ventrally; inner ligament area deep, intermuscular furrow wide, moderately deep, grades into intermuscular furrow, oblique furrow shallow, basin-shaped, merges dorsally into undulatory muscle area with no oblique ridge; lateral ridge sharp with nearly vertical adsutural slope, narrow long adsutural platform. Posterior interray wide, gently convex transversely and longitudinally. Three anals in cup, normal arrangement; RA pentagonal bordered by C radial, BC basal, CD basal, anal-X, and rt; anal-X hexagonal, slightly higher than wide, supported by CD basal, projects above summit; rt not present on specimen, space left shows it would have been supported by RA and projected above summit. Ornamentation is a microscopic granular texture covering all cup plates. Sutures faintly impressed with dimples at angles of BB and RR. IBr wider than high, strongly convex transversely, gently convex longitudinally, axillary in the three rays that are present. IIBr<sub>1</sub> quadrangular, rounded exterior. Distal arms and anal sac unknown; column round.

*Measurements* (mm).—H 6.3; W (max) 16.2; W (min) 10.8; W (average) 13.5; H/W ratio 0.47; HB 4.0; WB 5.1; HR 4.4; WR 6.6; HIBr 4.5; WIBr 6.2; HIIBr<sub>1</sub> 2.6; WIIBr<sub>1</sub> 4.6.

*Remarks*.—In general appearance and size *Plummericrinus retorrinus* is similar to *P.*

*uddeni* (Moore & Plummer), reported from the Mineral Wells Formation, Des Moines and/or Missourian, of Texas, but it differs from the latter in having a granular ornamentation. *Plummericrinus retorrinus* is easily distinguished from all other described species of the genus by the short interbasal sutures.

The specific name, *retorrinus*, is Latin for dried up, in allusion to the dry lakes to the east and west of where the specimen was found.

*Material*.—One partial crown and one dorsal cup fragment from the upper shales of the Indian Springs Formation (Chester) at the Dry Lake section, UCLA locality 5248-16c.

*Types*.—Holotype, 34192; paratype, 34193.

Family PIRASOCRINIDAE Moore & Laudon, 1943

Genus PERIMESTOCRINUS Moore & Plummer,  
1938

Type species.—*Hydreionocrinus noduliferus* Miller & Gurly, 1894, original designation.

PERIMESTOCRINUS QUINTORUS Webster & Lane,  
n. sp.

Pl. 55, figs. 22,23

*Description*.—Cup low truncate bowl-shaped, flat base, deep basal concavity. Five? IBB, confined to deep basal concavity covered by proximal columnals and matrix, not visible. Five BB, strongly convex longitudinally and moderately convex laterally; proximal ends downflared forming walls at basal impression; distal half upflared, visible in side view; central node in center of each basal, otherwise dorsal surface smooth; articular surfaces concave with denticulate rims. Five pentagonal RR, vertical in distal part, moderately convex longitudinally and laterally; articular surfaces except facet concave with denticulate rims; shallow but obvious notch at distal end of interrarial suture. Facet not as wide as radial width, slopes outward at 10-15°; outer ligament area narrow, consists of faint outer marginal ridge and furrow, and shallow ligament pit; transverse ridge denticulate. Inner ligament area deep, contains a faint central pit on an intermuscular ridge with a shallow intermuscular furrow merging into intermuscular notch, shallow oblique furrows ending in pits on side of intermuscular ridge, indistinct oblique ridges, merging with muscular arcs and smoothly undulating lobate muscle areas bounded laterally by steep adsutural slopes. Posterior interradius wide, convex outward, making cup appear hexagonal in outline in oral or aboral view. Three anals: radianal pentagonal surrounded in clockwise direction by C radial, BC basal, CD basal, anal-X, and rt; anal-X elongate hexagonal, half above summit; rt hexagonal, less than half below summit. Fragments of

three primibrachs suggest first primibrach axillary, higher than wide, and not spinose. Stem round, arms and anal sac unknown.

*Measurements* (mm).—H 4.9; W 10.7; H/W ratio 0.46; HB 3.8; WB 4.0; HR 3.5; WR 5.5; WBr<sub>1</sub> 5.0.

*Remarks*.—One radial plate in the cup of the holotype of *Perimestocrinus quintorus* has a centrally situated, laterally directed short spine that is not present, nor is there any suggestion of development of a similar structure, on any other radial of the holotype or loose radials from the same locality. The spine is believed to be an aberrant structure and not characteristic of the species. *Perimestocrinus quintorus* is most closely related to *P. pumilis* Moore & Plummer, 1938, a species reported from the Brentwood Limestone, Morrow age, of Oklahoma. It differs from the latter species in that *P. quintorus* has more convex radials and basals, with development of a central node on the basals, and facets that do not slope outward as steeply.

The specific name is derived from Latin, *quini* (five) and *torus* (round elevation) in reference to the five nodes, one on each basal.

*Material*.—One partial crown and six loose ossicles from the Middle Morrow part of the Bird Spring Formation, Arrow Canyon, Nevada.

*Types*.—Holotype, 43122; paratypes, 43123.

Genus *METAPERIMESTOCRINUS* Strimple, 1961

Type species.—*Metaperimestocrinus spiniferus* Strimple, 1961, original designation

*METAPERIMESTOCRINUS VERRUCOSUS* Webster & Lane, n. sp.

Pl. 55, figs. 18,19; Pl. 57, figs. 10–15

*Description*.—Cup low to medium-height truncate bowl-shaped; base flat with shallow depression. Five quadrangular IBB, dart-shaped, proximal part subhorizontal depressed for stem impression, distal parts slightly downflared, not visible in side view, interinfrabasal articular surfaces moderately deep concavities rimmed with denticulate ridges. Five hexagonal BB (BC or CD basal is heptagonal depending upon shape and position of radianal), strongly convex longitudinally, proximal tip downflared forming outer rim of basal impression, distal four-fifths upflared, visible in side view; all articular surfaces moderately deep concavities rimmed with denticulate ridges. Five pentagonal RR (except D radial which is hexagonal), wider than high, flaring slightly outward to vertical in distal extremities; radial-basal articular surfaces moderately deep concavities rimmed

with denticulate ridges; interradial articular surfaces triangular, shallow, flat-bottomed concavities rimmed with denticulate ridges. Radial facet deep and wide, subhorizontal to slightly outward sloping, extending maximum width of radial. Outer ligament area is formed by: a narrow sharp-crested outer marginal ridge; a narrow moderately deep outer ligament furrow; a denticulate outer ligament ridge which coalesces with transverse ridge on distal extremities; and a centrally located moderately shallow ligament pit of length less than one-third radial width merging laterally on distal ends into weakly developed ligament pit furrow. Transverse ridge denticulate throughout length, finer denticles than in outer ligament ridge, flat crest. Inner ligament area contains; a faint central pit on an intermuscular ridge; a shallow intermuscular furrow on ventral part of intermuscular ridge, grades ventrally into intermuscular notch; an oblique furrow, narrow, straight, moderately deep, extends from distal ends of radial to a shallow pit on each side of the intermuscular ridge, bounded ventrally by sharp-crested oblique ridge which merges with muscular area toward intermuscular ridge; a muscular area subtriangular lobe-shaped, slopes outward, surface irregular, slight indication of subparallel arcuate transverse ridges and grooves; a lateral lobe extending from oblique ridge to intermuscular notch. Adsutural platform narrow, widens ventrally, extending from oblique ridge to ventral edge of facet; adsutural slope steep dorsally becoming vertical and finally reclined under lateral ridge ventrally. Posterior interradius slightly indented, three anals below summit of cup, radianal variable, pentagonal or hexagonal, hexagonal when in contact with CD basal, normally pentagonal, in contact clockwise with C radial, CD basal, D radial, anal-X, and right tube plate; anal-X approximately half below summit. Right tube plate less than half below summit. Cup sutures strongly impressed, particularly in larger individuals, some dimpling at basal and radial apices. Surface of cup covered with irregular medium-size tubercles.

First primibrachs axillary with long well-developed spine, surface covered with same ornamentation as cup. Anal sac probably mushroom-shaped.

Column round, crenulate (32 crenellae on one cup) stem impression; lumen pentalobate.

*Measurements*.—See Table 2.

*Remarks*.—The abundant specimens and disarticulated material of *Metaperimestocrinus verrucosus* permit a study of detailed morphological features and growth stages. Growth stages show that deeper sutural impressions and more

TABLE 2—MEASUREMENTS IN MM OF TYPE SPECIMENS OF *METAPERIMESTOCRINUS SPINIFERUS*, N. SP.

	Holotype 43126	Paratype 43127	Paratype 43128	Paratype 43129
H	11.1	5.7	8.7	9.5
W	28.2	13.8*	19.7	20.9
H/W	0.39	0.41	0.44	0.45
WIBB	8.8	4.5	6.7	7.2
WIB	4.3	1.8	3.2	3.6
HB	9.2	4.5	6.7	7.3
WB	11.2	5.3	8.0	8.1
HR	9.4	4.6	6.5	6.9
WR	16.2	7.3	11.3	11.7
WS	4.0	2.5	3.0	3.2

\* Average of maximum and minimum values of slightly crushed specimen.

pronounced ornamentation develop in mature individuals. Only one poorly preserved cup (not illustrated) was found with an articulated primibrach; however, numerous loose primibrachs were found. One such primibrach shows development of a double spine, one immediately above the other, larger one proximal. This is believed to be an aberrant development. Several loose tegmen cap spines were found which are believed to belong to this species. They are covered with the same irregular medium-size tubercles and the articular surfaces have central moderately-deep concavities bordered by denticulate rims. The spines would have projected laterally to slightly upward and the ring of spine plates would have enclosed other plates at the apex of the anal sac.

Discovery of *M. verrucosus* extends the range of the genus, which has been reported from the Des Moines Series of the Midcontinent region. The stratigraphic range is now recognized as Morrow to Des Moines and the geographic range includes the Great Basin.

The specific name, *verrucosus*, is Latin meaning full of warts, in reference to the tuberculate ornamentation.

*Material*.—Eight complete and five partial cups, and numerous disarticulated cup, arm, and tegmen plates from the Middle Morrow part of the Bird Spring Formation, Arrow Canyon, Nevada.

*Types*.—Holotype, 43126; paratypes, 43127-43134.

*METAPERIMESTOCRINUS SQUARROSUS* Webster & Lane, n. sp.  
Pl. 57, figs. 4,5

*Description*.—This species is similar to *Metaperimestocrinus verrucosus* and only differences between the two species are described. Sutures appear impressed due to moderately wide smooth shelf between suture and elevated coarsely tubercled areas on all radials and basals; obvious dimpling at angles of basals and radials. Facets slope gently outward; ligament pit moderately deep, slopes ventrally under transverse ridge. First primibrach axillary, distal tip protruded but not spinose, surface covered with coarse tubercles.

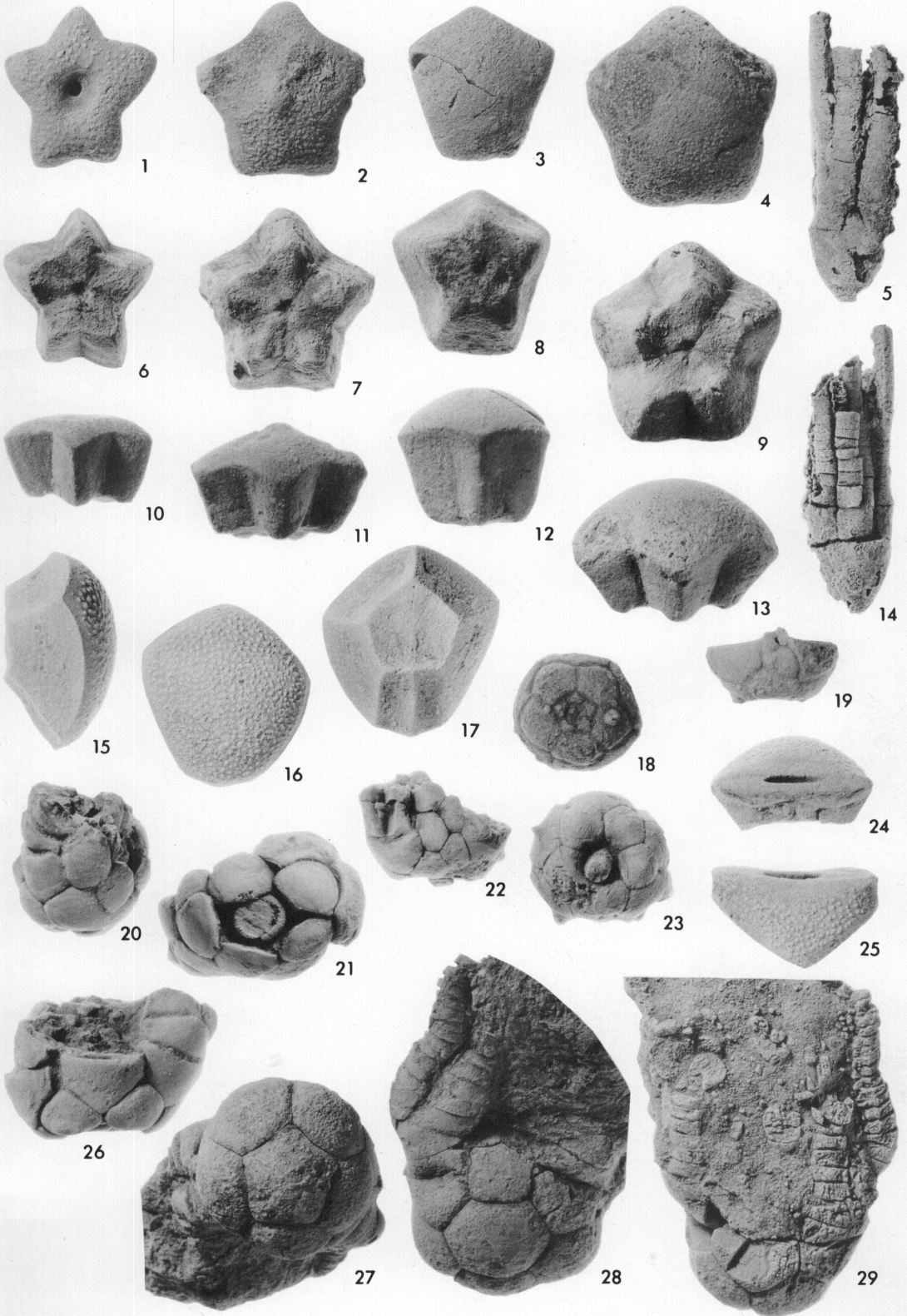
*Measurements* (mm).—H 10.9; W 28.8; H/W

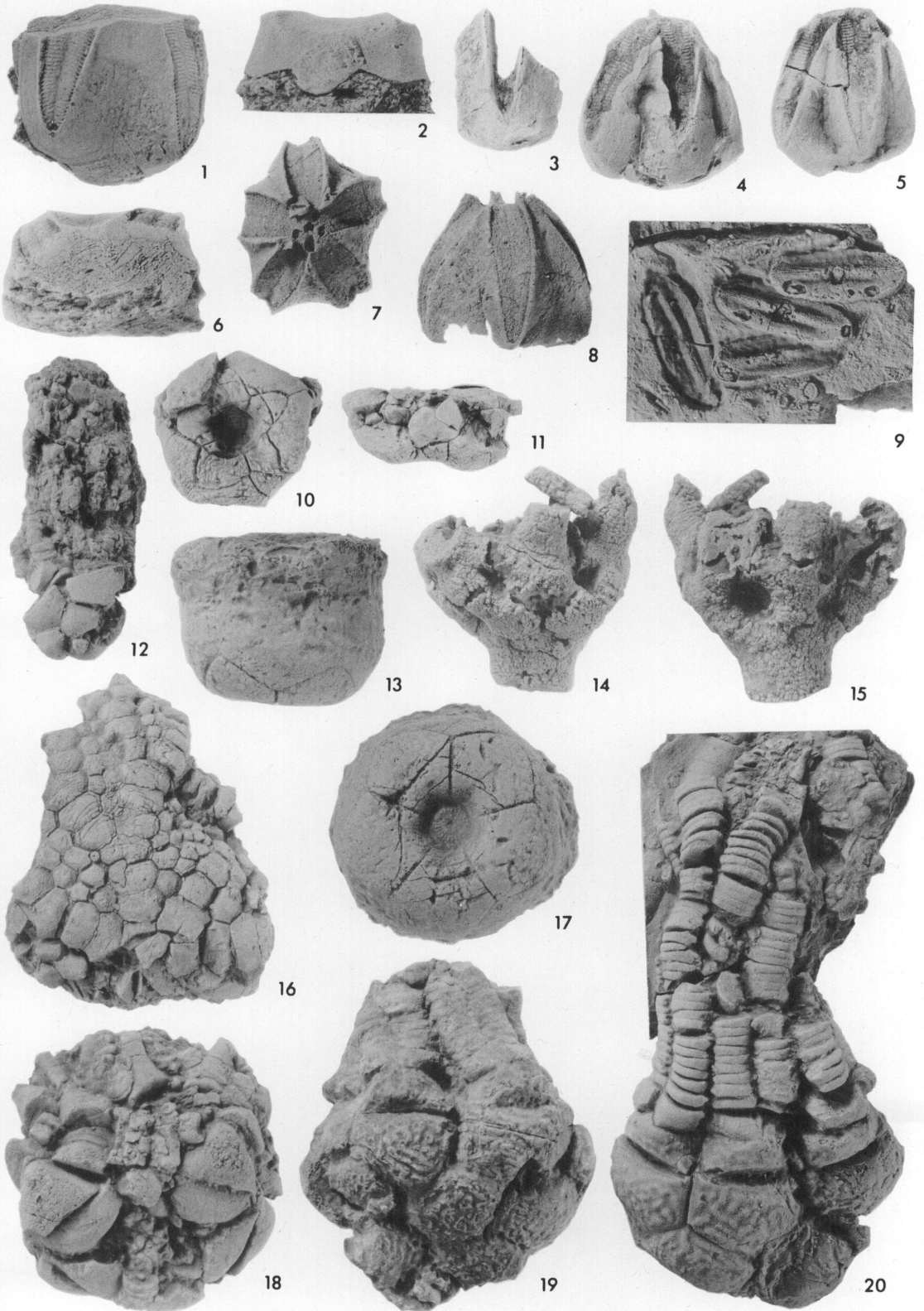
#### EXPLANATION OF PLATE 55

All figures are  $\times 1$  unless indicated otherwise

- Figs. 1-4, 6-13, 15-17, 24, 25, 27-29—*Paragassizocrinus calyculoides* (Lane). 1-4, 6-13, hypotypes 39492, 39493, 39495, 39496, external, internal, and lateral views of four infrabasal circllets showing variation in size, shape and thickness, loss of stem facet, and fusion of intra-infrabasal sutures,  $\times 2$ ; 15-17, hypotype 39498, lateral, external and internal views of basal,  $\times 2$ ; 24, 25, hypotype 39499, ventral and external views of radial,  $\times 2$ ; 27-29, hypotype 34198, dorsal, CD-interray, and A-ray views of partial crown.
- 5, 14—*Scytalocrinus reconditus* Webster & Lane, n.sp. Holotype, 34191, CD-interray and A-ray views of partial crown.
- 18, 19—*Metaperimestocrinus verrucosus* Webster & Lane, n.sp. Paratype 43128, basal and CD interrayer views of dorsal cup.
- 20, 21, 26—*Plummericrinus retorridus* Webster & Lane, n.sp. Holotype 34192, CD-interray, dorsal, and E-ray views,  $\times 2$ .
- 22, 23—*Perimestocrinus quintorus* Webster & Lane, n.sp. Holotype 43122, CD-interray and dorsal views,  $\times 2$ .







ratio 0.38; WIBB 7.7; WIB 3.7; HB 9.2; WB 10.5; HR 8.9; WR 16.0; WS 4.6.

*Remarks.*—The cup of *Metaperimestocrinus squarrosus* lacks part of the posterior interradius and the adjoining part of the C radial. However, enough ossicles are present to show that the radianal is in contact clockwise with the C radial, posterior basal, D radial, and anal-X. The radianal probably supports the right tube plate as well. The space left by the broken-out fragment suggests such a relationship. Primibrachs were not found articulated with the cup, but they are confidently assigned to this specimen on the basis of the ornamentation.

*Metaperimestocrinus squarrosus* differs from *M. verrucosus* in its coarser ornamentation on the elevated areas on the radials and basals and non-spinose IB<sub>r1</sub>.

The specific name, *squarrosus*, is Latin meaning rough with processes, in reference to the coarse tuberculate ornamentation.

*Material.*—One nearly complete cup and several loose ossicles from the Middle Morrow part of the Bird Spring Formation, Arrow Canyon, Nevada.

*Types.*—Holotype, 43124; paratypes, 43125.

Genus STENOPECRINUS Strimple, 1961

Type species.—*Perimestocrinus planus* Strimple, 1952, original designation

STENOPECRINUS PEDERSENORUM Webster & Lane,  
n. sp.

Pl. 56, figs. 10,11

*Description.*—Cup very low truncate-bowl-shaped with a deep narrow stem invagination on flat base. Five? IBB, restricted to base of invagination, covered by matrix. Five BB, strongly convex longitudinally, proximal parts downflaring forming walls of basal impression, distal tip upflaring, visible in side view. Five pentagonal RR, strongly convex longitudinally, slightly convex laterally, proximal tips touch basal plane, shallow narrow notch at distal end of interradial sutures. Facet does not occupy full width of radial, slopes outward at 20-25°; outer ligament area narrow, ligament moderately shallow? pit less than one-third width of radial; transverse ridge denticulate. Posterior interradius wide, concave laterally. Three anals: RA pentagonal, adjoins in a clockwise direction C radial, BC basal, CD basal, anal-X and rt; anal-X hexagonal less than one-third in cup; and rt, hexagonal, only proximal tip below summit. Associated first primibrach large, axillary, spinose in distal portion. Dorsal surfaces of cup plates not ornamented. Stem, arms, and anal sac unknown.

*Measurements* (mm).—H 7.5; W 24.4; H/W ratio 0.31; WIBB 4.8 (approximate); HB 7.8 (approximate); WB 6.0; HR 7.6; WR 13.6.

*Remarks.*—Preservation of the only specimen

#### EXPLANATION OF PLATE 56

All figures are  $\times 1$  unless indicated otherwise

- FIGS. 1-6—*Pentremites aridus* Webster & Lane, n.sp. 1,2,6, paratype 34187, lateral, basal, and oral views respectively of a fragmentary specimen that was ground unsuccessfully to determine the number of hydrospires folds,  $\times 2$ . 3, paratype 34189, exterior view of radial,  $\times 2$ . 4, holotype 34186, lateral view, specimen crushed. 5, paratype 34188, lateral view, specimen crushed.
- 7,8—*Pentremites crystalensis* Macurda. Hypotype 34190, oral and lateral views respectively.
- 9—*Platycrinites?* sp. Hypotype 47207, four columnals.
- 10,11—*Stenopecrinus pedersenorum* Webster & Lane, n.sp. Holotype 43121, basal and CD-interray views of dorsal cup.
- 12—Family Ampelocrinidae, Species B. Hypotype 47205, lateral view of crushed partial crown.
- 13,17—*Delocrinus* sp. Hypotype NAM G2.8691, lateral and basal views respectively,  $\times 2$ .
- 14,15—*Poteroocrinites cavus* Webster & Lane, n.sp. Holotype 47206, anterior and posterior views respectively.
- 16—Family Sagenocrinitidae, Species A. Hypotype NAM G2.8688, D-ray view of partial crown.
- 18—*Schedexocrinus* sp. Hypotype 47202, CD-interray view of crushed partial crown.
- 19,20—*Synarmocrinus carrizoensis* Webster & Lane, n.sp. Holotype NAM G2.8690, BC-interray and E-ray views of crushed partial crown.

of *Stenopeocrinus pedersenorum* is poor and numerous details of the facet are not observable. The associated C-ray primibrach was less than a centimeter out of articulated position and was removed from the matrix along with the cup.

*Stenopeocrinus pedersenorum* is more closely related to reported species from the Missouri Series of the Midcontinent than one from the Morrow Series of the same region. *Stenopeocrinus pedersenorum* is easily distinguished from *S. moseleyi* Strimple and *S. hexagonus* Strimple on the basis of ornamentation as the latter two species have granular ornamentation. *Stenopeocrinus pedersenorum* has shorter primibrachs than *S. planus* Strimple and *S. politus* (Moore).

The species is named in honor of Mr. and Mrs. Chris Pedersen of Moapa, Nevada.

*Material*.—One cup with an associated primibrach from the basal Atoka part of the Bird Spring Formation, Arrow Canyon, Nevada.

*Types*.—Holotype, 43121.

Genus SCHEDEXOCRINUS Strimple, 1961

Type species.—*Schedexocrinus gibberellus*  
Strimple, 1961, original designation

SCHEDEXOCRINUS sp.

Pl. 56, fig. 18

*Remarks*.—A moderately large crushed partial crown is referred to *Schedexocrinus* because there are three anals in the discoid? cup, cup plates are thick and tumid, radial facets slope outward, the axillary IBrr<sub>1</sub> protrude outwardly on the distal tips, proximal secundibrachs are low wide plates, visible higher axillary brachials (IIBrr<sub>1</sub>) have slender elongate spines projecting outwardly from distal tips, and the arms are uniserial. The specimen clearly is related to *Schedexocrinus gibberellus* Strimple from the Desmoines Series of Oklahoma, but differs in that cup plates are more tumid, the spines on the IIBrr<sub>4</sub> are longer and more slender, and the radial notches are barely perceptible. Because the infrabasal cirlet and basals are not exposed and the specimen is badly deformed by crushing, a specific name is not proposed.

*Material*.—One crushed partial crown, hypotype 47202 from UCLA locality 5154, Carrizo Creek, Naco Formation, Desmoines, Arizona.

Genus SCIADIOCRINUS Moore & Plummer, 1938

Type species.—*Hydreionocrinus acanthophorus*  
Meek & Worthen, 1870 original designation

SCIADIOCRINUS BREWI Webster & Lane, n. sp.

Pl. 57, figs. 6-9

*Description*.—Dorsal cup small, low bowl-shaped to subdiscoid, hexagonal in outline

viewed from above or below, moderately deep basal invagination, sides flaring outward. Infrabasals five, dart shaped, slightly higher than wide; cirlet pentagonal, proximal half subhorizontal, bearing round, radially crenulate stem impression; distal half slightly downflaring; not visible in side view. Basals five, hexagonal, higher than wide, strongly recurved longitudinally, concave transversely; proximal portions slightly downflaring, forming walls of basal invagination; distal tips upflaring, barely visible in side view; CD basal heptagonal, in contact with C and D radials, BC and DE basals, C and D IBB, anal-X, and radianal interbasal sutures short. Radials five, pentagonal, twice as wide as high, strongly convex longitudinally, gently convex transversely; proximal tips horizontal, forming base of cup; distal portions widely outflaring; distinct radial notches. Radial facet three-fourths width of radial, sloping strongly outward at 33°; outer ligament area shallow, vertical, not quite as wide as facet; outer marginal ridge narrow, faintly denticulate on some radials, extending width of facet to merge with transverse ridge on distal tips; outer ligament furrow distinct, slightly wider than ligament pit, merging with ligament pit furrow on distal tips; outer ligament ridge narrow, weakly denticulate, slightly wider than ligament pit, does not merge with transverse ridge; ligament pit central, moderately deep, 2.1 mm wide, horizontal, slightly less than one-third width of facet; ligament pit furrow shallow; transverse ridge denticulate distally, with deepest denticles proximally, nondenticulate above ligament pit; inner ligament area deep, divided into two halves by broad shallow intermuscular furrow and central pit; lateral furrow short, distinct, extending to distal tips of facet, grades into shallow undulatory muscle area ventrally, oblique ridge faint, nondenticulate; lateral ridge broad arcuate; adsutural slope steep against lateral ridge grading into shallow furrow between lateral ridge and interradianal suture; intermuscular notch approximately one-third as deep as facet, separated from intermuscular furrow by narrow ridge. Anal notch moderately wide, shallow, three anals below radial summit; radianal small, rectangular, in contact with C radial, CD basal, anal-X, and right tube plate; anal-X moderately large, approximately one-third below radial summit, adjoined by CD basal, D radial, D primibrach, two tube plates, right tube plate, and radianal; right tube plate missing but sutures show proximal portion would have been below radial summit. Arms unknown. Column round, consisting of three distinct columnal types: large and small nodals, and smaller internodals; large nodals prominent, radially crenulate, edges

strongly rounded, not all bearing cirri, adjoined by internodals; small nodals gently rounded distally, few bearing cirri; internodals radially crenulate, weakly rounded to flat on edges, adjoined by large nodal on one side and smaller nodal on opposite side.

*Measurements* (mm).—H, 3.0; W, 15.0; H/W ratio, 0.20; WIBB, 4.6; W stem impression, 2.5; depth basal invagination, 2.3; HIB, 2.6; WIB, 2.4; HB, 3.7; WB, 3.0; HR, 4.1; WR, 8.2. Nodal 3 mm from proximal columnal: H, 1.7; W, 3.9; adjacent distad internodal: H, 0.5; W, 3.2; adjacent distad smaller nodal: H, 1.0; W, 3.4.

*Remarks*.—*Sciadiocrinus brewi* n.sp. differs from previously described species in that the plates are less tumid, the radianal is not in contact with the BC basal and anal-X is more nearly or proportionately less below the radial summit.

The species is named for Douglas Brew, who discovered the Carrizo Creek locality and collected many of the specimens, including *Sciadiocrinus brewi*.

*Material*.—One dorsal cup and proximal part of column is the holotype NAM G2.8689 from Carrizo Creek, Naco Formation (Desmoinesian), Arizona.

Family SCYTAOCRINIDAE Moore & Laudon,  
1943

Genus SCYTAOCRINUS Wschsmuth & Springer,  
1880

Type species.—*Schaphiocrinus robustus* Hall,  
1861 (1872), original designation

SCYTAOCRINUS RECONDITUS  
Webster & Lane, n. sp.

Pl. 55, figs. 5,14

*Description*.—Crown elongate cylindrical; cup medium conical; arms dichotomous, long. Cup wider than high, slightly turbinate; five IBB, proximal parts horizontal with stem impression, distal three-fourths upflaring, visible in side view; five hexagonal BB (CD basal heptagonal), slightly higher than wide, gently convex transversely, moderately convex longitudinally; five pentagonal RR (C radial hexagonal), wider than high, gently convex transversely and longitudinally, distal part nearly vertical; facet full width of radial, details not observed. Three anals; RA quadrangular, in contact with C radial, BC basal, CD basal, and anal-X; anal-X large, pentagonal, in contact with C radial, RA, CD basal, D radial, D IBr, and rt, only distal tip extends above summit; rt, pentagonal, proximal tip below summit. Ten arms, long, wide, slightly convex transversely. Five IBr, wider than high,

strongly convex transversely, nearly straight longitudinally, axillary. More than 20 IBr in each arm, proximal ones quadrangular uniserial, distal ones wedge-shaped to cuneate uniserial with interspersed biserial brachials. Stem round; anal sac unknown. Ornamentation obliterated by silicification, if originally present.

*Measurements* (mm).—HC 44.8 (incomplete); H 10.3; W (maximum) 14.7; W (minimum) 13.2; W (average) 13.9; H/W ratio 0.74; WS 4.0; WIBB 7.7; WIB 3.6; HB 7.0; WB 6.3; HR 6.0; WR 8.0; HIBr 6.2; WIBr 7.7; HIBr<sub>1</sub> 3.6; WIIBr<sub>1</sub> 4.1; HIBr<sub>2</sub> 2.2; WIIBr<sub>2</sub> 4.0; HIBr<sub>3</sub> 1.8; WIIBr<sub>3</sub> 4.0; HIBr<sub>4</sub> 1.1; WIIBr<sub>4</sub> 4.0; HIBr<sub>5</sub> 1.1; WIIBr<sub>5</sub> 4.0.

*Remarks*.—The holotype and only specimen of *Scytalocrinus reconditus* is silicified and due to weathering only partially preserved. Great care was taken in determining sutures which are nearly obliterated by silicification. *Scytalocrinus reconditus* shows an advanced evolutionary trend in the posterior interradius with the right tube plate nearly removed from the dorsal cup and not in contact with the radianals. The only species of *Scytalocrinus* reported from the Morrow Series, *S. sansabensis* Moore & Plummer, is smaller, has more rounded arms, and a more primitive arrangement of the anals.

The specific name, *reconditus*, is Latin meaning hidden, concealed, and alludes to the nearly "hidden" sutures on the specimen.

*Material*.—One crown from the Chester part of the Bird Spring Formation at the Kane Springs Wash West section.

*Types*.—Holotype, 34191.

Family AMPELOCRINIDAE Kirk, 1942.

Genus AESIOCRINUS Miller & Gurley, 1890

Type species.—*Aesiocrinus magnificus* Miller & Gurley, 1890, original designation

AESIOCRINUS? INFLATUS Webster & Lane n. sp.

Pl. 57, fig. 26

*Description*.—Cup small, low flat-bottomed bowl-shaped, with steep-walled stem impression. Five IBB, strongly convex longitudinally and transversely, giving a bulbous appearance to IBB, downflaring proximal part covered by stem impression, distal part flat to slightly upflaring, exterior bulbous, barely visible in side view; five hexagonal BB (CD basal heptagonal, distal end flattened for reception of anal-X), slightly wider than high, strongly convex longitudinally and transversely making them appear bulbous, proximal part subhorizontal, distal tips approaching vertical; five pentagonal RR, moderately convex longitudinally, twice as wide as high; facet extends full width of R, features



unknown; anal-X large, partly below summit, supported by CD basal. Cup plates lack ornamentation except for bulbous nature of IBB and BB producing an impressed suture appearance for the cup. Two IBr in C ray, only ray exposed, and IBr<sub>2</sub> probably axillary. Distal brachials quadrangular, strongly convex ventrally, bipinnulate. Stem impression subpentagonal; column and anal sac unknown.

*Measurements* (mm).—H 3.7; W 12.7 (approximate); H/W ratio 0.29; WS 1.1; WIBB 4.5; WIB 1.8; HB 4.2; WB 4.6; HR 2.9; WR 5.8; HIBr<sub>1</sub> 1.5; HIIBr<sub>1</sub> 1.8.

*Remarks*.—Because the direction of slope of the radial facet is unknown at present in *Aesiocrinus? inflatus*, the generic assignment is questioned. The holotype and paratype with associated distal arm fragments of *A? inflatus* were found on one small slab of ferruginous limestone. The description is based on the holotype except for features of the distal part of the arms. *Aesiocrinus? inflatus* is easily distinguished from other reported species of *Aesiocrinus* by the bulbous nature of the infrabasals and basals.

The specific name, *inflatus*, is Latin meaning puffed up, swollen, and refers to the inflated nature of the IBB and BB.

*Material*.—Two partial crowns on one slab from the upper shales of the Indian Springs Formation at the Dry Lake Section.

*Types*.—Holotype, 34184; paratype, 34185.

GENUS AND SPECIES UNKNOWN  
SPECIES B

Pl. 56, fig. 12

*Description*.—Dorsal cup small, bowl-shaped, with deep basal concavity including infrabasals and proximal one-third of basals; basals gently convex; radials twice as wide as high, facet equal in width to plate; number of anal plates unknown but probably only one anal in cup; primibrach 1 wide, low, in close suture with tapering, axillary primibrach 2; at least two additional branches occur higher on the arms; secundibrach 3 or 4 axillary; arms uniserial, brachials low, strongly rounded.

*Remarks*.—The crushed and incomplete specimen on which this description is based has the two primibrachs, with primaxil a triangular, tapering plate, typical of the Ampelocrinidae. The specimen cannot be assigned to *Aesiocrinus* or *Cymbiocrinus*, both of which have only 10 arms, nor to *Ampelocrinus*, which has a convex base and infrabasals visible in side view. The arms of *Moundocrinus* are not known and the genus may be synonymous with *Aesiocrinus*. *Allosocri-*

*nus* has only five arms. Because the specimen is imperfect no attempt is made here to assign it to a genus.

*Material*.—One crushed partial crown is hypotype 47205, from UCLA locality 5245, 100 ft. stratigraphically above loc. 5245-108 (Webster, 1969). South wall of Arrow Canyon at right angle bend as canyon bends west; associated with abundant horn corals.

Family ERISOCRINIDAE S. A. Miller, 1889

Genus ENDELOCINUS Moore & Plummer, 1940

Type species.—*Eupachyrcrinus fayettensis*  
Worthen, 1873, original designation

ENDELOCINUS SOLUS Webster & Lane, n. sp.  
Pl. 57, figs. 22-25

*Description*.—Dorsal cup broad, low, truncate bowl-shaped; deep basal invagination; base flattened; sides vertical to slightly outflaring. Infrabasal cirlet fused, steeply downflared, not visible from side view, distal tips visible around proximal columnals. Five hexagonal basals (except for heptagonal CD basal, flattened on distal tip for reception of anal), slightly tumid, wider than high, strongly recurved, proximal ends only slightly below level of distal tips, proximal ends form major part of basal invagination, distal tips curve sharply inward to form major part of obvious dimple at point of mutual articulation with two superjacent radials. Five pentagonal radials, moderately tumid, nearly twice as wide as high, proximal tips moderately inflated forming dimple at point of mutual articulation with two subjacent basals.

Radial facet wide, deep, gently slopes outward; outer ligament area narrow, as wide as radial, no marginal furrow or ridge; outer ligament ridge denticulate, coalesces with transverse ridge on distal tips; ligament pit furrow faint, present only at ends of ligament pit; ligament pit, central deep, less than one-third width of radial, slopes ventrally under transverse ridge; transverse ridge denticulate, as wide as radial; inner ligament area divided into two mirror-image halves by broad shallow intermuscular furrow; no central pit, intermuscular furrow grades ventrally into broad intermuscular notch; oblique furrow shallow, grades into intermuscular furrow; oblique ridge faint, grades into muscle area; muscle area irregular to hummocky on lateral ends, becoming slightly undulating on inner ends before grading into intermuscular furrow. Three primibrachs present, all axillary, significant difference in heights, E-ray IBr highest, C-ray IBr lowest. Column round; axial canal and lumen pentalobate.

*Measurements* (mm).—H 7.0; W 17.8; H/W ratio 0.39; depth of basal invagination 2.5 (approximate); WIBB 4.3; HB 6.2; WB 7.3; HR 5.7; WR 10.0; H anal-X 3.4; W anal-X 3.0; HIAx (B ray) 4.9; WIAx (B ray) 9.9; HIAx (C ray) 4.4; WIAx (C ray) 9.3; HIAx (E ray) 5.4; WIAx (E ray) 9.8; W proximal columnals 1.9.

*Remarks.*—*Endelocrinus solus* is most closely related to *E. bransoni* Strimple, reported from the Desmoines Series in Oklahoma, but differs from the latter in having a deeper basal invagination with the proximal ends of the basals forming a larger part of the invagination, a fused infrabasal cirlet, and less tumid radials.

With the exception of *Endelocrinus matheri* (Moore & Plummer, 1938) Strimple, 1960, an allocation here questioned, all reported species of the genus are from rocks of Desmoines through Wolfcamp age from the Midcontinent region. Moore and Plummer, 1938 (p. 289-291; Pl. 13, fig. 3; Pl. 14, figs. 7a-d; Pl. 16, figs. 1a-c; Text-fig. 32), described *Delocrinus matheri* from the Brentwood Limestone near Fort Gibson, Oklahoma, making no mention of the species having impressed sutures or dimplelike depressions at the angles of the cup plates (a diagnostic feature of *Endelocrinus*) nor is there any suggestion of this feature on any of the illustrations. Also, when Moore & Plummer erected *Endelocrinus*, they (1940, p. 254) listed *D. matheri* as a species of *Delocrinus*. Their original generic assignment is here accepted. Another specimen from the Brentwood Limestone identified as *Endelocrinus matheri* (Moore & Plummer) by Strimple (1960, p. 153) may be an endelocrinid. If so, it is probably a new species and further corroborates a Morrow age as the recognized lower range of *Endelocrinus*.

The specific name is derived from the Latin *solus* meaning alone.

*Material.*—One partial crown from the Middle Morrow part of the Bird Spring Formation, Arrow Canyon, Nevada.

*Types.*—Holotype, 43120.

ENDELOCRINUS sp.  
Pl. 57, figs. 16, 21

*Description.*—Crown incomplete, intermediate size; dorsal cup low bowl-shaped, deep basal concavity, all plates smooth, suture impressed. Infrabasal cirlet downflaring confined to basal concavity. Basals five, wider than high, strongly recurved longitudinally, gently convex transversely; proximal parts outflaring slightly, forming walls of basal concavity; distal portions slightly outflaring, distal tips depressed; CD

basal flattened distally for reception of anal X. Radials five, nearly twice as wide as high, gently convex longitudinally and transversely; proximal tips depressed, distal portions vertical; radial facet extending full width of radial. Anal-X lost, would have projected below radial summit in contact with C radial, CD basal, and D radial. Probably ten biserial arms, only parts of A and E rays preserved; primibrach *1* axillary, slightly over twice as wide as high, distal tips sharply protruded outward; secondibrachs wider than high, moderately convex transversely, slightly convex longitudinally, increasingly cuneate distally; biserial above IIBrr<sub>3</sub>. Stem and anal sac unknown.

*Measurements* (mm).—H 9.6; W 22.8; H/W ratio 0.42; WIBB 5.2; HB 7.7; WB 9.1; HR 7.3; WR 13.5; HIBrr<sub>1</sub> 5.7; WIBrr<sub>1</sub> 12.7; HIIIBrr<sub>1</sub> 4.0; WIIIBrr<sub>1</sub> 7.6; HIIIBrr<sub>2</sub> 2.7; WIBrr<sub>2</sub> 6.0.

*Remarks.*—The size, impressed sutures, prominent basal concavity, and tendency of the brachials to become biserial distally illustrate the relationship of this specimen to *Endelocrinus*. Burke (1967) discussed the variation in arm structure of *Endelocrinus* noting that only distal parts of the arms are biserial in some species, whereas others are essentially biserial throughout. *Endelocrinus* sp. is most similar to *E. undulatus* (Strimple) however the arms become biserial with the IIBrr<sub>4</sub> in *E. sp.* and IIBrr<sub>2</sub> in *E. undulatus*. Because the specimen of *E. sp.* is slightly crushed, not complete, and better specimens may be found with additional collecting, a species is not designated.

*Material.*—One partial crown, hypotype NAM G2.8692, from UCLA Loc. 5154, Naco Formation (Desmoines), eastern Arizona.

Genus DELOCRINUS Miller & Gurley, 1890

Type species.—*Poteriocrinus hemisphericus*  
Shumard, 1850, original designation  
(Miller & Gurley, 1890)

DELOCRINUS sp.

Pl. 56, figs. 13, 17

*Description.*—Dorsal cup small, low flat-bottomed bowl-shaped; moderately deep basal invagination; sides evenly rounded, vertical in distal portions. Infrabasal cirlet covered by round proximal columnal. Basals five, slightly wider than high, strongly recurved longitudinally, gently convex transversely; proximal ends form walls of basal invagination, distal tips subvertical; posterior basal flattened on distal tip for reception of anal-X. Radials five, pentagonal, wider than high, proximal tips gently incurved, distal tips vertical. Outline circular in

oral or aboral view; interradius not depressed; all plates smooth.

*Measurements* (mm).—H 7.1; W 15.9; H/W ratio 0.45; W of visible columnal 2.6; HB (est) 6.4; WB 7.2; HR 6.2; WR 10.0.

*Remarks*.—Because only one specimen of *Delocrinus* sp. was found and the specimen is not suitable to serve as a holotype, a species is not designated. *Delocrinus* sp. is most similar to *D. vulgatus* Moore & Plummer, 1940, reported from the Virgil Series of Texas and Oklahoma, but has a higher H/W ratio (0.45 vs 0.35–0.37) than *D. vulgatus*.

*Material*.—One dorsal cup, hypotype NAM G2.8691 from Loc. 5154, Naco Formation (Des Moines), eastern Arizona.

#### Genus ERISOCRINUS Meek & Worthen, 1865

Type species.—*Erisocrinus typus* Meek & Worthen, 1865, original designation

*Erisocrinus typus* Meek & Worthen, 1873  
Pl. 57, figs. 19,20

See MOORE & PLUMMER, 1940 for synonymy.

*Erisocrinus typus* Meek & Worthen, MOORE & LAUDON, 1943, p. 135, Pl. 6, fig. 3; STRIMPLE, 1959, p. 120, Pl. 1, figs. 14–17, Pl. 2, figs. 2–5; STRIMPLE, 1960, p. 155, fig. 2D.

*Erisocrinus mediator* STRIMPLE, 1962, p. 14, Pl. 8, figs. 4–7.

*Description*.—See Moore & Plummer, 1940, p. 153.

*Measurements* (mm).—H 9.1; W 24.0; H/W ratio 0.38; WIBB 6.4; WIB 3.0; HIB 3.8; HB 7.7; WB 9.0; HR 7.5; WR 14.4.

*Remarks*.—Measurements, height/width ratio, and shape clearly indicate the close relationship between the Paradox Basin specimen and Moore & Plummer's (1940) emended description of *Erisocrinus typus*. Strimple (1962) described several specimens from the Oologah Formation (Des Moines) of Oklahoma, naming *E. mediator*. Noting that *E. mediator* is most comparable to *E. typus*, he distinguished the former from the latter by the lower height/width ratio (0.37 vs 0.40–0.42) and observed (p. 15) that *E. typus* "has a mild outward flare to the dorsal cup." There is some variation in the faint outward flare of the cup as shown by Moore & Plummer's illustrations (figs. 25a–c, p. 153). Strimple's illustration of *E. mediator* (Pl. 8, figs. 4–5) show the same profile as figure 25b of Moore & Plummer. Because these differences in the H/W ratios and shape are not considered to be of sufficient magnitude to permit recognition of *E. mediator* as a distinct species, it is considered a junior synonym of *E. typus*.

*Erisocrinus typus* is now recognized from

Des Moines strata of Illinois (Meek & Worthen, 1865), Nebraska (Meek & Worthen, 1865, as *E. nebrascensis*), Oklahoma (Strimple, 1938, 1959, 1962, the latter as *E. mediator*), Texas (Moore & Plummer, 1940) and Utah, herein. Furthermore, Moore & Plummer recognized *E. typus* from the Missouri Series of Texas.

*Material*.—One dorsal cup, hypotype 47204 from 4857-1, Paradox Formation, Des Moinesian, Ruplee Anticline, Utah.

#### Genus PARADELOCINUS Moore & Plummer, 1938

Type species.—*Paradelocrinus aequabilis* Moore & Plummer, 1937, original designation

*Paradelocrinus nederi* Webster & Lane, n. sp.  
Pl. 57, figs. 1–3

*Description*.—Dorsal cup large, low bowl-shaped; rounded pentagonal in outline viewed from above or below; deep basal invagination, plates ornamented with fine papillae; base flat; sides become vertical in distal portions and incurved on distal tips. Infrabasal circlet small subhorizontal, restricted to top of basal concavity, not visible in side view, distal portions downflaring. Basals five, longer than wide, moderately recurved longitudinally, gently convex transversely; proximal portions downflaring forming walls of basal concavity; distal tips upflaring, visible in side view. Radials five, twice as wide as high, moderately convex longitudinally, gently convex transversely; proximal tips incurved at base of cup; distal edges slightly incurved; radial facet occupies full width of radial. Anal notch small but clearly evident in side view of cup. Arms, column, and tegmen unknown.

*Measurements*.—See Table 3.

*Remarks*.—*Paradelocrinus nederi* n. sp. has a deeper basal concavity and relatively smaller infrabasal circlet than other described species assigned to the genus.

The species is named in honor of Irving Neder who found the holotype.

*Material*.—Two dorsal cups, holotype 47200

TABLE 3—MEASUREMENTS IN MM OF TYPE SPECIMENS OF *PARADELOCINUS NEDERI*, N. SP.

	Holotype (Slightly crushed)	Paratype (Moderately crushed)
H	8.1	—
W	27.8	—
H/W	0.29	—
WIBB	5.4	—
HB	11.5	—
WB	9.7	9.1
HR	8.3	8.9
WR	16.6	19.0



and paratype 47201 from Loc. 5154, Naco Formation, Desmoinesian, eastern Arizona.

Family ETHELOCRINIDAE Strimple, 1961

Genus PARETHELOCRINUS Strimple, 1961

Type species *Parethelocrinus ellipticus* Strimple, 1961; original designation

PARETHELOCRINUS sp.

Pl. 57, fig. 17

*Description*.—Dorsal cup broken and largely missing; infrabasals with a narrow deep basal concavity; cup plates smooth; at least one anal plate is preserved in the cup; arms branch on primibrach 1 in all rays; on the posterior side of the C and D rays secundibrach 1 is axillary, resulting in 12 arms in the crown; arms biserial above secundibrach 2.

*Measurements* (mm).—HC (almost complete) 36.9; H (approx.) 6.1; HIB (approx.) 2.8; WIB 2.5; HB (incomplete) 4.5; WB 6.0; HR 4.5; WR 6.8; HIBrr, 4.0; WIBrr, 6.7; HIIBrr<sub>1</sub> 2.6; WIIBrr<sub>1</sub> 3.9; HIIBrr<sub>2</sub> 2.9; WIIBrr<sub>2</sub> 1.6.

*Remarks*.—Presence of more than 10 biserial arms allies this species with the Ethelocrinidae. The preserved parts of radials and one basal indicate that prominent nodose ornament characteristic of *Ethelocrinus* is absent, consequently the specimen is assigned to *Parethelocrinus*, which has faint nodose or granulose ornament.

*Material*.—One incomplete compressed crown, hypotype 47203, from the Naco Formation, Middle Pennsylvanian, Kohl's Ranch, Arizona, center sec. 21, T. 11 N., R. 12 E., Promontory Butte Quadrangle.

Genus SYNARMOCRINUS Lane, 1964

Type species.—*Synarmocrinus brachiatus* Lane, 1964, original designation

SYNARMOCRINUS CARRIZOENSIS

Webster & Lane, n. sp.

Pl. 56, figs. 19, 20

*Description*.—Crown large, slender; dorsal cup crushed, probably globose, sutures impressed, cup plates and primibrachs covered with irregular coarse nodes and ridgelets. Infrabasal cirlet large, upflaring, visible in side view; infrabasals five, dart-shaped, higher than wide, gently convex longitudinally and transversely; proximal half outflaring; distal half vertical with tips inflaring slightly. Radials five, pentagonal, widest between bases of interradial sutures; proximal tips; distal portions weakly inflaring; radial facet occupies full width of distal edge. Two anals below radial summit: radianal large, in contact with C radial, BC basal, CD basal, D

radial, and anal-X; anal-X hexagonal, projecting above radial summit, in contact with C radial, radianal, D radial, D primibrach, tube plate, and C primibrach. Arms ten, uniserial, long, slender, convex externally, interlocking laterally up to arm girdle; primibrach axillary in all rays, over twice as wide as high, distal tip sharply extended between first secundibrachs for approximately one-third height of secundibrach; IIBrr<sub>1</sub> not quite twice as wide as high, strongly convex transversely; all higher secundibrachs approximately four times as wide as high, slightly cuneate. Pinnules not observed but one attachment scar only on widest end of each brach.

*Measurements* (mm).—HC (incomplete) 90.0; H (crushed) 21.7; WIBB 15.6; W stem impression 7.8; HIB (estimated) 8.2; WIB 7.5; HB 13.6; WB 16.7; HR 12.5; WR 19.4; HIBrr, 7.7; WIBrr, 19.0; HIIBrr, 4.6; WIIBrr, 8.3; HIIBrr<sub>2</sub> 1.7; WIIBrr<sub>2</sub> 7.5.

*Remarks*.—*Synarmocrinus carrizoensis* n. sp. is the first species of this genus reported from the Desmoinesian. Two species, *S. brachiatus* Lane and *S. fundundus* Strimple are known from the Atokan; one species, *S. depressus* Washburn is known from the Morrowan. *Synarmocrinus carrizoensis* is easily distinguished by the upflaring infrabasals and the less regular arrangement of the ornamentation. *Synarmocrinus carrizoensis* is similar to *S. brachiatus* in the arrangement of anal-X, in that anal-X is not in contact with the CD basal but rather rests on the radianal.

The lateral interlocking of proximal brachials in *S. carrizoensis* as well as numerous other late Paleozoic inadunates undoubtedly added considerable rigidity to the organism when the arms were in the closed position. Strimple (1966, p. 8) stated that Lane (1964) in the original definition of the genus considered that the lateral interlocking of the proximal brachs represented a "fused or fixed condition. . ." Actually Lane (1964, p. 678) stated "proximal brachials fixed into dorsal cup by lateral interlocking with adjacent brachials" which clearly did not imply fused. We would interpret the lateral interlocking as stated above to add rigidity to the specimen in the closed position and possibly as Strimple suggested (1961) to act as a protective mechanism. Undoubtedly the interlocking restricted to some degree the mobility of the proximal parts of the arms. A possible advantage to the proximal interlocking may have allowed the organism to feed with only the distal parts of the arms during periods of stronger current action thereby reducing the drag on the specimen which would have been much greater with complete opening of the arms. During periods of

calmer currents the arms may have been more completely flexed allowing larger surface area for food gathering.

The specific name *carrizoensis* is in reference to Carrizo Creek along which the specimen was found.

*Material*.—One crushed slightly incomplete crown, the holotype NAM G2.8690 is from 5154 Naco Formation, Desmoinesian, Eastern Arizona.

Family AGASSIZOCRINIDAE S. A. Miller, 1889

Genus PARAGASSIZOCRINUS  
Moore & Plummer, 1940

Type species.—*Agassizocrinus tarri* Strimple, 1938, original designation

PARAGASSIZOCRINUS CALYCULOIDES (Lane)

Pl. 55, figs. 1-4, 6-13, 15-17, 24, 25, 27-29

*Polusocrinus calyculoides* LANE, 1964, p. 682, Pl. 112, figs. 1-3.

*Polusocrinus pachyplax* LANE, 1964, p. 682-683, Pl. 112, figs. 4-10; Text-fig. 1

*Globocrinus bulbosus* WASHBURN, 1968, p. 122, Pl. 2, figs. 1-6.

*Emended Description*.—Dorsal cup low, bowl-shaped to slightly bulbous, 1.5 to 2 times as wide as high; base flattened with slight basal

depression in immature specimens, moderately convex on mature individuals; sides evenly convex, becoming straight on posterior and lateral sides, remaining convex on anterior; sutures appear impressed due to convexity of plates.

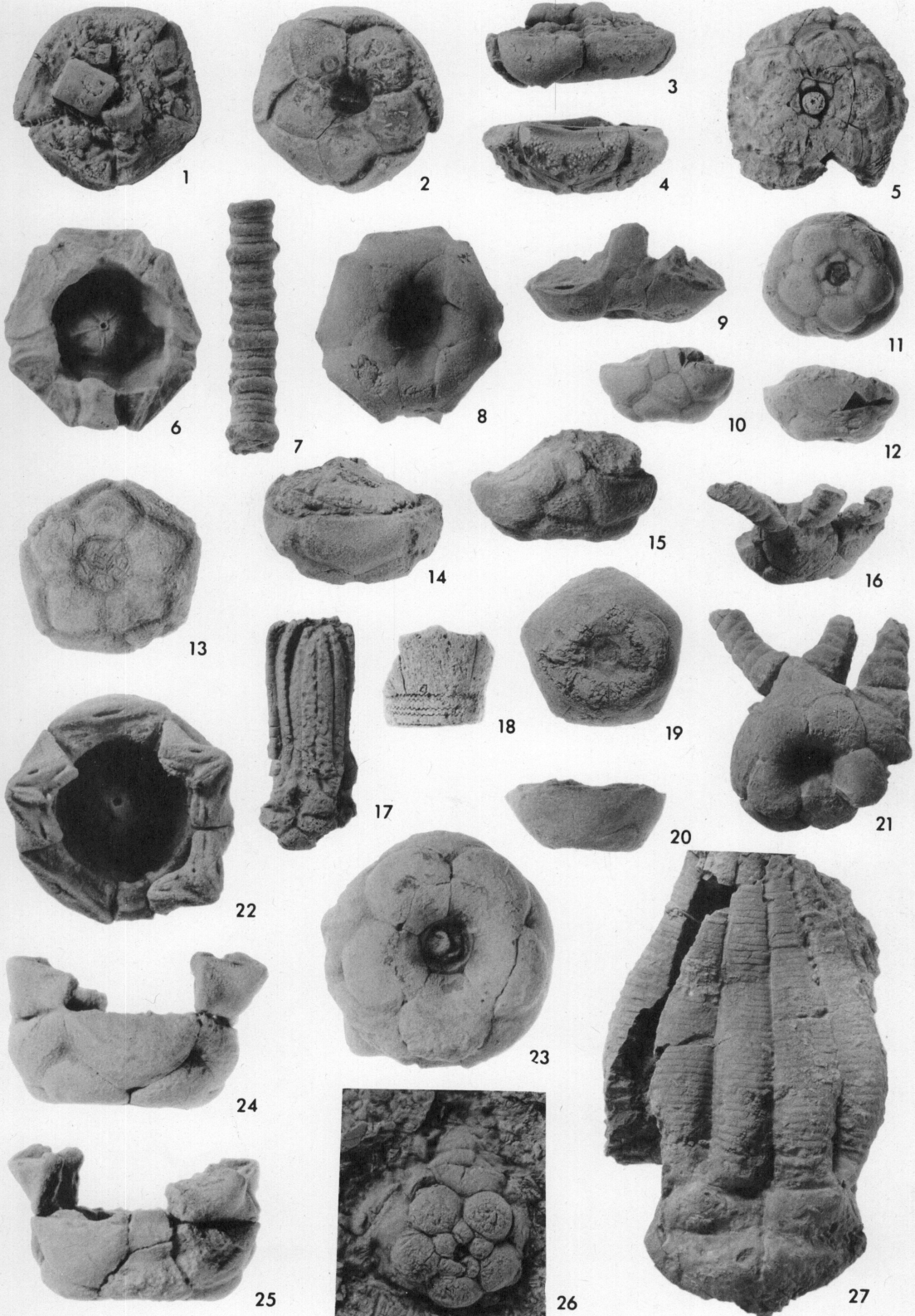
Infrabasal cirplet five quadrangular diamond-shaped plates in immature specimens, proximal ends sharply incurved around small pentalobate stem impression; one fused plate in mature individuals; in stages of early fusing cirplet angularly pentalobate with continued growth angularity subdued and gerontic individuals show subangular scalloped sutures with proximal ends of basals; articular faces distinctly slope outward; IBB gently to moderately convex longitudinally and transversely with distal extremities visible in side view throughout growth; BC- and DE-interray sutures between IBB and BB slightly wider than A-B, CD-, and EA-interray sutures. Articular faces smooth.

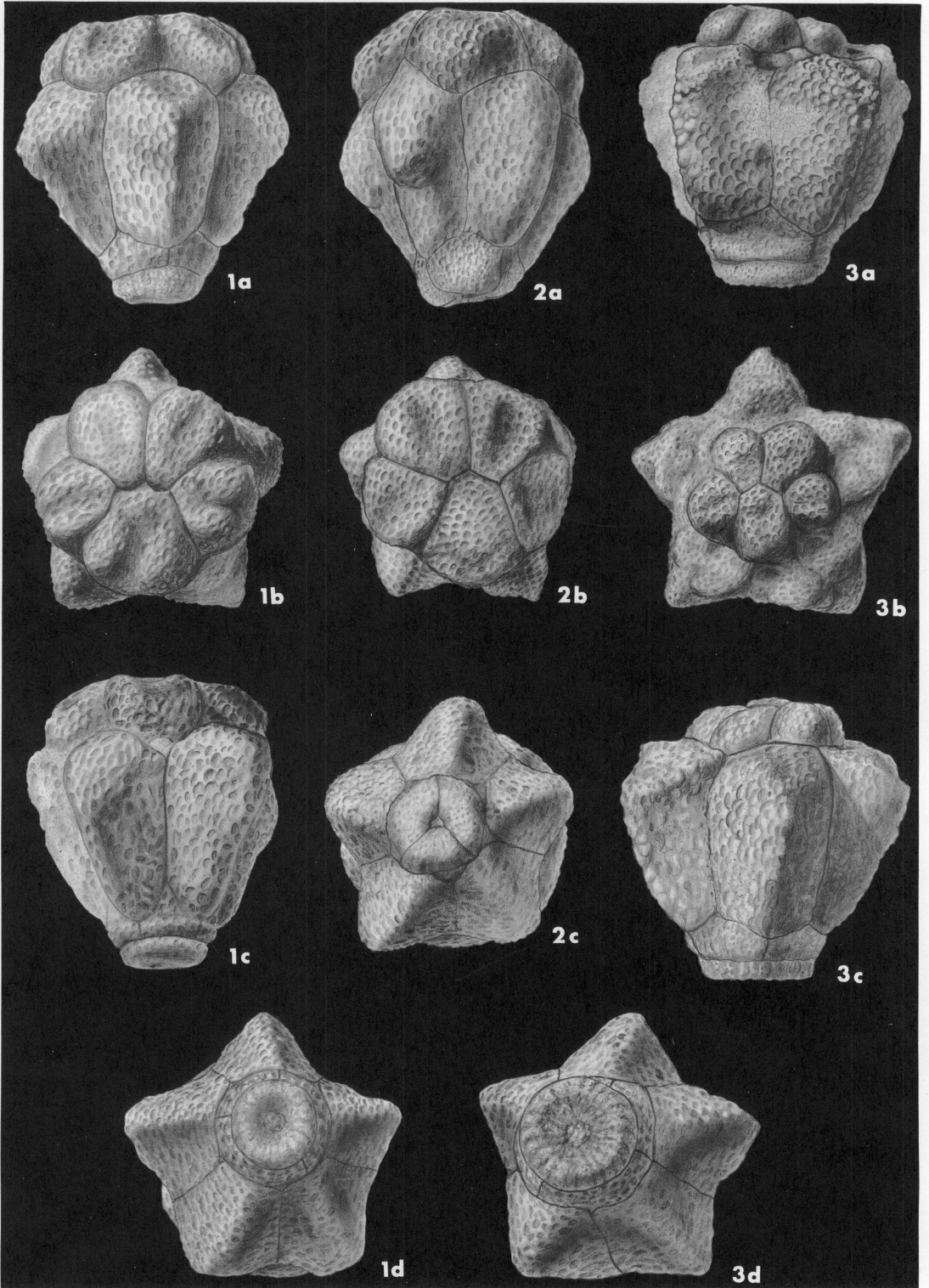
Five hexagonal basals (CD basal is heptagonal, being flattened on proximal end for articulation with anal), gently to moderately convex transversely and longitudinally; EA and AB basals subequal height and width with slight lateral extension towards CD interrayer; BC and DE basals wider than high with obvious extension laterally towards CD interrayer; CD basal wider than high. All articular faces smooth.

#### EXPLANATION OF PLATE 57

All figures  $\times 1$  unless indicated otherwise

- FIGS. 1-3—*Paradelocrinus nederi* Webster & Lane, n.sp. Holotype 47200, ventral, dorsal, and lateral views respectively of dorsal cup.  
4,5—*Metaperimestocrinus squarrosus* Webster & Lane, n.sp. Holotype 43124, anterior and basal views of dorsal cup.  
6-9—*Sciadiocrinus brewi* Webster & Lane, n.sp. Holotype NAM G2.8689, 6,8,9, ventral, basal, and CD-interrayer views of dorsal cup, 7, side view of proximal columnals that belong to holotype dorsal cup,  $\times 2$ .  
10-15—*Metaperimestocrinus verrucosus* Webster & Lane, n.sp. 10-12, paratype 43129, CD-interrayer, basal, and A-ray views. 13-15 holotype 43126, basal, A-ray, and CD-interrayer views.  
16,21—*Endelocrinus* sp. Hypotype NAM G2.8692, E-ray and basal views of partial dorsal cup and arms.  
17—*Parethelocrinus* sp. Hypotype 47203, D-ray view of partial crown.  
18—Family, genus, and species unknown, Species D. Hypotype 43135, infrabasal cirplet and attached proximal columnals,  $\times 2$ .  
19,20—*Erisocrinus typus* Meek & Worthen. Hypotype 47204, basal and lateral views of dorsal cup.  
22-25—*Endelocrinus solus* Webster & Lane, n.sp. Holotype 43120, ventral, dorsal, A-ray and CD-interrayer views,  $\times 2$ .  
26—*Aesiocrinus?* *inflatus* Webster & Lane, n.sp. Holotype 34184, oblique view of partial crown,  $\times 2$ .  
27—Family, genus, and species unknown, Species C. Hypotype NAM G2.8693, lateral view of partial crown.





Five radials, half again as wide as high, gently convex transversely and longitudinally. A radial bilaterally symmetrical; B and E radials extended slightly on posterior half; C and D radials obviously extended on posterior half. Interradial articulation faces have denticulate lateral ridge on distal, dorsal, and dorsal half of proximal edges, smooth otherwise. Facet wide, subhorizontal to slight inward slope. Narrow shelf on outer ligament area extending full width of radial; outer ligament ridge faint but present, coalesces with transverse ridge at extremities; ligament pit central, slightly less than one-third width of radial, extends proximally under transverse ridge; ligament pit furrow shallow, terminated at outer extremities by coalescence of outer ligament ridge and transverse ridge; transverse ridge not as wide as radial, crest straight, inner edge convex, outer edge convex notched by ligament pit. Inner ligament area divided into mirror images by moderately deep central pit, short shallow intermuscular furrow, and arched intermuscular notch; oblique ridge continuous from convex inward, extends from lateral edge of facet to center of transverse ridge separating oblique furrow from central pit. Muscular area tear-drop crescent-shaped, pointed on lateral extremities, rounded on inner, containing three obvious furrows on inner ends.

Anal plate pentagonal, erect, slightly convex longitudinally and transversely, little more than half below summit of dorsal cup, in clockwise direction adjoins the following plates: C-ray radial, CD-interray basal, D-ray radial, D-ray primibrach, left anal sac plate, right anal sac plate, and C-ray primibrach.

Ten arms, uniserial, branch isotomously on IB<sub>2</sub>, no further branching observed. Brachials approximately twice as wide as high, nearly circular in cross section with deep V-shaped food groove.

Ornamentation covering all cup plates and primibrachs consists of fine papillae.

*Measurements* (mm)—Measurements taken on hypotype 34198. H 20.0; W 29.5 (maximum), 25.5 (minimum), 27.5 (average); H/W 0.73; WIB 15.1; HB 15.1; WB 15.5; HR 9.0; WR 13.5, HIB<sub>1</sub> 4.4; WIB<sub>1</sub> 14.0; HIAx 5.4; WIAx 11.3; HIIB<sub>1</sub> 3.4; WIIB<sub>1</sub> 7.5.

*Remarks*.—Discovery of unsilicified crowns and disarticulated ossicles of *Paragassizocrinus calyculoides* prompted the emended description above. Lane's original description (1964, p. 682) was based on a silicified cup for *Polusocrinus calyculoides*. His material did not show ornamentation, articulation details, nor information about the arms, all of which are described here. Study of Lane's types of *P. calyculoides* and *P. pachyplax* and comparison with this new material leave no doubt that *P. pachyplax* is a junior subjective synonym of *P. calyculoides*.

*Paragassizocrinus calyculoides* is a new combination. Table 4 shows that *P. calyculoides* agrees quite well with *Paragassizocrinus* except for the shape of the dorsal cup. Strimple (1960, p. 7) showed that the shape of the infrabasal circlet of *Paragassizocrinus* is variable. Considering the other morphologic features of *P. calyculoides* it is assigned to the genus *Paragassizocrinus*, and the shape of the dorsal cup is considered to be only of specific significance. *Paragassizocrinus calyculoides* probably represents a transitional stage in the development of *Polusocrinus* from *Paragassizocrinus*.

One mature infrabasal circlet was split along the BC and DE sutures through the axial canal. This plate was 8.3 mm thick and showed the column was retained until the plate was 4.7 mm thick. Six proximal columnals were in place within the circlet which continued to grow after the loss of the column covering all external traces of the stem impression.

Because of the distinct appearance of the very

#### EXPLANATION OF PLATE 58

- Figs. 1,2—*Kallimorphocrinus inaquosus* Webster and Lane, n. sp. 1a-d, holotype 34194, A-ray, ventral, CD-interray, and basal views,  $\times 37$ . 2a-c, paratype 34195, CD-interray, ventral, and basal views,  $\times 50$ .  
3—*Kallimorphocrinus inhumectus* Webster and Lane, n. sp. Holotype 34197, CD-interray, ventral, A-ray, and basal views,  $\times 34$ .



TABLE 4—COMPARISON OF MORPHOLOGIC FEATURES AND RANGES OF *POLUSOCRINUS* AND *PARAGASSIZOCRINUS* WITH INCLUSION OF *PARAGASSIZOCRINUS CALYCULOIDES*

CHARACTER	POLUSOCRINUS	PARAGASSIZOCRINUS	PARAGASSIZOCRINUS CALYCULOIDES
Shape of dorsal cup	Truncated bowl	Truncated cone to bullet-shaped	Globose to truncated bowl
Number of arms	10-14	10	10
Infrabasal circlet	Non-fused	Fused with age	Fused with age
Column	Circular, not lost in mature specimens	Pentabolate, lost in mature specimens	Pentabolate, lost in mature specimens
Dorsal cup plates	Thick	Very thick	Very thick
Geologic range	Des Moines-Missouri	Morrow-Missouri, possibly lower Virgil	Upper Morrow

thick dorsal cup plates, disarticulated ossicles and partial cups of *P. calyculoides* are easily identified in the field and have been found at several localities in southern Nevada. Lane (1964) reported silicified specimens from the lower part of the Callville Formation at Frenchman Mountain, east of Las Vegas, and the Flintkote Quarry at Sloan, Nevada. Silicified partial cups of *P. calyculoides* were collected later from the lower part of the Bird Spring Formation in the southern part of the Bird Spring Range. Unsilicified crowns were found at the Arrowlime Quarry and Las Vegas range sections; disarticulated ossicles were observed at the Gunnery Range, Arrowlime, Dry Lake, Las Vegas Range, and Arrow Canyon sections. Loose ossicles collected from a thin shale 511 feet above the base of the Bird Spring Formation in Arrow Canyon provided most of the morphological details here described. At all localities the occurrence is a short distance, 5 to 200 feet, below the *Profusulinella* Zone and in the upper extent of the range of *Steptognathodus noduliferus* and *Polygnathodella* sp., thus indicating that the species is restricted to the upper part of the Morrow Series. Washburn (1968) described *Globocrinus bulbus* from the Morrowan part of the Oquirrh Formation. The genus *Globocrinus* is preoccupied (Weller, *et al.*, 1920). *Globocrinus bulbus* is considered by us to be a junior synonym of *P. calyculoides*. From the numerous occurrences it appears that *P. calyculoides* is a good late Morrow index fossil in southern Nevada.

*Material*.—Two crowns from UCLA locality 5247-37 and numerous disarticulated ossicles from UCLA locality 5245-60.

*Types*.—Hypotypes, 34198-34199, 39492-39499.

Family POTERICRINITIDAE Bassler, 1938.

Genus POTERICRINITES Miller, 1821

Type species.—*Potericrinites crassus*  
Miller, 1821

POTERICRINITES CAVUS Webster & Lane, n. sp.

Pl. 56, figs. 14,15

*Description*.—Dorsal cup large, low cone-shaped, base wide; infrabasals five, wide, visible in side view, making up about one-fourth of cup height, tips strongly depressed; basals large, convex, with large, deep, circular depressions between adjacent basals, extending from top of infrabasals to proximal tips of radials, and smaller depressions at distal angles of basals; radials large, convex, strongly depressed at angles with basals; facets one-half to two-thirds width of radials, horseshoe-shaped, directed obliquely upward, with wide, prominent ambulacral notch; anal-X directly above CD basal, quadrangular, distal surface with a conspicuous internal notch that presumably extended distally to anal sac plates; other anal plates missing, but depressions on edges of CD and BC basals, anal-X and C radial indicate radial and right tube plate were in the cup; C radial has two depressions along its adposterior edge.

Tegmen not preserved; arms broad, strongly rounded, uniserial; brachials low, broad, preserved to height of primibrach 6 in most complete (*E*) ray, without an axillary.

Stem large, wide, lumen large circular, making up over one-half columnal width; columnals thin, with fine crenellae on articular surface.

*Measurements*.—Dimensions (in mm) of the holotype are: height, cup, 22; width, cup, 34; width, stem, 12.5; width, lumen, 7; height and width, IB circlet, 4.5, 19; height and width, DE basal, 13, 14; height, width, E radial, 9, 14; width, B, radial facet, 8; width, brachials, 8.

*Remarks*.—This species is unlike any previously described Pennsylvanian crinoid and bears closest resemblance to several species of *Potericrinites* from the Lower Carboniferous of Great Britain, especially in having deep depressions between cup plates and at least six primibrachs to a ray. British Lower Carboniferous *Potericrinites* may have as many as 13 pri-

mibrachs to a ray, typically have facets one-half to two-thirds as wide as the radials, and several species have prominent depressions at the angles of cup plates. American Mississippian *Poteriocrinites*, and the closely related *Springericrinus*, may have similar sculpture on the cup, but the arms typically branch on or below the third primibrach, rather than higher. The few Pennsylvanian species still retained in this genus either have radial facets that almost fill the upper surface of the radial (*P. macoupsensis* Worthen; *P. lasallensis* Worthen), or arms that branch on the first primibrach (*P. ramonaensis* Strimple).

*Material*.—The holotype and only known specimen is no. 47206, from the Bird Spring Formation, at Indian Springs, Nevada, UCLA Loc. 4426 (see Lane, 1964).

## FAMILY, GENUS, AND SPECIES UNKNOWN

## SPECIES C

Pl. 57, fig. 27

*Description*.—Crown large, expanded upward with maximum width near lower third of arms. Dorsal cup incomplete, probably low bowl-shaped. Infrabasals and anals not preserved. Distal tips of two basals flaring strongly outward and upward. Radials wider than high, strongly convex longitudinally, facets occupy full width of plates, distal parts subvertical. First primibrachs axillary in all rays, moderately protruded at distal tip. Ten arms, broad, strongly rounded externally in proximal half, flat gently tapering distally; interlocking laterally in proximal third. Brachials short, biserial in proximal half of arm, becoming uniserial distally.

*Measurements* (mm).—HC 87 (incomplete); H arms 72.5; WB 13.4; HR 11.4; WR 19.7; HIBrr<sub>1</sub> 8.2; WIBrr<sub>1</sub> 18.1; HIIBrr<sub>1</sub> 4.1; WIIBrr<sub>1</sub> 10.6; HIIBrr<sub>2</sub> 1.5; WIIBrr<sub>2</sub> 10.6; HIIBrr<sub>3</sub> 1.4; WIIBrr<sub>3</sub> 9.7.

*Remarks*.—The shape of the crown and presence of 10 strongly rounded arms which interlock laterally in the proximal part suggests a relationship to the Cromyocrinidae.

*Material*.—One partial crown, NAM G2.8693 from the Carrizo Creek locality.

## SPECIES D

Pl. 57, fig. 18

*Description*.—Five upflaring infrabasals?, seven degrees from vertical; slightly wider than high, axial canal pentalobate, proximal part horizontal crenellate. Column round, composed of alternating thick and thin columnals, crenellate; lumen pentalobate.

*Measurements* (mm).—HIB? 5.5; WIB? 6.1; WS 8.4.

*Remarks*.—The specimen described above is so fragmentary it is not known if it is an infrabasal or basal circllet. No other loose ossicles were found that could be referred to this form. The round column and steeply inclined infrabasals? are features of some genera of the families Blothrocrinidae and Cercidocrinidae; however, no attempt is made to assign this specimen to either family.

*Material*.—One partial cup, hypotype 43135, is from the Middle Morrow part of the Bird Spring Formation, Arrow Canyon, Nevada.

## LOCALITY REGISTER

Detailed locality information including some stratigraphic sections has been published for numerous species described above. (Webster, 1969). Only data for new localities will be given herein to avoid duplication. Interested readers are referred to the original reference. All locality numbers are from the Paleontology Locality Register, Department of Geology, University of California at Los Angeles.

4426—Middle Pennsylvanian, Bird Spring Formation, Clark County, Nevada, sec. 16, T 16 N, R 56 E; 1.4 miles southwest of Indian Springs, Nevada. Along pole line road 0.2 mile west of Indian Springs Ranch, then 0.5 mile southwest along dirt track to limestone spur. Fossil bed just behind spur about 150 feet above valley floor.

4857-1—Middle Pennsylvanian, Honaker Trail Formation, San Juan County, Utah, sec. 34, T 41 S, R 19 E; along north bank of San Juan River immediately north of the old well-site road; uppermost shale of Desmoines part of formation as illustrated by Wengerd (1963, fig. 5).

5154—Middle Pennsylvanian, Naco Group, Gila County, Arizona. C S½, NW¼, sec. 7, T 6 N, R 20 E; north bank of Carrizo Creek where creek is flowing west. Greenish shale at base of bioclastic cliff-forming limestone.

5243-22 to 5248-16c—See Webster, 1969.

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