Crinoids from the Glen Dean Limestone (Middle Chester) of Southern Indiana and Kentucky

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Crinoids from the Glen Dean Limestone (Middle Chester) of Southern Indiana and Kentucky

By ALAN S. HOROWITZ

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CRINOIDS FROM THE GLEN DEAN LIMESTONE (MIDDLE CHESTER) OF SOUTHERN INDIANA AND KENTUCKY

BY ALAN S. HOROWITZ1[1]

ABSTRACT

Twenty-three species and eight *nomina aperta* of crinoids from the Glen Dean Limestone (middle Chester) are assigned to the genera *Agassizocrinus* Owen & Shumard, *Aphelecrinus* Kirk, *Eupachycrinus* Meek & Worthen, *Hypselocrinus* Kirk, *Onychocrinus* Lyon & Casseday, *Phacelocrinus* Kirk, *Phanocrinus* Kirk, *Pterotocrinus* Lyon & Casseday, *Tholocrinus* Kirk, and *Zeacrinites* Troost. The genus *Hypselocrinus,* represented in this fauna by the new species *H. campanulus,* has not hitherto been recorded from rocks of Chester (late Mississippian) age. Nine other species described herein have not been recognized formerly from the Glen Dean. Seventeen collecting sites in Indiana and six in Kentucky yielded the material forming the basis of this study.

As reported by previous workers, *Pterotocrinus* wing plates are most valuable for identifying the Glen Dean Limestone, and their distinctive morphology permits them to be recognized and used for this purpose by stratigraphers in the field. Thirteen of the twenty-three collecting localities furnished wing plates of *P. acutus* Wetherby, *P. bifurcatus* Wetherby, *P. depressus* Lyon & Casseday, *P. spatulatus* Wetherby, or *P. vannus* Sutton. Future collecting may also indicate the stratigraphic usefulness of two described but unnamed types of *Pterotocrinus* wing plates.

Glen Dean crinoids probably were most abundant in clear agitated water and are best preserved on the upper surfaces of limestones covered by shales or in calcareous shales formed under quieter water conditions. Most of the material studied came from interbedded limestone, sandstone, and shale in the upper part of the Glen Dean[2] and is associated with an abundant and diverse marine fauna.

INTRODUCTION

GENERAL CONSIDERATIONS

This study documents the occurrence of crinoids in the Glen Dean Limestone in the middle part of the Chester Series (late Mississippian), principally in south-central Indiana and northern Kentucky, so that they will be more useful in stratigraphic studies. This work is part of a larger study of the macroinvertebrate fauna of the Glen Dean which the author is conducting. Utgaard and Perry (1960) and Perry and Horowitz (1963) have described the Glen Dean bryozoan fauna; the author will treat other Glen Dean faunal elements in subsequent publications.

1 Curator of Paleontology, Department of Geology, Indiana University, Bloomington.

2 These rocks, which yielded most of the crinoids, are considered to be a lower part of the Tar Springs Formation according to the official position of the Indiana Geological Survey (Gray, Jenkins, and Weldman, 1960, p. 38).

No systematic study of the Glen Dean crinoid fauna has been published. Bassler and Moodey (1943, p. 101) cited 55 crinoid species from the Glen Dean at Sloans Valley, Pulaski County, Ky. (fig. 1, locality 23), which is the type locality for 35 of these species. Fourteen species previously reported at Sloans Valley are found in the Glen Dean of southern Indiana and northern Kentucky. Ulrich (1917, p. 133) listed eight crinoid species from the Glen Dean of western Kentucky, but the author did not find any of these species in the present study. Butts (1917, p. 102; 1941, pt. 2, p. 248) figured Glen Dean crinoids from Kentucky and from rocks of equivalent age in the Appalachian region. Sutton (1934, p. 393416), Sutton and Hagan (1939, p. 82-96), Sutton and Winkler (1940, p. 544-567), and Kirk (1937, p. 598-608; 1939, p. 469-473; 1940a, p. 47-55; 1940b, p. 321-334; 1942a, p. 22-28; 1944b, p. 233245) discussed or figured Glen Dean crinoids, particularly those involved in generic revisions or reviews.

The author used collections from 23 localities in this study (fig. 1). T. G. Perry, of the Indiana University Department of Geology, and A. C. Brookley, formerly of the Indiana Geological Survey, obtained specimens from 15 of these localities during the summer of 1954 while they were employed by the Indiana Geological Survey. The author also studied material in four collections which were made by J. J. Galloway and C. A. Malott; these specimens are housed in the paleotologic collections of the Indiana University Department of Geology. The author obtained specimens from three additional collecting sites in northern Kentucky, including the type locality of the Glen Dean (fig. 1, locality 20) ; collected additional material from three sites in southern Indiana; and studied specimens in the American Museum of Natural History collections obtained by Haas (1946, p. 2). In general, the best crinoid collections came from weathered beds in the upper part of the Glen Dean (lower part of the Tar Springs Formation of Gray, Jenkins, and Weidman, 1960, p. 38) that had been discarded in quarrying to expose the commercially valuable thick- and massive-bedded strata in the lower part of the formation (Glen Dean Limestone as restricted by Gray, Jenkins, and Weidman, 1960, p. 38). At locality 8 (fig. 1), the author collected wing plates of *Pterotocrinus acutus* Wetherby, *P. bifurcatus* Wetherby, and *P. spatulatus* Wetherby and infrabasal cones of *Agassizocrinus* Owen & Shumard from measured sections of the upper part of the Glen Dean; this is the only locality from which specimens were collected in place.

Perry and Smith (1958, p. 90-101), Utgaard and Perry (1960, p. 10-12), and Perry and Horowitz (1963, p. 9) have discussed and reviewed the stratigraphy of the Glen Dean Limestone. The reader is referred to these publications for information concerning the lithology, areal distribution, thickness, and other aspects of the formation.

AGE

The Glen Dean includes crinoid genera which clearly indicate its Chester (late Mississippian) age. As now defined, *Zeacrinites* Troost is a typical Chester genus, although it may be represented in rocks of middle Pennsylvanian age (Moore and Plummer, 1939, p. 245). *Agassizocrinus* Owen & Shumard, *Tholocrinus* Kirk, and *Pterotocrinus* Lyon & Casseday are confined to rocks of Chester age. North American species of Pennsylvanian age, originally assigned to *Agassizocrinus*, are now referred to *Paragassizocrinus* Moore & Plummer (Moore and Plummer, 1939, p. 334; Strimple, 1960, p. 5). Sutton (1934, p. 393-416) used *Pterotocrinus* wing plates to zone the Chester, and the five *Pterotocrinus* species recorded herein either are restricted to the Glen Dean or are found rarely in other formations. *Aphelecrinus* Kirk, although not confined to the Chester, reached its greatest diversification during Chester time.

Horowitz and Perry (1961, p. 866) concluded, on the basis of crinoid faunas, that the Glen Dean should be correlated with rocks near the Vis6an-Namurian boundary as defined in Europe.

PALEOECOLOGY OF GLEN DEAN CRINOIDS

Abundant crinoid plates are found in Glen Dean calcarenites and calcirudites, but entire calyces are uncommon. Identifiable specimens have been found both in shales and on surfaces of limestones that are overlain by shales or argillaceous limestones. The preservation of nearly complete specimens found on the upper surfaces of limestone beds suggests rapid burial because crinoid skeletons probably disarticulated rapidly after death. As Perry and Horowitz indicated (1963, p. 16), other faunal elements are also well preserved on such surfaces.

Agitated waters prevailed during part of Glen Dean time as shown by crossbedded limestones and oolites, and disarticulated crinoidal debris is common in beds displaying these features. Crinoids are found less abundantly in shales in the upper part of the formation, but they are not as well preserved as might be expected

in a quiet environment in which mud was deposited. Perry and Horowitz (1963, p. 17) cited evidence suggesting that strong currents prevailed, at least part of the time, in areas of shale accumulation.

The crinoids are associated with a large varied fauna of brachiopods, bryozoans, and blastoids. The variety and abundance of the fauna suggest shallow open marine waters as indicated in Perry and Horowitz (1963, p. 14). Coprophagous platycerid gastropods are associated with the genera *Pterotocrinus* Lyon & Casseday and *Aphelecrinus* Kirk.

A few silicified specimens were found, but skeletal disarticulation, crushing, and weathering are the major causes of poor preservation.

In summary, Glen Dean crinoids were associated with an abundant, highly diversified marine fauna which existed in clear, shallow agitated water and in quieter waters where muds were deposited.

ACKNOWLEDGMENTS

Dr. Charles F. Deiss, former chairman of the Indiana University Department of Geology and State Geologist, provided financial assistance which enabled the author to examine type specimens in the Walker Museum in Chicago and granted access to Indiana Geological Survey collections on which this work is largely based. The author is equally grateful to officials of the Marathon Oil Co. for granting the time necessary to complete this manuscript and for providing the photographs of *Onychocrinus pulaskiensis* Miller & Gurley taken by Mr. Billy Upchurch.

The following paleontologists have been helpful in providing information, lending type specimens, and allowing access to collections in their care: Drs. N. D. Newell and D. F. Squires, American Museum of Natural History; Drs. J. M. Weller and M. H. Nitecki, Walker Museum, University of Chicago; Dr. G. A. Cooper, U. S. National Museum; Dr. Charles W. Collinson, Illinois State Geological Survey; Dr. F. H. T. Rhodes, formerly associated with the University of Illinois Department of Geology; and Dr. Hertha Sieverts-Doreck, Stuttgart, Germany. Dr. T. G. Perry, Indiana University Department of Geology, assisted in the preparation of the manuscript and prepared the plates.

Mr. George R. Ringer, of the Indiana Geological Survey, photographed all specimens illustrated in this report except those of *Onychocrinus pulaskiensis.*

COLLECTING LOCALITIES

Glen Dean crinoids used in this study were collected from the following sites (fig. 1)

1. Quarries listed by Haas (1946, p. 1) in the Glen Dean Limestone within two-thirds of a mile around the road junction called Sargent's Corner, about 2.5 miles due south of the east end of Lake Greenwood, Crane Naval Ammunition Depot, Martin County, Ind. Upper and lower parts of the Glen Dean.
2. NW¼NE¼ sec. 18, T. 2 N., R. 2 W., Orange County, Ind.; natural exposure on the Henry Hallaway Farm, approximately 1.5 miles northeast of the village of Rollins; Hillham Quadrangle. Lower part of the Glen Dean.
3. North line of the SE¼SE¼, sec. 26, T. 2 N., R. 3 W., Martin County, Ind.; natural exposure about 2 miles southwest of Rollins; Hillham Quadrangle. Lower part of the Glen Dean.
4. NE¼SW¼ sec. 22, T. I N., R. 3 W., Dubois County, Ind.; abandoned quarry 1.85 miles southwest of the village of Hillham and 310 feet northwest of Indiana State Highway 56; Hillham Quadrangle. Upper part of the Glen Dean.
5. SW¼NE¼ sec. 25, T. I N., R. 3 W., Dubois County, Ind.; abandoned quarry on north side of road about 0.4 mile southwest of the village of Norton; Cuzco Quadrangle. Upper part of the Glen Dean.
6. NE¼NE¼ sec. 27, T. 1 S., R. 2 W., Orange County, Ind.; natural exposure about 310 feet north of road and approximately 5.8 miles north of the village of Eckerty; Greenbrier Quadrangle. Upper part of the Glen Dean.
7. NW¼,NW¼ sec. 34, T. 1 S., R. 1 W., Crawford County, Ind.; natural exposure east of road near house and 0.85 mile northwest of the village of Brownstown; Greenbrier Quadrangle. Lower part of the Glen Dean.
8. E½ sec, 10, T. 2 S., R. 2 W., Crawford County, Ind.; Mulzer Brothers Co. quarry 0.8 mile south of the junction of Indiana State Highways 145 and 164 and about 2.5 miles north of the village of Eckerty; Taswell Quadrangle. Upper and lower parts of the Glen Dean.
9. SW¼SW¼ sec. 10, T. 2 S., R. 2 W., Crawford County, Ind.; abandoned quarry on the west side of Indiana State Highway 145 and about 0.3 mile south of the entrance to the

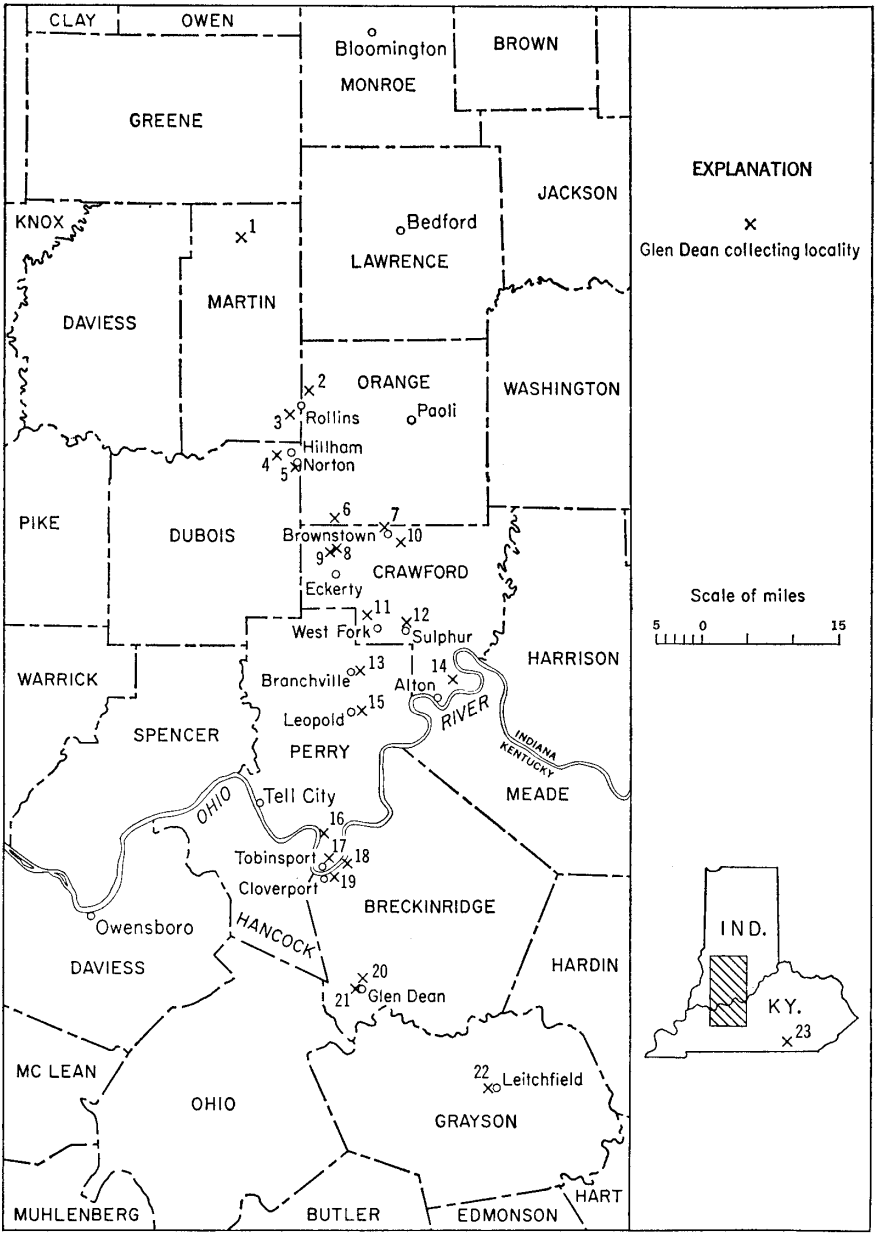

Figure 1.—Map showing Glen Dean collecting localities.

Mulzer Brothers Co. quarry (locality 8) ; Taswell Quadrangle. Upper part of the Glen Dean.

10. SE¼SE¼ sec. 2, T. 2 S., R. 1 W., Crawford County, Ind.; natural exposure 500 feet north of a house near the northern boundary of see. 11, T. 2 S., R. 1 W., and about 1.2 miles southeast of Brownstown; English Quadrangle. Lower part of the Glen Dean.
11. SW¼SW¼ sec. 17, T. 3 S., R. 1 W., Crawford County, Ind.; abandoned quarry approximately 1.8 miles northwest of the village of West Fork; Taswell Quadrangle. Lower part of the Glen Dean.
12. SE¼NW¼ sec. 25, T. 3 S., R. 1 W., Crawford County, Ind.; small abandoned roadside quarry 0.25 mile north of the village of Sulphur on Indiana State Highway 37; Beechwood Quadrangle. Upper part of the Glen Dean.
13. NW¼SW¼ sec. 18, T. 4 S., R. 1 W., Perry County, Ind.; abandoned quarry about 0.6 mile east of the village of Branchville; Branchville Quadrangle. Upper part of the Glen Dean.
14. NE¼SW¼ sec. 23, T. 4 S., R. 1 E., Crawford County, Ind.; natural exposure 50 feet north of road opposite a house and about 2.6 miles northeast of the village of Alton; Beechwood Quadrangle. Lower part of the Glen Dean.
15. SE¼SW¼ sec. 6, T. 5 S., R. 1 W., Perry County, Ind.; abandoned quarry 1.5 miles east of the village of Leopold; Derby Quadrangle. Upper part of the Glen Dean.
16. SW¼NW¼ sec. 16, T. 7 S., R. 2 W., Perry County, Ind.; road cut on the north side of Indiana State Highway 166 at road junction and about 3.8 miles north of the village of Tobinsport; Cannelton Quadrangle. Upper part of the Glen Dean.
17. NE¼NE¼ sec. 33, T. 7 S., R. 2 W., Perry County, Ind.; abandoned quarry within 100 feet of road bend to northeast about 1 mile northeast of the village of Tobinsport; Cloverport Quadrangle. Most probably upper part of the Glen Dean.
18. Abandoned quarry overlooking the Ohio River about 100 yards south of Louisville and Nashville Railroad tracks and approximately 2 miles northeast of the village of Cloverport, Breckinridge County, Ky.; Mattingly Quadrangle. Upper and lower parts of the Glen Dean.

19. "Old quarries" 0.8 mile east of Cloverport, Breckinridge County, Ky.; Mattingly Quadrangle. (Material collected by Dr. J. J. Galloway presumably from the upper part of the Glen Dean.)
20. Type section of the Glen Dean Limestone about 0.8 mile north of the village of Glen Dean, Breckinridge County, Ky., along road that was formerly bed of railroad; Glen Dean Quadrangle. Lower part of the Glen Dean.
21. Abandoned quarry 0.25 mile west of post office in the village of Glen Dean, Breckinridge County, Ky.; Glen Dean Quadrangle. Upper and lower parts of the Glen Dean.
22. Rogers and Brunnhoeffer Co. quarry north of U. S. Highway 62 on the west side of Leitchfield, Grayson County, Ky.; Leitchfield Quadrangle. Upper part of the Glen Dean.
23. Sloans Valley, Pulaski County, Ky.; Burnside Quadrangle. (Material collected by Dr. C. A. Malott in 1940 probably from the upper part of the Glen Dean.)

SYSTEMATIC DESCRIPTIONS

The abbreviations used in the specific descriptions are those proposed by Moore and Laudon (1941, p. 412-423). In the synonymies, the dates of publication are the imprint dates on the title pages of the cited articles or books. Where the actual date of printing is known to be different, it is shown in brackets at the end of the citation in Literature Cited.

All type specimens have been examined except the type of *Phacelocrinus longidactylus* (McChesney), which was lost in the Chicago fire (Kirk, 1955, p. 4), and the types of *Zeacrinites wortheni* (Hall), *Aphelecrinus randolphensis* (Worthen), and *Agassizocrinus dactyliformis* Shumard, which the author has been unable to locate. Specimens in the different collections and museums are designated as follows: AMNH, American Museum of Natural History; IU, Indiana University Paleontologic Collections; UI, University of Illinois; USNM, U. S. National Museum; and WM, Walker Museum, University of Chicago.

Table 1 shows the distribution of Glen Dean crinoid species by locality.

Class CRINOIDEA Miller, 1821

Subclass INADUNATA Wachsmuth & Springer, 1885

Order CLADIDA Moore & Laudon, 1943

Suborder POTERIOCRINITINA Jaekel, 1918

Family ZEACRINITIDAE Moore & Laudon, 1943

Genus ZEACRINITES Troost, 1858

Type species: Zeacrinites magnoliaeformis Troost

Kirk (1939, p. 470) showed that ascription of the type species of *Zeacrinites, Zeacrinites magnoliaeformis,* to Owen and Norwood, 1847 (not 1846 as cited by Sutton and Hagan, 1939, p. 94) is incorrect because Owen and Norwood (1847, p. 5) merely referred to their figure as "the beautiful *Encrinite*, fig. 13." Characters of the type species and genus are based on the description of Troost (in Hall, 1858, p. 544 and footnote). Hall (1858, p. 544) published the name as *Zeacrinus* but attributed the genus to Troost, who used the spelling *Zeacrinites* in his manuscript. Because Hall quoted Troost's description and spelling, Troost's name is valid and should be spelled as he intended. Moore and Plummer (1939, p. 245) and subsequent authors have followed Troost's spelling.

Kirk (1938, p. 158; 1939, p. 470) and Sutton and Hagan (1939, p. 82) discussed and revised *Zeacrinites.* Sutton and Hagan (1939, p. 93-95,) retained *Z. coxanus* (Worthen), *Z. ramoittq* (Hall), *Z. salemensis* (Miller & Gurly), and *Z. troostanus* (Meek & Worthen) in *Zeacrinites.* The author agrees with Kirk (1938, p. 165, 166) that the foregoing species belong in *Eratocrinus* Kirk. *Z. merope* (Hall) and *Z. paternus* (Hall) also seem more appropriately assigned to *Eratocrinus* than to *Zeacrinites.* Kirk (1942b, p. 383) placed *Z. pocillum* (Miller) in *Sarocrinus* Kirk. The description and figures of *Z. planobrachiatus* (Meek & Worthen) indicate that it does not belong in *Zeacrinites* because the rami do not bifurcate after the auxillary secundibrachial. With those emendations, the described species of *Zeacrinites* in North America are reported only from rocks of the Chester Series and from rocks of middle Pennsylvanian age in Texas.

Sutton and Hagan (1939, p.82) considered that the most reliable taxonomic characters of *Zeacrinites* are a concave base, extra primibrachials in the anterior ray, and quadrangular brachials. Two complete and seven incomplete specimens from the Glen Dean Limestone of southern Indiana and adjacent Kentucky fulfill these requirements. Sutton and Hagan (1939, p. 84) believed that the

shape, arrangement, size, and number of plates in the anal interray and the number of extra primibrachials in the anterior ray were stable characters on which specific differentiation could be based. Wright (1926, p. 156 ff., text figs. 61-88, pl. 15; 1952, p. 109, 115, pl. 34, figs. 44-49, 51-55, 57-62, 64-68, 70) showed that the anal area of the British species *Zeacrinites koninckі* (Bather) varies considerably. He recognized four basic patterns of anal plate arrangement in more than 300 specimens from three localities but did not establish any new species on this basis. Springer (1926, p. 81-84, text figs. 1-9; pl. 22, figs. 1-12; pl. 23, figs. 1-8) illustrated and discussed similar variation in North American species of *Zeacrinites.*

Although four specimens of *Zeacrinites* from the Glen Dean have been assigned to three previously recognized species, *Z. doverensis* (Miller & Gurley), Z. *trapeziatus* (Sutton & Hagan), and *Z. wortheni* (Hall), only one (identified as Z. *doverensis)* of the four specimens shows very close resemblance to a holotype in all features that can be compared. Until larger collections are studied so that features can be compared. Until larger collections are studied so that structural variability can be evaluated, variation in the characters of *Zeacrinites* will probably be conducive to the erection of spurious species. New species are not created herein because most of the specimens are incomplete. All interrays have been

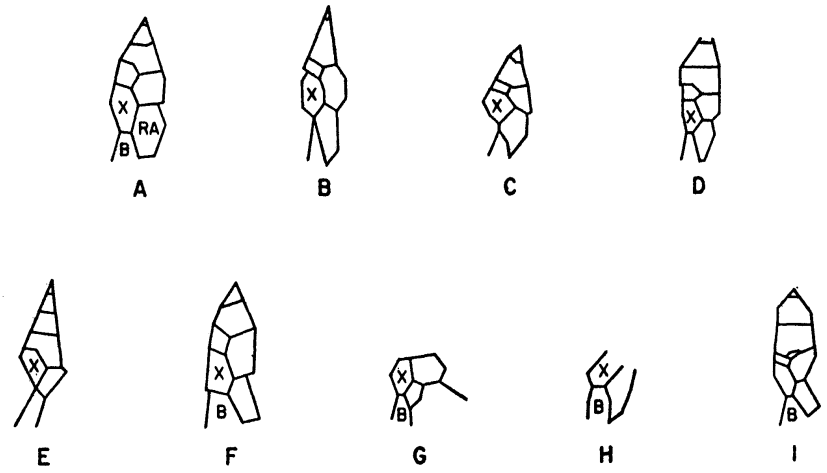

Figure 2.--Posterior interradii of *Zeacrinites* Troost. B, basal plate; RA, radianal; X, anal plate. Individual figures X 2. *A, Zeacrinites doverensis* (Miller & Gurley), IU 5728, locality 17; *B* and *C, Zeacrinites wortheni* (Hall), IU 5094, locality 12, and IU 5731, locality 13, respectively; *D, Zeacrinites trapeziatus* (Sutton & Hagan), IU 5094a, locality 12; *E, Zeacrinites* sp. B, IU 5730, locality 17; *F, Zeacrinites* sp. A, IU 5732, locality 13*; G, Zeacrinites* sp. C, IU 5733, locality 15; *H, Zeacrinites* sp. D, IU 5734, locality 15; *I, Zeacrinites ovalis* (Lyon & Casseday), holotype, USNM S 2686, previously unfigured.

Table 2.--*Number* of *secundibrachials in Glen Dean specimens* of Zeacrinites Troost

Species	Anterior ray		Left anterolateral ray		Right anterolateral ray		Left posterior ray		Right posterior ray		Museum No.
	Right	Left	Anterior	Posterior	Anterior	Posterior	Anterior	Posterior	Anterior	Posterior	
Zeacrinites wortheni. . . .	4	4	4	5	4	4	4	4	4	3	IU 5094
Zeacrinites wortheni. . . .	4	4	2	3	4 ?	4	2	3	3	3	IU 5731
Zeacrinite trapeziatus	5	9	4	3	4	3	4	3	4	3	IU 5094a
Zeacrinites doverensis	1+	2+	4	3+	2+	2+	3+	3	1+	1+	IU 5728
Zeacrinites sp. A	5	4	2	4	5	3	3 ?	3	4	4	IU 5732
Zeacrinites sp. B	4	5	4	3	4	3	4	3	3	4	IU 5730
Zeacrinites sp. C.	4	4	4	4	3	4	4	3	-	-	IU 5733
Zeacrinites sp. D.	4	3	3	2	1+	3	3	3	1+	1+	IU 5734
Zeacrinites sp. E	3	3	4	4	-	-	4	3	-	-	IU 5729

Table 3.--*Morphologic data on Glen Dean specimens of* Zeacrinites *Troost*
[Linear measurements in millimeters]

Species	Number of anal plates	Extra PBrBr in anterior ray	Number of arms	Greatest height of specimen	Greatest width of specimen	Height of dorsal cup	Width of dorsal cup	Museum No.
Zeacrinites wortheni. .	6	1	36	29	21	1.5	13	IU 5094
Zeacrinites wortheni. .	6	1	37 ?	35	24 X 12	2	12 X 14	IU 5731
Zeacrinites trapeziatus	7	1	27	26	19 X 13	2	9 X 10.5	IU 5094a
Zeacrinites doverensis	7	2	26 ?	19.5	19 X 14	2	11.5 X 14	IU 5728
Zeacrinites sp. A.	4+	2	26+	25	25 X 11	2	9 X 14	IU 5732
Zeacrinites sp. B.	6 or 7	1	24+	23	10	1.5	9 X 10	IU 5730
Zeacrinites sp. C.	3+		23+	20.5	20 X 14	1.5	11	IU 5733
Zeacrinites sp. D.	2+	1	21+	19	22 X 8	2 ?	9 X 13	1U 5734
Zeacrinites sp. E.	2+	1	30 ?	21.5	28 X 14	2	16 X 13 ?	IU 5729

figured (fig. 2) so that they can be compared with published illustrations.

The author recorded the number of secundibrachials in each ray (table 2) with the hope that this might be a stable character for specific determination. Although the comparison of the number of secundibrachials is favorable for the specimen of *Z. doverensis,* it did not prove useful for identifying the other Glen Dean specimens of *Zeacrinites.* Most species of *Zeacrinites* have three to five securidibrachials in rami that have additional bifurcations. Table 3 records additional measurements on Glen Dean specimens of *Zeacrinites.*

Zeacrinites trapeziatus (Sutton & Hagan)

Plate 1, figures 3-5; text figure 2D

Zeacrinus trapeziatus Sutton & Hagan, 1939, Jour. Paleontology, v. 13, p. 88, pl. 15, figs. 15-17, text fig. 2. Chester Series, Monroe County, III.

Description.--Crown slightly crushed, ovate. Dorsal cup low, basin shaped, and deeply invaginated. IBB in basal pit and concealed by column. BB small and not visible in lateral view, except PB. PB lanceolate; RPB shorter and not spatulate as other basals. RR 5.5 mm wide along superior edge and 3.5 mm high. PBrBr two in anterior ray and one in other rays. Rami 27, 5 in anterior ray, 4 in right posterior ray, and 6 in other rays. Post IR, six plates visible and possibly small seventh plate obscured. X, one-half in dorsal cup and resting on PB. RA narrow, entirely in cup, and with base resting on PB. Ventral sac unknown. Column round.

Remarks.-- The figured hypotype (IU 5094a) compares favorably with the holotype (WM 9402) of *Zeacrinites trapeziatus.* The

lower four plates of the interradial area are smaller and narrower in the Glen Dean specimen, but its interradial plate arrangement is identical with *Z. trapeziatus*. Six interradial plates are visible in the Glen Dean specimen, but the upper part of the anal interray is obscured, so that a small seventh plate may be present. The holotype of *Z. trapeziatus* has a larger number of secundibrachials per ramus and is larger than the Glen Dean specimen.

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5094a.

Zeacrinites wortheni (Hall)

Plate 1, figures 6-8, 15, 19; text figures 2B, 2C

Zeacrinus wortheni Hall, 1858, Iowa Geol. Survey, v. 1, pt. 2, p. 683, text fig. 111. Kaskaskia Limestone, Chester, Ill.-Springer, 1926, U. S. Natl. Mus. Proc., v. 67, art. 9, p. 65, 81, 83, pl. 22, fig. 12; pl. 23, figs. 1-8; text figs. 6-9. Glen Dean Formation, Pulaski County, Ky.-Sutton and Wagner, 1931, Jour. Paleontology, v. 5, p. 32, text fig. 1-C. Chester Series, Chester, Ill.-Sutton and Hagan, 1939, Jour. Paleontology, v. 13, p. 86, 95. Chester Series, Chester, Ill.

Zeacrinites wortheni (Hall). Moore and Laudon, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 165, pl. 61, figs. 2a, b. Mississippian, Glen Dean, Ky.

Description.--Crown ovoid, complete. Dorsal cup low, basin shaped, and deeply invaginated. IBB in basal pit and concealed by column. BB small and not visible in side view. RR 6 mm wide along superior edge and 4 to 5 mm high. PBrBr two in anterior ray and one in others. Rami 36, 6 in anterior ray, 7 in posterior rays, and 8 in lateroanterior rays. Post IR six anal plates, and X separated from PB by RA. Ventral sac unknown. Column round. In incomplete specimen, RR 7 mm wide along superior edge and 4 to 5 mm high. Rami 24 visible, 4 in anterior ray, and probably at least 6 in others. Post IR six plates, RA resting on PB and separating X completely from PB. In other respects, incomplete specimen similar to complete form.

Remarks.--Two Glen Dean specimens are placed in *Zeacrinites wortheni* on the basis of the anal interray pattern. In both specimens the radianal separates the anal plate from the posterior basal. The six anal plates, the number of arms, and other features compare favorably with the figures of Springer (1926, pl. 23, figs. 1-8), whose specimens were from the Glen Dean Limestone at Sloans Valley, Ky. Figure 6 of Springer (1926, pl. 23), his only illustration showing the anterior ray, does not have any extra primibrachials. A small collection of *Z. wortheni* from Sloans Val-

ley in the U. S. National Museum shows variability in the number of primibrachials in the anterior ray. The author has not been able to locate the type specimen of *Z. wortheni*.

Strimple (1962, p. 310) stated that *Z. peculiaris* (Miller & Gurley) can be distinguished from *Z. wortheni* only on the basis of the number of primibrachials in the anterior ray. *Z. peculiaris* has two anterior primibrachials and *Z. wortheni* three. On this basis, the Glen Dean specimens should be referred to *Z. peculiaris*. The stability of the anterior primibrachials in *Zeacrinites* is no better established for use in specific differentiation than is the pattern of plates in the posterior interradius. The author has placed major emphasis on characters of the posterior interradius and has used the oldest specific name applicable to the anal interray pattern exhibited by *Z. wortheni* and *Z. peculiaris*. But at the present state of our knowledge, this taxonomic procedure does not have any special merit over others.

Sutton and Hagan (1939, p. 86) indicated that *Z. wortheni* has five anal plates. Their conclusion is probably based on the type figure of Hall, which shows five anal plates, but the truncation of the top plate suggests that there is space available for an additional plate. Hall did not state the number of anal plates displayed by his type material. Most of the specimens figured by Springer (1926, pl. 23, figs. 1, 2, 6-8) have five anal plates, but the line drawings (1926, p. 83, text figs. 6-9) show five, six, and seven plates. Five anal plates are apparently most common. The extra anal plate in the Glen Dean specimens is small and at the top of the anal area.

Glen Dean specimens of *Z. wortheni* show a small quadrangular plate above the first anal plate and thus resemble *Z. doverensis* (Miller & Gurley). The anal plate in *Z. doverensis*, however, does not reach the posterior basal, and an extra plate is found in the distal part of the anal interray. The original figure of *Z. wortheni* shows a small triangular plate above the anal plate.

Z. bifurcatus (McChesney) has only three visible anal plates, but the radianal separates the anal plate from the posterior basal (McChesney, 1867, p. 6, text fig.; pl. 5, fig. 3). The arrangement of the three visible plates in *Z. bifurcatus* and in the Glen Dean representatives of *Z. wortheni* is similar, but the basals of McChesney's specimen, destroyed in the Chicago fire, are larger. Kirk (1955, p. 4) indicated that R. P. Whitfield made sulfur casts of McChesney's crinoids, and casts of Z. *bifurcatus* were examined in the Walker Museum at the University of Chicago. Unfortunately,

the sutures between the plates in the anal interray are not preserved in the sulfur casts.

Locality.--See table 1 (in pocket).

Types.--Figured hypotypes, IU 5094, IU 5731.

Zeacrinites doverensis (Miller & Gurley)

Plate 1, figures 16-18; text figure 2A

Zeacrinus doverensis Miller & Gurley, 1896, Illinois State Mus. Bull. 8, p. 35, pl. 2, figs. 20-22. Kaskaskia Group, Dover Hill, Ind.-Sutton and Wagner, 1931, Jour. Paleontology, v. 5, p. 32, text fig. 1-B. Chester Series, Dover Hill, Ind.-Sutton and Hagan, 1939, Jour. Paleontology, v. 13, p. 86, 93, text fig. 9. Chester Series, Dover Hill, Ind.

Description.--Crown incomplete. Dorsal cup low, basin shaped, and deeply invaginated. 113B in basal pit, concealed by column. 1313 small and not visible in side view, except PB. PB lanceolate. RR 6 or 7 mm wide along superior edge and 4 to 5 min high. Dorsal cup encrusted and silicified. PBrBr three in anterior ray and one in other rays. Rami 14 visible, 2 visible in anterior ray. Post IR seven anal plates; X rests on PB, one-half in cup; RA completely in cup, rests on PB and right PR. Ventral sac unknown. Column round.

Remarks.--This specimen does not differ in any measurable way from the holotype (WM 6457) of *Zeacrinites doverensis.* The Glen Dean specimen has the same number of interradial plates, extra primibrachials, and the same arrangement of the interradial plates and secundibrachials insofar as comparison is possible.

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5728.

Zeacrinites sp. A

Plate 1, figures 1, 2; text figure 2*F*

Description.--Crown crushed and lacking distal parts of rami. Dorsal cup low, basin shaped, and having deeply invaginated base. IBB in basal pit and concealed by column. BB small and, except PB, not visible because of poor preservation. RR 6 mm. wide along superior edge and 4 mm. high. PBrBr three in anterior ray and one in others. Rami 25 visible, probably 28 in complete specimen, 4 observed in anterior ray, and probably 6 in all others. Post IR having four plates clearly visible, probably six present, and position of X and RA not fully determinable. Ventral sac and column unknown.

Remarks.--The interpreted pattern of the interradial plates (fig. 2F) in the described specimen is very close to the arrangement of these plates in *Zeacrinites doverensis (*Miller & Gurley). The specimen has two rather than three plates above X_2 and RX, but the positions of the radianal and anal plates are apparently the same. The small plate (X_2) that is observed above the anal plate is apparently characteristic of interray arrangements that are similar to *Z doverensis.*

Locality.--See table 1 (in pocket).

Type.--Figured specimen, IU 5732.

Zeacrinites sp. B

Plate 1, figures 9-11; text figure 2E

Description.--Specimen incomplete and having crushed crown. Dorsal cup low, basin shaped, and having deeply invaginated base. IBB in basal pit and concealed by column. BB small, largely in basal pit, and not visible from lateral view except lanceolate PB. RR 5 mm wide at articulating edge and 3 mm high. PBrBr two in anterior ray and one in others. Rami 23 visible, probably at least 29 in complete specimen, 5 discernible in anterior ray, and not more than 6 in other rays. Post IR showing six or seven displaced plates. RA resting on PB; X between AR and RA. Other plates not in dorsal cup. Ventral sac unknown. Column round, having definite nodals and internodals, and having preserved length of 3 mm.

Remarks.--The described specimen shows only the lower part of the crown. The secundibrachial distribution does not compare favorably with other species. The plates of the posterior interradius have been displaced, and their arrangement has been reconstructed (fig. 2E). The position of the posterior interradial plates compares most favorably with *Zeacrinites wortheni* (Hall) and *Z. peculiaris* (Miller & Gurley) because the anal plate and the posterior basal touch at a single point. The entire anal plate arrangement is unlike that of any species of *Zeacrinites* whose anal interray has been figured.

Locality.--See table 1 (in pocket).

Type.--Figured specimen, IU 5730.

Zeacrintes sp. C

Plate 1, figures 12, 13; text figure 2*G*

Description.--Specimen incomplete and having badly crushed crown. Dorsal cup low, basin shaped, and having deeply invagi-

nated base. IBB in basal pit and concealed by solumn. BB small and not visible, except lanceolate PB, from lateral view. RR 6 mm along superior edge and 4 mm high. PBrBr two in anterior ray and one in others. Rami 20 visible, probably 30 in complete specimen, 6 in anterior ray, and at 1east 6 in others. Post IR having three plates observable; X one-half in cup, resting on PB, and twice as large as RA. Ventral sac not visible. Column circular, displaying definite nodals and internodals, and having observed length of 6 mm.

Remarks.--This specimen cannot be compared with previously described species of *Zeacrinites* because it displays so few interradial plates. The size and arrangement of the three anal plates is unlike any described species of this genus. The radianal is small, and the superjacent anal plate is very wide.

Locality.--See table 1 (in pocket).

Type.--Figured specimen, lU 5733.

Zeacrinites sp. D

Plate 1, figure 14; text figure 2H

Description.--Specimen incomplete and having crushed crown. Dorsal cup low, basin shaped, and having deeply invaginated base. IBB in basal pit and not observable. BB small and not visible, except lanceolate PB, in side view. RR 6 mm wide at upper articulating edge and 3.5 mm high. PBrBr two in anterior ray and one in others. Rami 20 visible, at least 28 in complete specimen, 4 observable in anterior ray, and probably at least 6 in others. Post IR only X and RA visible; X resting on PB. Ventral sac and column unknown.

Remarks.--The incomplete interradial area in the described specimen makes its comparison with previously described species of *Zeacrinites* difficult. The secundibrachial pattern of this Glen Dean specimen is not comparable to any described species of the genus.

Locality.--See table 1 (in pocket).

Type.--Figured specimen, IU 5734.

Zeacrinites sp. E

Plate 2, figures 1, 2

Description.--Specimen incomplete. Crown crushed and lacking anterolateral and posterior rays. Dorsal cup low, basin shaped, and having deeply invaginated base. IBB in basal pit and concealed by column. BB small and, except PB, visible only in basal

view. RR pentagonal, 9 mm wide along superior edge, and 5 mm high. Post IR two plates visible; X hexagonal, resting on PB, and supporting additional X$_2$. PBrBr two in anterior ray and one in others. Rami 17 visible, probably at least 29 in complete specimen, 5 in anterior ray, and at least 6 in other rays. Ventral sac poorly preserved. Column round, composed of definite nodals and internodals, and having observed length of 6 mm.

Remarks.--The described specimen shows only the lower part of the crown. The absence of most of the anal plates makes it difficult to compare this form with previously described species. The secundibrachial pattern does not compare with other known species, which have more secundibrachials in the posterior ray than this specimen.

Locality.--See table 1 (in pocket).

Type.--Figured specimen, IU 5729.

Genus THOLOCRINUS Kirk, 1939

Type species: Hydreionocrinus spinosus Wood

Plates, which are interpreted as spinose axillary primibrachials and spinose plates from the distal end of the ventral sac of *Tholocrinus* specimens, are found at several Glen Dean localities but apparently cannot be assigned to any particular species of *Tholocrinus*. Examples of such plates are illustrated on plate 2, figure's 5 and 6.

Tholocrinus spinosus (Wood)

Plate 2, figures 5-10

Hydreionocrinus spinosus Wood, 1909, U. S. Natl. Mus. Bull. 64, p. 93, Chester Group, Pulaski County, Ky.

Tholocrinus spinosus (Wood). Kirk, 1939, Washington Acad. Set. Jour., v. 29, p. 471. Upper Chester, Mississippi Valley and Kentucky.-Moore and Laudon, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 167, pl. 59, fig. 2. Glen Dean Limestone, Kentucky.-Moore, 1952, *in* Moore, Lalicker, and Fischer, Invertebrate fossils, p. 643, figs. 18-31, pt. 10. Chesteran Series, Kentucky.

.*Hydreionocrinus depressus* Wetherby (not Troost), 1881, Cincinnati Sec. Nat. History Jour., v. 3, p. 325, pl. 9, figs. 1-4, 6. Upper part of Kaskaskia Group, Pulaski County, Ky.-Springer, 1926, U. S. Natl. Mus. Proc., v. 67, art. 9, p. 89, 90, pl. 26, figs. 1-12. Glen Dean Formation, Sloans Valley, Ky.

Xystocrinus depressus Moore & Plummer (not Troost) (part), 1938, Denison Univ., Set. Lab., Bull., v. 32, p. 269, fig. 21, Upper Mississippian, North America.

Table *4.--Morphologic data on Glen Dean specimens of* Tholocrinus spinosus *(Wood)*
[Linear measurements in millimeters. Linear measurements in parentheses are for incompletely preserved features.]

Feature measured	Holotype, WM 6408	IU 5937, loc. 23	IU 5937a, loc. 23	IU 5937c, loc. 23	IU 5937d, loc. 23	IU 5937e, loc. 23	IU 6535, loc. 17
Calyx:				Incomplete	Incomplete	Incomplete	Incomplete
height	21	25	23	(9)	(13.5)	(15)	(7)
Diameter excluding distal ventral sac	10 X 14	15 X 9	11 X 13.5	-	10 X 12	9 X 13	-
Dorsal cup:							
height	2.3	2.5	2.5	2	3	2.5	2
diameter	11 X 12	12	12 X 11	9.5 X 10	13 X 12	11 X 13.5	9 X 10
Anal plates							
Visible	4	3	5	3	4	4	3

Remarks.--The author cannot add to the very complete description of this species given by Wetherby (1881, p. 325, pl. 9, figs. 1-4, 6). Two nearly complete specimens, five cups that have the lower rami attached, and one specimen containing only the distal spiniferous end of the ventral sac are referred to this species. Table 4 gives measurements on Glen Dean specimens of *Tholocrinus spinosus* (Wood).

Kirk (1939, p. 469, 470) discussed the involved nomenclature of *Tholocrinus spinosus.* The trivial name *spinosus*, proposed by Wood (1909, p. 93), is the earliest valid name for this species. Kirk (1939, p. 470) erected the genus *Tholocrinus* to receive this species and two others that formerly were referred to *Hydreionocrinus* de Koninck.

A deeper basal invagination, more bifurcations in each ray, and the nonaxillary nature of the first primibrachial in the anterior ray distinguish *T. spinosus* from *T. wetherbyi* (Wachsmuth & Springer). *T. armiger* (Meek & Worthen) is based on an incomplete specimen whose shallow basal invagination suggests that it is related more closely to *T. wetherbyi* than to *T. spinosus*. According to Strimple (1951, p. 675), *T. foveatus* is characterized by "the presence of small pits at the apices of the plates of the BB and RR circlets" and has a broad flat base showing a small basal invagination.

Localities.--See table 1 (in pocket).

Types.--Topotypes; figured, IU 5937b; unfigured, IU 5937, IU 5937a, IU 5937c-f. Figured hypotype, IU 6535.

Family SCYTALOCRINIDAE Moore & Laudon, 1943

Genus APHELECRINUS Kirk, 1944

Type species: Aphelecrinus elegans Kirk

Aphelecrinus hayensis (Meek & Worthen)

Plate 2, figures 3, 4

Poteriocrinus (Scaphiocrinus) bayensis Meek & Worthen, 1865, Acad. Nat. Sci. Philadelphia Proc., v. 17, p. 157. Chester Group, Pope County, Ill.-Meek and Worthen, 1873, Illinois Geol. Survey, v. 5, p. 550, pl. 20, fig. 2. Chester Group, Pope County, Ill.

Aphelecrinus bayensis (Meek & Worthen). Kirk, 1944, Am. Jour. Sci., v. 242, p. 192. Chester Series, Pope County, Ill.

Description.--Crown incomplete. Dorsal cup crushed, turbinate, 12 mm high, and 13 mm and 4 mm wide at radials and base, respectively. IBB five, 2 mm high and 3.5 to 4 mm wide and forming about one-fifth of dorsal cup. BB large and comprising over two-fifths of height of dorsal cup; RPB heptagonal, other BB hexagonal, and 5.5 mm high and 5.5 mm wide. RR 6.5 mm wide at superior surface and 4 mm high. PBrBr five, pentagonal, tumid, 4.5 mm high, and occupying all of superior surface of RR. Rami having only lower parts preserved and at least two in visible rays; ossicles short and cuneate. Post IR has four plates visible and three in dorsal cup. RA hexagonal, 6 mm high, 5 mm wide, and equally supporting X, which does not rest on PB, and RX; X 5 mm high, 4.5 mm wide, and resting on LPR and RA; RX 5 mm high and 4 mm wide; a fourth anal plate, having only lower part visible, rests equally on RX and X, but only lower part visible. Ventral sac unknown. Column unknown but probably round as indicated by basal scar.

Remarks.--The Glen Dean specimen closely resembles the original figure and description of *Aphelecrinus bayensis.* Examination of the holotype (UI X-57) indicated that the anal plates were exposed by clearing away the matrix, but the positions of the radianal and anal plate are still not clear. Apparently a single anal plate rests upon the radianal in the holotype, but the Glen Dean specimen has two anal plates resting upon the radianal. The holotype evidently has a pentagonal radianal, but this plate is hexagonal in the Glen Dean specimen. In all other respects, however, the Glen Dean form is similar to the holotype and is assigned to *A. bayensis* because the radianal prevents the anal plate from resting on the posterior basal; this is not the typical posterior interradial ar-

rangement of *Aphelecrinus*. The Glen Dean specimen of *A. bayen*sis is 1½ times larger than the holotype.

Kirk (1944a, p. 192) noted that a specimen labeled *Scaphiocrinus bayensis* (USNM S 2739) in the U. S. National Museum is an undescribed species of *Aphelecrinus*. The Glen Dean specimen does not compare closely with this undescribed form.

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5727.

Aphelecrinus oweni Kirk

Plate 2, figures 15-17

Aphelecrinus oweni Kirk, 1944, Am. Jour. Sci., v. 242, p. 198, pl. 1, figs. 1-3 (mislabeled "lyoni" on pl. 1). Upper Chester?, Falls on Rough Creek, Breckinridge County, Ky.

Description.--Crown incomplete. Dorsal cup turbinate, RR flaring, 16 by 19 mm in diameter across the RR, 11 mm high, and 6 mm in diameter at base. IBB five, 2 mm high, 3.5 mm wide, and forming about one-quarter height of dorsal cup. BB five; PB and RPB heptagonal, others hexagonal and 6 mm wide. RR five, heptagonal, flaring; RPR 6.5 mm in maximum width and 6 mm wide along superior edge; other RR 8 mm in maximum width, 7 mm wide at superior surface, and 5 mm high. PBrBr one preserved, 7 mm wide at base, 6 mm high, and constricted medially. SBrBr very few preserved, cuneate, about as wide as long, and tending to be constricted medially. Post IR has three plates preserved in dorsal cup; RA 5 mm. high and 5 mm wide, hexagonal, resting equally and not deeply on PB and RPB, and entirely within cup; X hexagonal, 5 mm high, 4.5 mm wide, and one-half in dorsal cup; RX hexagonal, 4 mm wide and high, and one-third in dorsal cup. Ventral sac unknown. Column unknown but probably round and 5 mm wide as suggested by its impression on base of dorsal cup.

Remarks.--Only the dorsal cup of the Glen Dean specimen is preserved, but except for size it does not differ appreciably from the holotype (USNM S 4436a) of *Aphelecrinus oweni*. The infrabasals and primibrachials are broader in the Glen Dean specimen, and its radials are more tumid and protuberant from the sides of the dorsal cup than those in the holotype. These differences are not considered of specific value because they might be found in a specimen that is more mature than the holotype.

The sides of the dorsal cup of *A. oweni* diverge more rapidly than those of *A. mundus* Kirk. *A dilatatus* Wright, which is a similar British species, has more widely flaring radials than *A. oweni*.

A. randolphensis (Worthen), although similar to *A. oweni,* contains thinner plates and has pentagonal basals in contrast to the hexagonal or heptagonal basals in *A. oweni.*

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5725.

Aphelecrinus randolphensis (Worthen)

Plate 2, figure 18

Poteriocrinites (Scaphiocrinus) randolphensis Worthen, 1873, *in* Meek and Worthen, Illinois Geol. Survey, v. 5, p. 551, pl. 21, fig. 14. Chester Group, Chester, Ill.

Description.--Crown of moderate height; arms about four or five times as high as dorsal cup. Dorsal cup crushed but possibly 13 mm high and 7 mm in diameter at base. IBB five, pentagonal in side view, 3 mm high, and 4 mm wide. BB: PB and RPB heptagonal, others pentagonal; and BB forming about two-fifths of height of dorsal cup. RR pentagonal, 7 mm wide along superior edge and 6 mm. high. PBrBr five, pentagonal. SBrBr cuneate, uniserial. Post IR has three plates visible within dorsal cup; RA possibly pentagonal, entirely in dorsal cup, and about 6 mm in diameter; RX obscured and almost out of dorsal cup. Arms uniserial, bifurcating on 10th or 12th secundibrachial and apparently bifurcating again on 16th tertibrachial; ossicles cuneate. Ventral sac poorly preserved and not definitely reflexed. Column unknown.

Remarks.--The calyx plates in the Glen Dean specimen are crushed, so that their accurate measurement is difficult. The holotype (UI X-726) was not examined, but the original figure indicates that the holotype of *Aphelecrinus randolphensis* is smaller than the Glen Dean form.

Cuneate brachials and bifurcations above the secundibrachials differentiate *A. randolphensis* from *A. okawensis* (Worthen). *A. bayensis* (Meek & Worthen) has a distinctive posterior interradius by which it can be distinguished from *A. randolphensis,* and *A. crassus* Kirk has larger infrabasals than *A. randolphensis*. Other species of *Alphelecrinus* are either small with relatively large primibrachials or have flaring radials.

Kirk (1944a, p. 190) stated that species of *Alphelecrinus* typically have a single isotomous division of the rami above the primibrachial. Additional bifurcations are believed to be distributed irregularly. Although the Glen Dean specimen shows only two rami having additional bifurcations, these divisions are at about the same position in the bracbial series. Additional bifurcations

may have been overlooked in other species because rami were poorly preserved or lacking. Unidentified specimens of *Aphelecrinus* from middle Chester rocks in Indiana (IU 5613) also show bifurcations, beyond the secundibrachials.

Pinnules are well preserved in the Glen Dean specimen and are as much as 13 mm. in length. The ossicles of the pinnules are two, or three times as long as wide and are attached to every other brachial.

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5954.

Genus HYPSELOCRINUS Kirk, 1940

Type species: Poteriocrinus hoveyi Worthen

Hypselocrinus campanulus Horowitz, n. sp.

Plate 2, figures 11-14; text figure 3

Description.--Dorsal cup turbinate to campanulate, 12.5 mm high and 21.5 mm in maximum diameter. IBB 4 to 4.5 mm high and 5.5 to 6 mm. wide. IBB cone 3 mm high or about one-quarter height of dorsal cup. BB: ABB and LPB hexagonal, 8 mm high, and 7.5 mm wide; PB and RPB heptagonal, 8 mm high, and 9 mm wide. RR: ARR 5 mm high and 10 mm wide.; PRR 9 mm wide. PBrBr three preserved, axillary 4.5 mm high, posterior PBrBr 8.5 mm wide, others 9 mm wide, all laterally appressed, and having straight sides; facets for reception of SBrBr 5 mm wide. SBrBr quadrangular, cuneate, and maximum of three preserved in any arm. Post IR (fig. 3) ; RA pentagonal, 6.5 mm high, 7 mm wide, completely in dorsal cup, resting equally on PB and RPB, right and left superior surfaces supporting RPR and X, respectively, and superior surface supporting RX. X heptagonal, 7 mm high, 7 mm wide, two-thirds in cup, and resting equally on PB, LPR, and RA; X supporting LX on left superior surface and X_2 on right superior surface. RX hexagonal, 5.5 mm high, 6 mm wide, one-half in cup, resting on RA, and supporting X_2 and RX_2on its superior

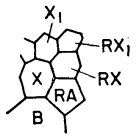

Figure 3.--Posterior interradius of *Hypselocrinus campanulus* Horowitz, n. sp. B, basal plate; RA, radianal; X, anal plate; RX, right anal plate; RX, second right anal plate; X,, second anal plate. Scale X 1.

surfaces. Tier of three anal plates, from right to left: RX, hexagonal, 5 mm high and 5 mm wide; X, hexagonal, 6 mm high, 5 mrn wide, and resting equally on X and RX; LX pentagonal, 4 mm high, and 3.5 mm wide; additional tier of anal plates containing five or possibly six plates arranged in a circle and forming ventral sac; possible fourth tier of anal plates broken away and obscured. Width of anal area one-half of the diameter of dorsal cup.

Preserved lower part of ventral sac composed of tiers of hexagonal plates. Column having one plate attached, 5 mm. in diameter, and containing pentagonal petaloid lumen 1 mm in diameter.

Remarks.--Kirk (1940b, p. 325) erected *Hypselocrinus* for a group of Kinderhook and Osage species containing turbinate cups, infrabasal cones that are visible in lateral view, and dichotomous rami having cuneate brachials. A single Glen Dean specimen, assigned to the new species *H. campanulus,* meets these criteria, although two of the five primibrachials are not preserved and only a few brachials are preserved in four arms. Early Mississippian forms have smaller cups, lack the slightly gaping sutures between radials and primibrachials that occur in the Glen Dean specimen, and contain relatively high primibrachials. The genus has not been recorded previously from upper Mississippian rocks, although Moore and Laudon (1944, p. 169) placed three species of Pennsylvanian age in *Hypselocrinus. H. campanulus* appears to be the largest, most robust species of the genus.

The specific name is derived from a Latin adjective meaning little bell and refers to the shape of the dorsal cup.

Locality.--See table 1 (in pocket).

Type.--Figured holotype, IU 5936.

Genus PHACELOCRINUS Kirk, 1940

Type species: Poteriocrinus wetherbyi Miller

Phacelocrinus longidactylus (McChesney)

Plate 2, figures 19-21

Scaphiocrinus longidactylus McChesney, 1859, Description of new species of fossils, p. 7. Kaskaskia Group, Kaskaskia, Ill.-McChesney, 1865, Illustrations of new species of fossils, pl. 4, fig. 4McChesney, 1867, Chicago Acad. Sci. Trans., v. 1, p. 4, pl. 4, fig. 4, and text fig. Kaskaskia Group, Kaskaskia, Ill.
Poteriocrinus wetherbyi Miller, 1879, Cincinnati Sec. Nat. History Jour., v. 2, P. 36, pl. 8, figs. 1-1b. Kaskaskia Group, Pulaski County, Ky.

Description.--Crown incomplete. Dorsal cup turbinate, 9 mm high, 14.5 mm wide at radials, and 4 mm wide at base. IBB five,

pentagonal in side view, 3 to 3.5 mm high and 3.5 to 4 mm wide, and forming about one-quarter of the height of dorsal cup. BB five; PB and RPB heptagonal; others hexagonal, about 5 mm high, and 4.5 to 5 mm wide. RR 7.5 mm in maximum width and 4.5 mm high. PBrBr only one visible; axillary 6 mm high and 6 mm wide at base, constricted medially, and separated from radial by gaping suture; ossicles few and about as high as wide. Post IR has three plates visible in cup but all crushed and partly obscured; RA smaller than X; X hexagonal, 6 mm high and ?4 mm wide, and resting equally on LPR, PB, and RA; RX hexagonal and ?4 mm high and 4 mm. wide. Ventral sac and column unknown.

Remarks.--The holotype of *Phacelocrinus longidactylus* was destroyed at the time of the Chicago fire. Kirk (1955, p. 4) noted that R. P. Whitfield made sulfur casts of many of McChesney's crinoids, but the author has not found casts of *P. longidactylus* in the Walker Museum at the University of Chicago, where sulfur casts of some of McChesney's specimens now reside. Fortunately, McChesney's figures of *P. longidactylus* are good, and although the plate figure does not show the posterior interradius, the text diagram and description adequately depict and describe it.

The holotype of *P. wetherbyi* (Miller) is larger than *P. longidactylus;* however, because the shape and arrangement of the anal plates are the same in *P. wetherbyi* as in *P. longidactylus,* the author regards *P. wetherbyi* as a subjective junior synonym of *P. longidactylus.* After examination of the literature indicated that the two species were probably synonymous, the author was surprised to find that the holotype of *P. wetherbyi,* which is part of the Gurley Collection in the Walker Museum, was labeled *"Poteriocrinus wetherbyi* SAM = S*cytalocrinus longidactylus* McCh." According to Dr. J. M. Weller (oral communication), the label probably was written by A. W. Slocum, but it is not known whether Slocum made the determination of the synonymy.

The crushed specimen of *Phacelocrinus longidactylus* from the Glen Dean is much smaller than Miller's type specimen of *P. wetherbyi,* but the relation of the plates in the dorsal cup and the constricted primibrachials are similar in these two species. The anal area of the holotype of *P. wetherbyi* is invisible as it is now embedded in plaster. The infrabasals apparently form a more tapered dorsal cup in the Glen Dean specimen of *P. longidactylus* than in *P. wetherbyi,* but this may partly result from distortion of the dorsal cup in the Glen Dean form.

P. columbiensis (Worthen) and *P. internodius* (Hall) are small species whose primibrachials equal the height of the dorsal sup. *P. dactyliformis* (Hall), *P. decabrachiatus* (Hall), and *P. wachsmuthi* (Wetherby) have relatively shorter dorsal cups that have smaller infrabals than *P. longidactylus*. Wachsmuth and Springer (1880, p. 340) considered *P. longidactylus* a synonym of *P. decabrachiatus*, but subsequent workers have not followed them. The type (WM 9858) of *P. vanhornei* (Worthen) is a much smaller species than *P. longidactylus*, it contains two unfused primibrachials, and the right posterior radial does not intervene between the radianal and the first right anal plate. *P. bisselli* (Worthen) and *P. gracilis* (Troost) are very similar to *P. longidactylus*. *P. bisselli* has longer narrower infrabasals, and the right posterior radial does not intervene between the radianal and the first right anal plate as in *P. longidactylus*. *P. gracilis* has slightly lower and wider infrabasals than *P. longidactylus*.

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5726.

Family ERISOCRINIDAE Miller, 1889

Genus PHANOCRINUS Kirk, 1937

Type species: Zeacrinus formosus Worthen

Phanocrinus parvaramus Sutton & Winkler

Plate 3, figures 1-3

Phanocrinus parvaramus Sutton & Winkler, 1940, Jour. Paleontology, v. 14, p. 556, pl. 67, figs. 9, 10.
?Glen Dean Formation, Pulaski County, Ky.

Description.--Crown 36.5 mm high and 18 by 8 mm in diameter. Dorsal cup low, saucer shaped, smooth, containing moderately tumid plates, and 4 turn high and 10.5 by 13.5 mm in diameter. RR 6 mm at superior edge and 5 mm high. PBrBr five, pentagonal, axillary. Rami 10, 2 in each ray, distinctly constricted at primibrachials, and composed of a single series of quadrangular ossicles. Post IR has two plates in dorsal cup. RA pentagonal, 3 mm long and 2 mm wide, and resting on PB and RAR. X narrow and obscured. RX obscured and having only small part in dorsal cup. Ventral sac unknown. Column round, 1.5 mm in diameter.

Remarks.—The foregoing description is based on an almost complete specimen from the Glen Dean. In addition, six low saucer-shaped dorsal cups are placed in *Phanocrinus parvaramus* because they are composed of smooth moderately tumid plates. Three of the cups have a few axillary primibrachials attached. The larger

Table 5.--*Morphologic data on dorsal cups* of Phanocrinus parvaramus *Sutton & Winkler*
[Linear measurements in millimeters]

	Museum No. and locality					
Character	IU 5940, loc. 15	IU 6960, loc. 15	IU 6961, loc. 15	IU 6962, loc. 19	IU 6963, loc. 19	IU 5941, loc. 9
Dorsal cup:	---	---	Lacks LPR	---	---	Crashed
Height	4	3.5	3	4	4.5-5	3.5-4 ?
Diameter	12 X 13.5	11 X 13	87 X 10	12.5 X 13.5	13 X 13.5	14?
Radials (RR) width on superior surface	6.5	6-6.5	4-4.5	6-7	6-7	7
Radianal (RA)	Entirely in cup. rests on PB and RPB. Pentagonal					
Anal plate (X) rests on PB.	One half in cup	One-half in cut)	All in cup	One-half in cap	One half in cap	One-half in cup
Right anal plate (RX)	Hexagonal, one-third in cup	Poorly preserved	Very small; rests on RA, entirely in cup	Lacking	Hexagonal, one-third in cup)	Lacking
Primibrachials (PBrBr)	Axillary	Axillary	Lacking	Lacking	Axillary	- Lacking

cups exhibit more conspicuously tumid anal plates than the complete specimen. Data on additional dorsal cups are given in table 5.

The holotype (WM 9414) of *P. parvaramus* differs from the complete Glen Dean specimen in having more tumid plates, a slightly higher dorsal cup, and greater size. These differences are not considered taxonomically significant because a sufficient number of cups were studied to indicate that differences exist in the height of the dorsal cups as well as in the tumidity of the plates. Other species of *Phanocrinus* do not have a combination of relatively small size, low dorsal cup consisting of smooth moderately tumid plates, and arms that are distinctly constricted at the primibrachials. *P. alexanderi* (Strimple, 1948, p. 493, pl. 77, figs. 1-6) is related very closely to *P. parvaramus* and may be a subjective junior synonym. *P. alexanderi* apparently is less constricted at the primibrachials, and its crown begins tapering at a lower position than in *P. parvaramus*.

Localities.--See table 1 (in pocket).

Types.--Hypotypes; figured, IU 5724; unfigured, IU 5939-IU 5941, 1U 6959-IU 6963.

Phanocrinus compactus Sutton & Winkler

Plate 3, figures 7-9

Phanocrinus compactus Sutton & Winkler, 1940, Jour. Paleontology, Y. 14, p. 555, pl. 67, figs. 7, 8. Golconda Limestone, near Golconda, Ill.

Description.--Crown 30 mm high and 14 by 7 mm in diameter. Dorsal cup crushed, bowl shaped, outline smooth, sutures closely knit, 4.5 mm high and 10 by 8 mm in diameter. RR 5 mm. wide along superior edge and 3.5 mm high. PBrBr five, pentagonal, axillary, except APBr. Rami nine, one in anterior ray, two in others, and composed of single series of quadrangular ossicles. Post IR has three plates in dorsal cup; RA pentagonal, 3.5 mm high, 2.5 mm wide, and entirely within cup; X hexagonal, 3 mm high, 2.5 mm wide, and resting equally on PB and RA; RX pentagonal, 2.5 mm. high, and 1.5 mm wide; X, hexagonal and 1.5 mm high and wide. Ventral sac unknown. Column round, 1.5 mm in diameter, composed of definite nodals and internodals, and having attached length of 3 mm.

Remarks.--The Glen Dean specimen of *Phanocrinus compactus* is larger than the holotype (WM 30244) and is more complete. The holotype shows only a few of the secundibrachials in each arm and does not have any columnals attached. The Glen Dean specimen has an additional anal plate, but this probably results from better preservation and is not considered distinctive because the size and relation of the other anal plates are similar to the holotype. The very closely knit plates and flush sutures are characteristic of *P. compactus* and distinguish it from other species of *Phanocrinus.*

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5723.

Phanocrinus cf. P. formosus (Worthen)

Plate 3, figures 13-15

Zeacrinus formosus Worthen, 1873, *in* Meek and Worthen, Illinois Geol. Survey, v. 5, p. 549, pl. 21, fig. 2. Chester Group, Chester, Ill.

Phanocrinus formosus (Worthen). Kirk, 1937, Jour. Paleontology, v. 11, p. 603, pl. 84, figs. 1, 2. Glen Dean Formation, Pulaski County, Ky.-Sutton and Winkler, 1940, Jour. Paleontology, v. 14, p. 553, pl. 68, figs. 17-19. Chester Series, Chester, Randolph County, Ill.-Moore and Laudon, 1943, Geol. Soc. America Spec. Paper 46, p. 435, pl. 6, fig. 1. Chesterian Series, Pulaski County, Ky.-Moore and Laudon, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 171, pl. 65, fig. 32. Glen Dean Limestone, Kentucky. Termier and Termier, 1950, Service géol. Maroc Notes et Mem. 79, p. 78, 226, pl. 221, figs. 1-8. Upper Visé, Morocco. Moore, 1952, *in* Moore, Lalicker, and Fischer, Invertebrate fossils, p. 624, 643, fig. 18-16, pt. 1a-b. Chesteran Series, Illinois.

Description.--Dorsal cup 5 mm high, 12 by 13 mm in diameter, and having somewhat impressed sutures and slightly tumid plates. IBB three, extending beyond base of column, and forming pentagonal disc 3.5 mm in diameter. BB large and forming about one-third of height of dorsal cup. RR 6 to 6.5 mm wide at superior edge and 4 mm high, except RPR, which is 3 mm. high. Post IR has four plates visible, three in dorsal cup. RA pentagonal, 4 mm long, and 2.5 nun wide. RX ?hexagonal, one-half in dorsal cup, 2.5 mm long, and 2.5 mm wide. X hexagonal, two-thirds in dorsal cup, 3.5 mm long, and 2.5 mm wide. X_2 out of dorsal cup and 2 mm high. Column round, 2 mm in diameter.

Remarks.--The above description is based on an uncrushed cup; in addition, a crushed cup is also referred to *Phanocrinus* cf. *P. formosus*. Part of a uniserial arm is attached to the matrix above each calyx. *Phanocrinus* is characterized by simple uniserial arms that have rectangular brachials, but most other crinoid genera in the Glen Dean have cuneate brachials which tend to develop into biserial arms. The character of the dorsal cup and the associated uniserial arms do not leave much doubt that these specimens are correctly referred to *Phanocrinus*. The shape and size of the plates in the dorsal cups are very similar to *P. formosus*, especially to the figures of a complete specimen published by Kirk (1937, pl. 84, figs. 1, 2). Kirk's material differs only in size from the Glen Dean dorsal cups. The holotype (UI X-817) of *P. formosus* is larger than the Glen Dean specimens, exhibits more of the radials in lateral view than either Kirk's specimen or the Glen Dean forms, and contains more tumid plates as might be expected of a more mature specimen. The holotype is incomplete as it displays only the radianal plate of the posterior interradius and lacks two rays.

The shape of the dorsal cup and the extension of the infrabasal disc beyond the column are diagnostic of this species. The plates of *P. formosus* are not granular and are not as tumid as in *P. cylindricus* (Miller & Gurley). Termier and Termier (1950, p. 78, 226, pl. 221, figs. 1-8) referred some crinoid material from Morocco to *Phanocrinus* cf. *P. formosus*, but the pustulose character of the plates suggests that this may be a new species more closely related to *P. cylindricus* (Miller & Gurley) than to *P. formosus*.

Locality.--See table 1 (in pocket).

Type.--Hypotypes; figured, IU 5935; unfigured, IU 6964.

Family EUPACHYCRINIDAE Miller, 1889

Genus EUPACHYCRINUS Meek & Worthen, 1865

Type species: Graphiocrinus quatuordecembrachialis Lyon

Eupachycrinus germanus Miller

Plate 3, figures 4-6

Eupachycrinus germanus Miller, 1879, Cincinnati Soc. Nat. History Jour., v. 2, p. 40, pl. 8, fig. 3. Kaskaskia Group, Pulaski County, Ky.-Sutton and Winkler, 1940, Jour. Paleontology, v. 14, p. 551, pl. 66, figs. 16, 17. Chester Series, Pulaski County, Ky.

Description.--Crown incomplete. Dorsal cup 5 mm high, 10.5 by 14.5 mm in diameter, smooth, bowl shaped, and having invaginated base. IBB hidden by column and not visible. BB five and only partly visible from side view. RR five, 6 to 6.5 mm wide at superior edge, 4.5 mm high, and pentagonal. PBrBr five, pentagonal. Rami 14, 2 in anterior ray, and 3 in others; ossicles cuneate, uniserial at base and becoming biserial, and only a few preserved in most rami. Post IR has three plates clearly visible; RA pentagonal, entirely within cup, and 4 mm high and 3 mm wide; X hexagonal, 3 mm. high and 3 mm wide, its base resting on PB, and three-quarters within dorsal cup; RX hexagonal, resting equally on RA and X, one-half in dorsal cup, and 3 mm high and 2.5 mm wide. Ventral sac unknown. Column round, 3 mm in diameter, composed of definite nodals and internodals, and having an attached length of 2 mm.

Remarks.--The arms are not as well shown in the Glen Dean specimen as in the holotype (WM 6411), but in both specimens the shape of the dorsal cup and the arrangement of the plates are similar. Wachsmuth and Springer (1887, p. 173) placed *Eupachycrinus germanus* in synonymy with *E. spartarius* Miller, but not all authors have followed them.

Locality.--See table 1 (in pocket).

Type.--Figured topotype, IU 5738.

Eupachycrinus spartarius Miller

Plate 3, figures 10-12

Eupachycrinus spartarius Miller, 1879, Cincinnati Soc. Nat. History Jour., v. 2, p. 38, pl. 8, fig. 2. Kaskaskia Group, Pulaski County, Ky.-Kirk, 1937, Jour. Paleontology, v. 11, p. 601, pl. 84, figs. 8-14. Glen Dean Formation, Sloans Valley, Pulaski County, Ky.-Moore and Laudon, 1943, Geol. Soc. America Spec. Paper 46, p. 135, pl. 6, figs. 8a, b. Chesterian, Pulaski

County, Ky.-Moore and Laudon, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 175, pl. 64, figs. 28a-c. Chester, Kentucky.

Intermediacrinus spartarius (Miller). Sutton and Winkler, 1940, Jour. Paleontology, v. 14, p. 561, pl. 66, figs. 3-5. Chester Series, Pulaski County, Ky.

Description.--Crown 18 mm high and 8 by 14 mm in diameter. Dorsal cup 3 mm high, 7.5 by 9.5 mm in diameter, and having deeply invaginated base. IBB not visible; BB five: and forming about one-quarter of height of dorsal cup. RR five, pentagonal, 5 mm wide at superior edge, and 3 mm high. PBrBr five, axillary, about one-half as high as wide. Rami 14, 2 in anterior ray, and 3 in others; lowest ossicles cuneate and uniserial but becoming biserial. Post IR has six plates visible, three in dorsal cup; RA pentagonal and entirely within dorsal cup; X hexagonal, base resting on RA, and one-half in dorsal cup. Ventral sac unknown. Column round, 2 mm in diameter, and having attached length of 2 mm.

Remarks.--The Glen Dean form is very similar to, a young specimen of *Eupachycrinus spartarius* figured by Kirk (1937, pl. 84, figs. 10, 11). The Glen Dean specimen differs from Kirk's form only in having shorter primibrachials, which is not of taxonomic significance.

Locality.--See table 1 (in pocket).

Type.--Figured topotype, IU 5739.

Eupachyerinus boydii Meek & Worthen

Plate 3, figures 16-18

Eupachycrinus boydii Meek & Worthen, 1870, Acad. Nat. Sci. Philadelphia Proc., v. 22, p. 30. Chester Group, Chester, Ill.-Meek and Worthen, 1873, Illinois Geol. Survey, v. 5, p. 554, pl. 21, figs. 6a-d. Chester Group, Chester, Ill. Sutton and Winkler, 1940, Jour. Paleontology, v. 14, p. 550, pl. 67, figs. 16, 17. Chester Series, near Chester, Randolph County, Ill.

not *Eupachyerinus boydii* Wood, 1909, U. S. Natl. Mus. Bull. 64, p. 95, pl. 7, figs. 1-5 [= *E. tumidus* (Sutton & Winkler)].

Encrinites sp. Yandell and Shumard, 1847, Contributions to the geology of Kentucky, p. 25, pl., figs, 4, 4a. Two miles north of Litchfield, Ky.

Description.--Crown 51 mm high and 25 by 15 mm in diameter above dorsal cup. Dorsal cup 24 by 22 mm in diameter, 10 to 12 mm high, and having deeply invaginated base. IBB not visible and presumably within basal invagination. BB five, 12 mm wide, and 17 mm high; PB and RPB having five sides visible, and other BB having four sides visible; BB forming one-half of height of

dorsal cup. RR five, pentagonal, 12 to 12.5 mm wide at widest position but tapering to 11 mm at superior surface, and 7.5 mm high; RPR 6 mm high. Post IR has three plates visible, two in dorsal cup; RA 9.5 mm long, 6.5 mm wide, pentagonal, moderately tumid, and entirely within dorsal cup; X 5 mm wide, 5 mm high, hexagonal, and one-half within dorsal cup; RX partly obscured, 3 mm high, 2 mm wide, and resting on RA. PBrBr five, pentagonal, 4.5 mm high, 11.5 mm. wide, and moderately tumid. Rami 14, 2 in anterior ray, and 3 in others, first few ossicles uniserial, cuneate, and becoming biserially arranged and remaining biserial for visible length of rami. Ventral sac and column unknown.

Remarks.--The incomplete holotype (Ul X-138) of *Eupachycrinus boydii* lacks two primibrachials and the radianal, but the anterior ray containing two arms is preserved. The anal plate in the almost complete Glen Dean specimen, on which the foregoing description is based, is not as tumid as that in the holotype. An incomplete dorsal cup from the Glen Dean is also assigned to *E. boydii.*

The Glen Dean specimens contain two interradial plates in the dorsal cup; Sutton and Winkler (1940, p. 559) based the genus *Intermediacrinus* on this character. Some inadunate species exhibit considerable variability in the plates of the anal interradius as demonstrated by Wright (1926) for *Phanocrinus calyx* (McCoy) ; therefore, some authors do not consider the position of the anal plates in a closely related group of species a completely reliable character for taxonomic differentiation. For this reason, Bassler and Moodey (1943, p. 470) and Moore and Laudon (1943, p. 62) consider *Intermediacrinus* Sutton & Winkler to be a synonym of *Eupachycrinus* Meek & Worthen. Sutton and Winkler (1940, p. 550) did not place *E. boydii* in *Intermediacrinus* because the posterior interradius is incomplete but assigned this species with some reservation to *Eupachycrinus.*

The Glen Dean specimens of *E. boydii* have less tumid plates and larger infrabasals than the holotype of *E. variabilis* Sutton & Winkler, which the author has examined. *E. spartarius* Miller, *E. irregularis* Sutton & Winkler, *E. germanus* Miller, and *E. durabilis* (Miller & Gurley) have low dorsal cups, which are not constricted at the superior surfaces of the radials as in *E. boydii. E. asperatus* Worthen has angular protuberances on the basals, and the radials and basals of *E. pentalobus* (Hall) and *E. tumidus* Sutton & Winkler are more tumid than those of *E. boydii. E. vapidus*

Wright has more tumid plates, and *E. macreanensis* Wright has larger and more readily observed infrabasals than *E. boydii;* the foregoing species have been described from Ireland. *E. modernus* Strimple has a different arrangement of arms in its rays than *E. boydii.* Neither Kirk (1937, p. 599) nor Sutton and Winkler (1940, p. 549) believed that species from China assigned to *Eupachycrinus* by Tien (1926, pl. 2, figs. 1-4) are appropriately placed in this genus; Kirk (1937, p. 599) suggested that Tien's species would be more properly placed in *Cromyocrinus* Trautschold or *Ulocrinus* Miller & Gurley.

Sutton and Winkler (1940, p. 550) indicated that the specimen assigned to *Eupachycrinus boydii* by Wood (1909, p. 95, pl. 7, figs. 1-5) would be better assigned to *E. tumidus* Sutton & Winkler. Meek and Worthen (1873, p. 555) noted that the unnamed figures of Yandell and Shumard (1847, pl., figs. 4, 4a) are apparently con-specific with *E. boydii* and are here placed in synonymy.

Localities.--See table 1 (in pocket).
Types.--Hypotypes; figured, IU 5722; unfigured, IU 6045.

Family AGASSIZOCRINIDAE Miller, 1889

Genus AGASSIZOCRINUS Owen & Shumard, 1851

Type species: Agassizocrinus conicus Owen & Shumard

All but one of the Glen Dean specimens of this genus are infrabasal cones; about three-quarters of the forms have fused infrabasals. Springer (1926, p. 122) inferred that only *Agassizocrinus conicus* Owen & Shumard has a distinctive infrabasal cone. Springer (1926, p. 63) identified most species in this genus by features shown by entire calyces. Most of the Glen Dean specimens are similar to infrabasal cones figured by Springer (1926, pl. 16, figs. 18-23), who did not apply specific names to them.

Following suggestions by Rodriguez (1960, p. 207, fig. 15) for *Agassizocrinus* and by Strimple (1960, p. 6, 7, fig. 1) for *Paragassizocrinus* Moore & Plummer, the author has presented measurements (table 6) on some infrabasal cones from the Glen Dean. Similar information obtained from specimens from other formations may provide a basis for differentiating the infrabasal cones of *Agassizocrinus*. For example, Strimple (1960; 1961) erected a number of Pennsylvanian species of *Paragassizocrinus* on the basis of their infrabasal cones.

Agassizoerinus cf. A. conicus Owen & Shurnard

Plate 4, figures 1, 2

Agassizoerinus conicus Owen & Shumard, 1851, Acad. Nat. Sci. Philadelphia Jour., ser. 2, v. 2, p. 92, pl. 11, fig. 6. Subcarboniferous limestone, Chester, Ill.-Owen and Shumard, 1852, *in* Owen, Report of a geological survey of Wisconsin, Iowa, and Minnesota, p. 597, pl. 5B, fig. 6. Subcarboniferous limestone, Chester, Ill.-Meek and Worthen, 1873, Illinois Geol. Survey, v. 5, p. 557, pl. 21, fig. 3. Chester Group, Chester, Ill.-Ulrich, 1905, U. S. Geol. Survey Prof. Paper 36, p. 58, pl. 6, figs. 20a-c. Birdsville Formation, Pulaski County, Ky.-Butts, 1917, in Mississippian formations of western Kentucky, Kentucky Geol. Survey, p. 80, pl. 21, figs. 27-29. Glen Dean Limestone, Kentucky.-Miller, 1919, Kentucky Geol. Survey, ser. 5, Bull. 2, p. 135, pl. 61, figs. 14-17. Gasper Oolite.-Butts, 1926, Alabama Geol. Survey Spec. Rept. 14, p. 180, pl. 59, figs. 5, 6. Gasper Oolite, Huntsville, Ala.-Springer, 1926, U. S. Natl. Mus. Proc., v. 67, art. 9, p. 53, 59, 63, pl 15, figs. 1-4. Chester Series, Chester, Ill. Okaw Formation, Union County, Ill.-Moore and Laudon, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 177, pl. 61, figs. 7a, b. Chesteran Series, Illinois.

Remarks.--A single worn infrabasal cone is referred to *Agassizocrinus* cf. *A. conicus*. This specimen has fused infrabasals, but the sutures can be seen on the ventral surface of the cone and on a deeply weathered side. The height and width of this infrabasal cone are 13 and 11.5 mm, respectively.

A. conicus and *A. lobatus* Springer are apparently the only species of *Agassizocrinus* which have distinctive infrabasal cones. *A. constrictus* Hall has an elongate infrabasal cone that contains a small extra intercalated plate and is much smaller than *A. conicus*.

Springer (1926, pl. 15, fig. 2) has figured a specimen of *A. conicus* that does not have a typical elongate cone. The infrabasal cone of this specimen could not be distinguished from similar cones of other species if it were detached from the remainder of the calyx. Infrabasal cones illustrated by Ulrich (1905, pl. 6, figs. 20a, b) and Butts (1917, pl. 21, figs. 27-29; 1926, pl. 50, figs. 5, 6) are doubtfully *A. conicus*, as they are not narrow and elongate; they are large enough, however, to have formed one-half of a dorsal cup.

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, 1U 5736.

Agassizocrinus dactyliformis Shumard

Plate 4, figures 3, 4

Agassizocrinus dactyliformis Shumard, 1854, *in* Marcy, Exploration of the Red River of Louisiana, app. E, p. 199, pl. 1, fig. 7. Carboniferous, Washington County, Ark.

Remarks.--Agassizocrinus dactyliformis Shumard has commonly been cited as a synonym of *A. laevis* (Roemer), although *A. dactyliformis* clearly has priority as recognized by Roemer (1856, p. 230). Unfortunately, *A. dactyliformis* is based on an incomplete calyx, so that precise comparison with *A. laevis* is not possible. As a result, the type figure of *A. laevis* has been much more widely published and recognized.

A single Glen Dean specimen, in which only basals and infrabasals are preserved, is referred to *A. dactyliformis*. Although only one-half as large as the type specimen figured by Shumard, the Glen Dean specimen and the type agree closely in calyx shape, plate arrangement, and relative sizes of the plates. Although not impressed, the sutures of the plates of the Glen Dean specimen show plainly even in the infrabasal cone, and the calyx has a smooth broadly conical appearance. The posterior basals are hexagonal, and the anterior ones are pentagonal.

Dimensions in mm of the Glen Dean specimen follow: height of dorsal cup 8.5; width of dorsal cup 8.5 by 9.5; height of infrabasal cone 4; and width of infrabasal cone 7.

Locality.--See table 1 (in pocket).

Type.--Figured hypotype, IU 5737.

Subclass FLEXIBILIA Zittel, 1879

Order TAXOCRINIDA Springer, 1913

Family TAXOCRINIDAE Angelin, 1878

Genus ONYCHOCRINUS Lyon & Casseday, 1860

Type species: Onychocrinus exsculptus Lyon & Casseday

Onychocrinus pulaskiensis Miller & Gurley

Plate 4, figures 11, 12

Onychocrinus pulaskiensis Miller & Gurley, 1895, Illinois State Mus. Bull. 6, p. 40, pl. 4, figs. 1, 2. Kaskaskia Group, Pulaski County, Ky.-Springer, 1920, Smithsonian Inst. Pub. 2501, p. 421, 437, pl. 74, figs. 1-10; pl. 75, figs. 15a, b. Okaw Formation, Pulaski, Grayson, and Breckinridge Counties, Ky.; Huntsville, Ala.; Randolph County, Ill.-Moore and Laudon, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 179, pl. 69, fig. 3. Mississippian (Chester), Kentucky, Alabama, and Illinois.

?Onychocrinus parvus Miller & Gurley, 1894, Illinois State Mus. Bull. 3, p. 52, pl. 4, fig. 5. Kaskaskia Group, Shoals, Martin County, Ind.-Springer, 1920. Smithsonian Inst. Pub. 2501, p. 437, pl. 74, fig. 8. Martin County, Ind.

Remarks.--Figures of the holotype (WM 6416) of *Onychocrinus pulaskiensis* do not show any nodose axillaries nor are they mentioned in the original description (Miller and Gurley, 1895, p. 40,

Table 7.-*Morphologic data on* Onychocrinus pulaskiensis *Miller & Gurley*
[Linear measurements in millimeters]

Character	Springer's specimens[1]	AMNH 26198
Length of ramus, below AxPBr	31	20-25
Length of ramus above AxPBr	63	At least 60
Diameter of calyx	30	15
Diameter of stem at base of calyx	12	10.5
Number of clusters of rarmules	10 or more	6 or more

[1]Average of two specimens. Springer, 1920, p. 437, pl. 74, figs. 2-3.

pl. 4, figs. 1, 2). Springer (1920, p. 437) has given a very complete description of this species and noted that the nodose axillaries do not show well in weathered specimens, such as the holotype. The author has studied one complete specimen and the rami of two other forms that exhibit nodal axillaries. The material agrees very well with the holotype and with the descriptions of Springer. Table 7 gives data on an almost complete Glen Dean specimen in the collections of the American Museum of Natural History. Haas (1946, p. 2) referred this specimen to *Tholocrinus* Kirk.

The author has examined the type material of *Onychocrinus parvus* Miller & Gurley which Springer (1920, p. 437) regarded as an indistinguishable juvenile form. On the basis of its stratigraphic position, *0. parvus* might be an immature specimen of *0. pulaskiensis;* both species have been found in Martin County, Ind. Following Springer, the author has questionably placed *0. parvus* in synonymy with *0. pulaskiensis,* although the former has nomenclatorial priority.

British specimens, previously referred to *0. pulaskiensis,* have been placed in the species *0. liddelensis* Wright (1954, p. 171). Wright (1954, p. 172) stated that his specimens do not have nodal axillaries and exhibit flatter calyx bases and more strongly pustolose and wrinkled plates than *0. pulaskiensis.*

0. pulaskiensis is characterized by the combination of three primibrachials and two or three secundibrachials. No other member of the *0. ramulosus* group of this genus has this combination of characters; species in the *0. ramulosus* group display few interbrachials. According to Springer (1920, p. 437), *0. pulaskiensis* is one of the last species of this genus.

Localities.--See table 1 (in pocket).

Types.--Hypotypes; figured, AMNH 26198, AMNH 26076; unfigured, IU 6088-IU 6090.

Subclass CAMERATA Wachsmuth & Springer, 1885

Order MONOBATHRIDA Moore & Laudon, 1943

Suborder TANAOCRINIDA Moore, 1952

Superfamily HEXACRINITICEA Ubaghs, 1953

Family DICHOCRINIDAE Miller, 1889

Subfamily TALAROCRININAE Ubaghs, 1953

Genus PTEROTOCRINUS Lyon & Casseday, 1859

Type species: Asterocrinus capitalis Lyon

The genus *Pterotocrinus* is represented in the Glen Dean collections almost entirely by wing plates, a term used in quotation marks by Sutton (1934). Wachsmuth and Springer (1897, p. 792), Springer (1926, p. 45), and Sutton (1934, p. 396) indicated that wing plates probably represent the first radial dome or axillary plates of the tegmen. *Pterotocrinus* wing plates evolved very rapidly during Chester time and are extremely variable in form; as a result, large collections show many variants that generally have been described with the species they most closely resemble.

Because of their distinctive characters, short geologic range, and wide distribution in the Illinois Basin, *Pterotocrinus* wing plates are excellent guide fossils for the Glen Dean Limestone and can be used successfully in the field by geologists to identify formations within the Chester Series. The author has followed the terminology and procedures of Sutton (1934) in describing wing plates and assigning them to species.

The author has not created new names for the *nomina aperta* of *Pterotocrinus* because they are based on single specimens or incomplete materials. Further work may confirm the validity and usefulness of these forms.

Pterotocrinus bifurcatus Wetherby

Plate 4, figures 5-10

Pterotocrinus bifurcatus Wetherby, 1879, Cincinnati Soc, Nat. History Jour.,v. 2, p. 136, pl. 11, figs. 1a-c. Kaskaskia Group, Pulaski County, Ky.-Butts, 1917, *in* Mississippian formations of western Kentucky, Kentucky Geol. Survey, p. 100, pl. 24, fig. 14. Glen Dean Limestone, Kentucky.-Miller, 1919, Kentucky Geol. Survey, ser. 5, Bull. 2, p. 139, pl. 63, fig. 14. Glen Dean Limestone.-Weller, 1920, Illinois Geol. Survey Bull. 41, p. 372, pl. 10, fig. 14. Glen Dean Limestone, Pulaski County, Ky.-Springer, 1926, U. S. Natl. Mus. Proc., v. 67, art. 9, p. 50, pl. 14, fig. 5. Glen Dean Formation, Pulaski County, Ky.-Weller, 1931, Kentucky Geol. Survey, ser. 6, v. 36, p. 288, fig. 3. Glen Dean Limestone.-Sutton, 1934, Jour, Paleontology, v. 8, p. 412, pl. 50

figs. 14-16. Upper part, lower Okaw limestone, Randolph County, Ill.; Glen Dean Limestone, Breckinridge and Pulaski Counties, Ky.; Golconda Formation, Johnson County, Ill.-Moore and Laudon, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 119, pl. 70, fig. 17. Glen Dean Limestone, Kentucky.-Moore, 1952, in Moore, Lalicker, and Fischer, Invertebrate fossils, p. 644, fig. 18-15A. Chesteran Series, Kentucky.

Pterotocrinus acutus var. *bifurcatus* Wachsmuth & Springer, 1897, Harvard Coll. Alus. Comp. Zoology Mem. 21, p. 801, pl. 79, figs. 9a, b. Kaskaskia Group, Pulaski County, Ky.

Remarks.--The species *Pterotocrinus bifurcatus*, which has been considered as an index fossil for the Glen Dean, is represented in the collections studied only by wing plates. Although many illustrations of the type specimen (WM 6401) have been published, few additional forms have been figured.

In a typical wing plate of this species, the proximal region and base are suggestive of *P. acutus* Wetherby. In the type specimen of *P. bifurcatus* the distal ends of the wing plates bifurcate at angles ranging from 140º to nearly 180º. The angle of bifurcation is commonly as low as 110º in Glen Dean material. The holotype of *P. bifurcatus* has horizontally flattened distal bifurcations, but some variants have bifurcations which are pointed or awl shaped. The length of the wing plates from the base to the bifurcation is commonly 15 to 20 mm. The distal parts of the bifurcations are commonly broken, and only a few millimeters of their original length remain attached to the proximal part of the wing plates. A few aberrant forms show additional distal blades and bifurcations (pl. 4, figs. 9, 10).

P. bifurcatus has been reported from one locality in the Golconda Formation of Illinois; elsewhere in the Illinois Basin it has been found only in the Glen Dean Limestone and is considered a good guide fossil for this formation.

Localities.--See table 1 (in pocket).

Types.--Hypotypes; figured, IU 5917b-c, IU 5926, IU 5928 IU 5929a-b; unfigured, IU 5745, IU 5916, IU 5918, IU 5932, IU 5933. Unfigured topotypes; IU 5751, IU 5757.

Pterotocrinus acutus Wetherby

Plate 5, figures 7-9

Pterotocrinus acutus Wetherby, 1879, Cincinnati Soc. Nat. History Jour., v. 2,p, 134, pl. 11, figs. 2a-c. Kaskaskia Group, Pulaski County, Ky.-Wachsmuth and Springer, 1897, Harvard Coll. Mus. Comp. Zoology Mem. 21, p. 799, pl. 79, figs. 3a-g. Pulaski County, Ky.-Ulrich, 1905, U. S. Geol. Survey Prof. Paper 36, p. 58, pl. 6, figs. 23, 24. Birdsville Formation, Kentucky.- Wood, 1909, U. S. Natl. Mus. Bull. 64, p. 43.Chester Group, Cumberland

Mountains, Tennessee; Pulaski County, Ky.; Huntsville, Ala.-Butts, 1917, in Mississippian formations of western Kentucky, Kentucky Geol. Survey, p. 100, pl. 24, figs. 15, 16. Glen Dean Limestone, Sloans Valley, Ky.-Miller, 1919, Kentucky Geol. Survey, ser. 5, Bull. 2, p. 139, pl. 63, figs. 15, 16. Glen Dean Limestone.-Springer, 1926, U. S. Natl. Mus. Proc., v. 67, art. 9, p. 50, pl. 13, fig. 16. Glen Dean Formation, Sloans Valley, Ky.-Weller, 1931, Kentucky Geol. Survey, ser. 6, v. 36, p. 288, pl. 18, figs. 4a, b. Glen Dean Limestone.--Sutton, 1934, Jour. Paleontology, v. 8, p. 411, pl. 50, figs. 10-13. Glen Dean and upper Okaw limestones, Eastern Interior Basin.

Remarks.--This species is represented only by wing plates in the Glen Dean collections. Mature wing plates are between 25 and 30 mm long and are thickest one-third the distance from the base. In adult forms the wing plates are typically 6 to 7 mm, ranging from 4 to 9 mm, in width. The height of the bases is as much as 11 mm but is generally 7 to 8 mm.

Variation of *Pterotocrinus* wing plates is well illustrated among specimens that the author has assigned to *P. acutus*. Although *P. acutus* typically has a single pointed blade, large collections of specimens normally contain aberrant forms having two to four points that lack any definite arrangement. Some of these forms (pl. 5, fig. 8) are placed in *P. acutus*, but others (pl. 4, figs. 9, 10) seem more logically arranged with *P. bifurcatus* Wetherby. Specimens from near Sulphur, Crawford County, Ind. (locality 12), and from Sloans Valley, Pulaski County, Ky. (locality 23), exhibit variation in the amount of curvature in the blades of the wing plates which can be arranged in a series showing straight to moderately curved blades (pl. 5, figs. 7, 9).

P. acutus normally has a pointed blade that distinguishes it from *P. spatulatus* Wetherby and *P. subspatulatus* Sutton. In the Illinois Basin *P. acutus* is considered a widespread and relatively abundant guide fossil in the Glen Dean.

Localities.--See table 1 (in pocket).

Types.--Hypotypes; figured, IU 5917a, IU 5741; unfigured, IU 5747, IU 5923, IU 5927. Topotypes; unfigured, IU 5755, IU 5758.

Pterotocrinus vannus Sutton

Plate 5, figures 10-13

Pterotocrinus vannus Sutton, 1934, Jour. Paleontology, v. 8, p. 408, pl. 49, figs. 9, 10. Glen Dean Limestone, Menard, Ill.

Remarks.--Six wing plates are referred to *Pterotocrinus vannus*, which Sutton (1934, p. 408) based on a single complete wing plate from the Glen Dean Limestone. The distal edges of the blades are incomplete in some specimens. The two largest forms

Table 8--*Measurements in millimeters of wing plates of* Pterotocrinus vannus *Sutton*

Specimen	Minimum Length	Maximum height of blade	Maximum thickness	Maximum height of petiole
Holotype, Sutton, 1934, p. 408	20.1	18	4.93	8.8
IU 5742a, loc. 12	16.5	12.5	3	8.5
IU 5742b, loc. 12	23	20	3	13
IU 5742c, loc. 12	19	17	3.5	12.5
IU 5749a, loc. 23	19	15	3	9
IU 5749b, loc. 23	15.5	13.5	3	9
IU 5749c, loc. 23	15	14.5	3.5	8.5

have a wider petiole and are thinner than the holotype (WM 26713). Dimensions of the Glen Dean specimens of *P. vannus* are given in table 8.

P. vannus is thinner and has a more flaring blade than *P. cuneatus* Sutton. Neither *P. depressus* Lyon & Casseday nor *P. scapulatus* Sutton has its blades as constricted near the petiole as *P. vannus. P. lingulaformis* Sutton and *P. spatulatus* Wetherby do not have widely flaring blades.

Localities.--See table 1 (in pocket).

Types.--Hypotypes; figured, 1U 5742a, b, IU 5749a, c.

Plefrotocrinus spatulatus Wetherby

Plate 5, figures 14, 15

Pterotocrinus spatulatus Wetherby, 1879, Cincinnati Sec. Nat. History Jour., v. 2, p. 137, pl. 2, figs. 3a-c. Kaskaskia Group. Pulaski County, Ky.-Sutton, 1934, Jour. Paleontology, v. 8, p. 410, pl. 50, figs. 5-8. Glen Dean Limestone, Pulaski County, Ky.-Butts, 1941, Virginia Geol. Survey Bull. 52, pt. 2, pl 132, fig. 61. Glen Dean Limestone, Cumberland Gap, Tenn.

Remarks.--Only wing plates of the species *Pterotocrinus spatulatus* are represented in the Glen Dean collections. The blade, 5 to 6 mm high in mature specimens, is expanded vertically toward the distal end. Specimens are thickest about one-third of the distance from the base; the thickness is typically 4 to 6 mm but ranges from 3 to 8 mm. Adult specimens are 20 to 31 mm long and have bases 6 to 8 mm high.

One variety of this species has the flattened distal blade divided into two prongs, one above the other. This variety is found at Sloans Valley, Ky. (locality 23), and near Sulphur, Ind. (locality 12). Another variety has the distal blade twisted at different angles from the vertical, rarely to a horizontal position.

Spatulate wing plates distinguish *P. spatulatus* from the awl-shaped blades of *P. acutus* Wetherby. *P. subspatulatus* Sutton has

a shorter blade and has been reported only from the Menard Limestone. *P. spatulatus*, an excellent Glen Dean guide fossil, has been found only in this formation and strata of equivalent age in Tennessee.

Localities.--See table 1 (in pocket).

Types.--Figured hypotypes, IU 5931a, b.

Pterotocrinus depressus Lyon & Casseday

Plate 5, figures 16-19

Pterotocrinus depressus Lyon & Casseday, 1860, Am. Jour. Sci., ser. 2, v. 29, p. 68. Third Limestone, Millstone Grit, Grayson and Edmonson Counties, Ky.--Wetherby, 1879, Cincinnati Soc. Nat. History Jour., v. 2, pl. 8, fig. 11. ?Pulaski County, Ky.--Wachsmuth and Springer, 1882, Acad. Nat. Sci. Philadelphia Proc. 1881, p. 264. Kaskaskia Limestone, Grayson County, Ky.--Wachsmuth and Springer, 1897, Harvard Coll. Mus. Comp. Zoology Mem. 21, p. 796, pl. 79, figs. 2a-e. Kaskaskia Group, Grayson, Edmonson, and Pulaski Counties, Ky.--Ulrich, 1905, U. S. Geol. Survey Prof. Paper 36, p. 58, pl. 6, figs. 25, 26. Birdsville Formation, Pulaski County, Ky.--Butts, 1917, *in* Mississippian formations of western Kentucky, Kentucky Geol. Survey, p. 100, pl. 24, fig. 12. Glen Dean Limestone, Pulaski County, Ky.--Miller, 1919, Kentucky Geol. Survey, ser. 5, Bull. 2, p. 139, pl. 63, fig. 12. Glen Dean Limestone.--Springer, 1926, U. S. Natl. Mus. Proc., v. 67, art. 9, p. 50, pl. 14, figs. 4, 4a. Glen Dean Formation, Pulaski County, Ky.--Sutton, 1934, Jour. Paleontology, v. 8, p. 403, pl. 49, figs. 7, 8, 40-44. Upper part, lower Okaw limestone, Illinois; Glen Dean Limestone, Illinois, Kentucky.

not *Pterotocrinus depressus* Meek and Worthen, 1873, Illinois Geol. Survey, v, 5, p. 559, pl. 21, fig. 13 (= *P. cuneatus* Sutton).

Remarks.--Lyon and Casseday (1860, p. 68) did not figure any of their specimens of *Pterotocrinus depressus.* The first illustrations of the cotypes (USNM S 1567) were published by Wachsmuth and Springer (1897, pl. 79, figs. 2a-e).

The Glen Dean collections contain only wing plates of this species. The wing plates of the cotypes apparently do not expand rapidly upward from the narrow petiole. Specimens from Sloans Valley, Ky. (locality 23), show the typical form, but a common variant has the blade expanding rapidly upward as well as downward, as Sutton (1934, p. 405) recognized. Almost complete wing plates of both forms are figured (pl. 5, figs. 16-19). The edges of some plates may have been slightly serrated rather than smooth during the life of the crinoid. Dimensions of some wing plates of *P. depressus* are given in table 9.

P. depressus has a shorter petiole than *P. scapulatus* Sutton, *P. cuneatus* Sutton, and *P. vannus* Sutton and is narrower than *P. cuneatus* and *P. scapulatus.* The blades of *P. cuneatus* and *P. lingulaformis* Sutton do not flare as much as those of *P. depres-*

Table 9.--*Measurements in millimeters of wing plates of* Pterotocrinus depressus *Lyon & Casseday*

Specimen	Maximum length	Greatest height distally	Maximum thickness
Average of three, Sutton, 1934, p. 405	16.8	18.6	2.68
Wachsmuth and Springer, 1897, pl. 79, fig. 2b (left).	23.5	21.5	---
Wachsmuth and Springer, 1897, pl. 79, fig. 2b (right).	22	21	---
Ulrich, 1905, pl. 6. fig. 26	21	22.5	---
Ulrich, 1905, pl. 6. fig. 25	22	20	---
Sutton, 1934, pl. 49, fig. 7	17	14.5	3
IU 5750a, loc. 23	23	21	4
IU 5750b, loc. 23	24.5	18	3.5
IU 5750c, loc. 23	24.5	21.5	4.5
IU 5750d, loc. 23	23	18	3
IU 5750e, loc. 23	17	16	3
IU 5750f, loc. 23	16.5	15.5	4
IU 5750g, loc. 23	26	23	4.5
IU 5750h, loc. 23	21.5	21.5	4.5
IU 5750i, loc. 23.	22	21.5	4
IU 5750j , loc. 23	19.5	23	4.5
IU 5750k, loc. 23	17	20	4
IU 57501, loc. 23	1 0	21	3.5
IU 5750m, loc. 23.	17	16	3
IU 5750n, loc. 23	12	16.5	3
IU 5744a, loc. 12	17	17.5	2.5

sus. The late Chester species, *P. menardensis* Sutton and **P.** *chlorensis* Sutton, lack well-defined petioles in lateral view.

The specimen figured by Meek and Worthen (1873, pl. 21, figs. 31b, c) and questionably referred to *P. depressus* is probably *P. cuneatus* Sutton because their figured specimen is much thicker and has a longer petiole and less flaring blade than *P. depressus.*

Sutton (1934, p. 405) reported wing plates similar to *P. depres*sus in the Golconda, but Rodriguez (1960) did not obtain any specimens of this species from 45 collecting localities in the Golconda of the Illinois Basin.

Localities.--See table 1 (in pocket).

Types.--Hypotypes; figured, IU 5744a, h; IU 5750g, 1; unfigured, IU 5750a-f, h-k, m, n.

Pterotocrinus sp. A

Plate 5, figures 1-3

Pterotocrinus sp. 2 Rodriguez, 1960, unpublished Ph. D. thesis, Indiana Univ., p. 227, pl. 11, figs. 34-36. Golconda Formation, Crawford County, Ind.

Description.--Arms and wing plates unknown. Dorsal cup, excluding BrBr, 4 mm high and 16 mm in diameter. Sides of dorsal cup expand rapidly outward to form shallow expanded bowl-shaped

cup. BB two, pentagonal, 5 mm high and 7.5 mm wide, forming about one-quarter of height of basal cup, and invaginated for columnal that probably filled all of invaginated area; invagination causing slight truncation of basals where viewed laterally. RR five, heptagonal, and 5 mm high and 8 mm wide; upper surface convex but somewhat scalloped to receive SBrBr and TBrBr; PRR arching over X plate. X quadrangular and having moderately convex sides. PBrBr absent. SBrBr 1 mm high and 3 mm wide, two per radial, quadrangular, resting on median upper surfaces of RR and not all preserved. TBrBr quadrangular, 1.5 mm high and 3 mm wide, resting on outer upper surfaces of radials, and only first TBrBr preserved. Tegmen pyramidal having concave sides and furrowed longitudinally in proximal part; sutures of tegmen plates not everywhere clearly visible; apparently wing sockets formed by parts of six plates. Wing plate sockets five, 7 mm high, and 2.5 mm in maximum width. Anal opening subcentral.

Remarks.--A single incomplete calyx is related to *Pterotocrinus acutus* Wetherby, *P. spatulatus* Wetherby, *P. bifureatus* Wetherby, *P. depressus* Lyon & Casseday, and *P. wetherbyi* Miller & Gurley. None of these species or the other nine described species, whose basal cups are known, have radials that are convex on their upper surfaces. *P. wetherbyi*, in which the upper surfaces of the radials are flat, most nearly resembles the Glen Dean specimen in this character. In most previously described species, the radials have concave upper surfaces for the reception of the primibrachials and secundibrachials. The described specimen does not compare favorably with any of the holotypes of species of *Pterotocrinus* in the U. S. National Museum or the Walker Museum at the University of Chicago. The shape of the wing plate sockets suggests that it is related to the *P. depressus* gens of Sutton (1934, p. 397).

Both Wachsmuth and Springer (1897, p. 791) and Sutton (1934, p. 394) stated that primibrachials are commonly hidden and do not show in exterior views of the calyx, but all published dorsal views of calyces clearly show small primibrachials. In other species of *Pterotocrinus,* the primibrachials consist of a single triangular plate in each arm which is much smaller than the overlying secundibrachials. Examination of the upper articulating surface of the right anterolateral radial of the Glen Dean specimen does not reveal any groove or notch for the reception of a primibrachial between the surfaces occupied by the secundibrachials. Further, primibrachials are not visible between the secundibrachials on the outer surface of the calyx in the other rays. The author concludes

that this specimen does not have primibrachials. In view of the reduction of primibrachials in other species of the genus, their absence in this specimen is not entirely surprising.

Rodriguez (1960, p. 228) reported similar silicified calyces from two Golconda localities in Indiana.

Locality.--See table 1 (in pocket).

Figured specimen.--IU 5735.

Pterotocrinus sp. B

Plate 5, figures 4-6

Description.--Wing plates spatulate and attaining maximum thickness at base or slightly beyond petiole; maximum height at distal end of blade and only slightly higher than base; ventral and dorsal edges of blades either straight or containing one or more broad undulations; blade laterally constricted slightly beyond petiole; distal edge broken and questionably serrate.

Remarks--This form is similar to *Pterotocrinus spatulatus* Wetherby except that (1) the blade broadens slightly distally beyond the petiole and maintains a nearly constant width throughout its length and (2) the base is narrow and related to the *P. depressus* gens of Sutton (1934, p. 397) rather than to the heavier bases of the *P. spatulatus* gens. In *P. spatulatus* the blade is consistently thinner than the base, although in *P. spatulatus* the height increases slightly at the distal end of the blade. Dimensions of the three Glen Dean wing plates placed in this unnamed species are given in table 10.

Localities.--See table 1 (in pocket).

Figured specimens.--IU 6038, IU 6056, IU 6534.

Table 10-*Morphologic data on wing plates of* Pterotocrinus *sp. B*
[Linear measurements in millimeters]

Character	Museum No. and locality		
	IU 6038, loc. 13	IU 6056, loc. 8	IU 6534, loc. 6
Condition	Probably complete	Incomplete	Complete?
Total length	24	16.5	16
Maximum thickness	3	2.5	1.5
Minimum height of blade	7.5	8.5	8
Height of base	8	7.5	7.5
Width of base	2.5	3	3
Height of petiole in lateral view	5.5	6	6
Width of petiole in vertical view	2.0	2.0	2.5

Pterotocrinus sp. C

Plate 5, figure 20

Description.--Wing plate 25 mm long; base narrowly triangular or wedge shaped, *9.5* mm high, and *5* mm in maximum width; petiole with narrowest part in ventral view 1.5 to 2.5 mm distally from base and narrowest part in lateral view 3.5 to 8.5 mm distally from base; blade in ventral view thickening from *5* mm at petiole to 6 mm at 6 mm beyond petiole and tapering to about 1 mm thick at distal edge of blade; in lateral view, blade only slightly flaring and expanding from 8 mm at petiole to about 10 mm at 10 mm. distally from petiole. Distal edge partly broken and possibly serrate.

Remarks.--A single wing plate from Sloans Valley, Ky. (locality *23),* is intermediate in form between *Pterotocrinus spatulatus* Wetherby and *P. cuneatus* Sutton. The spatulate nature of the blade is very suggestive of *P. spatulatus*, but in the described specimen the blade swells beyond the petiole, which is characteristic of *P. cuneatus*, before tapering toward the distal edge. The blade of the Glen Dean specimen does not flare vertically beyond the petiole and is not as thick as the holotype of *P. cuneatus*. The proximal region resembles *P. acutus* Wetherby and *P. spatulatus*. The distal edge of the blade is not entire in the Glen Dean specimen, and complete wing plates may possibly have been serrate. Sutton (1934, pl. 49, fig. 27) figured a specimen of *P. lingulaformis* Sutton that has a serrate distal edge, but the described specimen is larger and thicker than the form illustrated by Sutton. *P. serratus* Weller is smaller than the Glen Dean specimen and has a flaring blade.

Locality.--See table 1 (in pocket).

Figured specimen.--IU 5760.

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PLATES 1-5

PLATE 1

[All figures are natural size.]

Figures 1, 2. *Zeacrinites* sp. A. *1*, View showing posterior interradius: figured specimen, locality 13, lU 5732. *2*, Anterior view displaying extra primibrachial in anterior ray; figured specimen, locality 13, IU 6732.

3-5. *Zeacrinites trapeziatus* (Sutton & Hagan). *3*, View of posterior interradius; hypotype, locality 12, IU 5094a. *4*, Anterior view showing extra primibrachial in anterior ray; hypotype, locality 12, IU 5094a. 5, Basal view of dorsal cup; hypotype, locality 12, lU 5094a.

6-8. *Zeacrinites wortheni* (Hall). *6*, View showing posterior interradius; hypotype, locality 12, IU 5094. *7*, Basal view of dorsal cup; hypotype, locality 12, IU 5094. *8*, Anterior view exhibiting extra primibrachial in anterior ray; hypotype, locality 12, IU 5094.

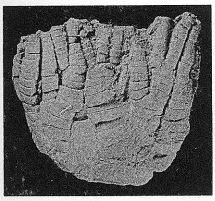
9-11. *Zeacrinites* sp. B. *9*, View showing displaced plates in posterior interradius; figured specimen, locality 17, IU 5730. *10*, Basal view of dorsal cup revealing posterior interradius; figured specimen, locality 17, IU 5730. *11*, Anterior view showing extra primibrachial in anterior ray; figured specimen, locality 17, IU 5730.

12, 13. *Zeacrinites* sp. C. *12*, Basal view of dorsal cup; figured specimen, locality 15, IU 5733. *13*, Anterior view not revealing primibrachial; figured specimen, locality 15, IU 5733.

14. *Zeacrinites* sp. D.*14*, Left to right are anterior, left anterolateral, and left posterolateral rays; figured specimen, locality 15, IU 5734,

15, 19. *Zeacrinites wortheni* (Hall). *15*, Posterior interradius at left; hypotype, locality 13, IU 5731. 19, Left to right are anterior, anterolateral, and left posterolateral rays; hypotype, locality 13, IU 5731.

16-18. *Zeacrinites doverensis* (Miller & Gurley). *16*, Basal view of dorsal cup of silicified specimen; hypotype, locality 17, IU 5728. *17*, View of posterior interradius; bypotype, locality 17, IU 5728. *18*, View showing two extra primibrachials in anterior ray; hypotype, locality 17, IU 5728.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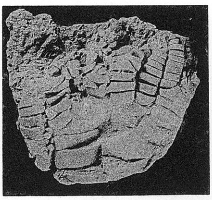
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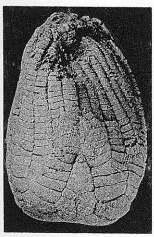
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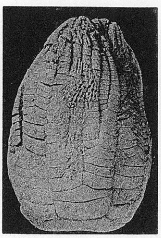
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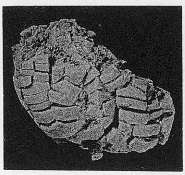
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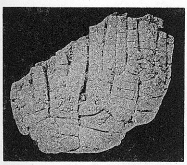
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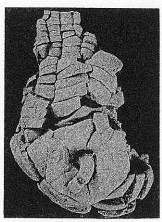
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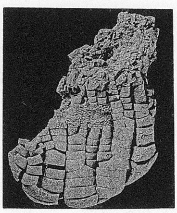
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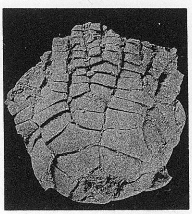
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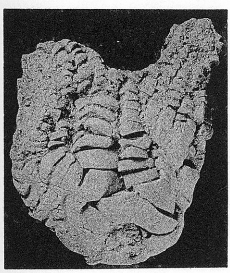
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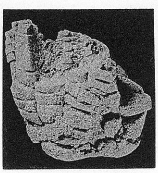
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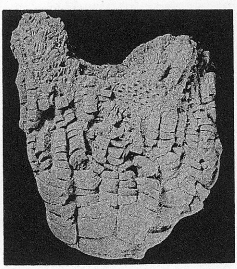
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ZEACRINITES

PLATE 2

[All figures are natural size except figure 16, which is X 2/3.]

Figures 1, 2. *Zeacrinites* sp. E. *1*, Left to right, anterior ray showing extra primibrachial, right anterolateral ray, and right posterolateral ray; figured specimen, locality 17, IU 5729. *2*, Basal view showing posterior interradius at upper left; figured specimen, locality 17, IU 5729.

3, 4. *Alphelecrinus bayensis* (Meek & Worthen). *3*, View of posterior interradius of crushed specimen; radianal plate prevents anal plate from resting on posterior basal; hypotype, locality 13, IU 5727. *4*, Anterior view; hypotype, locality 13, IU 5727.

5, 6. *Tholocrinus* spines. *5*. Ventral (upper), lateral, and dorsal views of spinose primibrachial plates; figured specimens, locality 12, IU 5938 *6*, Ventral (upper), lateral, and dorsal views of spinose plates from distal end of ventral sac; figured specimen, locality 12, IU 5938a.

7, 8. *Tholocrinus spinosus* (Wood). *7*, *8*, Two views of specimen oriented to show spinose character of primibrachials; topotype, locality 23, IU 5937b.

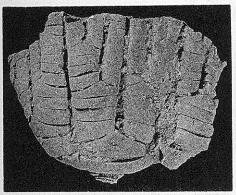
9, 10. *Tholocrinus spinouis* (Wood). *9*, Basal view; hypotype, locality 17, IU 6535. 10, View of posterior interradius of dorsal cup with incomplete crown showing primibrachials; hypotype, locality 17, IU 6535.

11-14. *Hypselocrinus campanulus* Horowitz, n. sp. *11*, View showing posterior interradius and plates at base of ventral sac; holotype, locality 19, IU 5936. *12*, Anterior view showing axillary primibrachials, gaping suture between radials and prim1brachials, and cuneate secundibrachials; holotype, locality 19, IU 5936. *13*. Ventral view displaying parts of four rami (bottom) and ventral sac (top) ; holotype, locality 19 IU 5936. *14*. Basal view; bolotype, locality 19, IU 5936.

15-17. *Aphelecrinus oweni* Kirk. *15*, Posterior view of dorsal cup, hypotype, locality 8, 11) 5725. *16*. Basal view showing flaring radials; hypotype, locality 8, IU 5725. *17*. Ventral view of dorsal cup showing constricted prirnibrachial at lower right; hypotype, locality 8 IU 5725.

18. *Aphelecrinus randolphensis* (Worthen). *18*. Posterior view crushed specimen showing pinnules and branching of secundibrachials and tertibrachials; hypotype, locality 8, IU 5954.

19-21. *Phacelocrinus longidactylus* (McChesney). *19*, Basal view of silicified specimen; hypotype, locality 15, IU 5726. *_20*, Posterior interradius; only radianal plate shows clearly; hypetype, locality 15, IU 5726. *21*, Left posterolateral view showing elongate constricted primibrachial and gaping suture between primibrachial and radial plates; hypotype, locality 15, IU 5726.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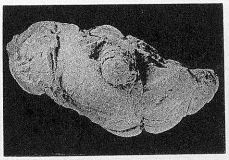
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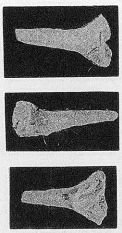
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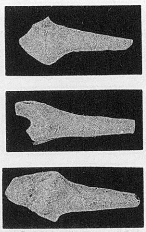
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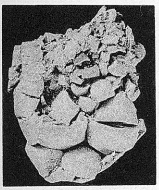
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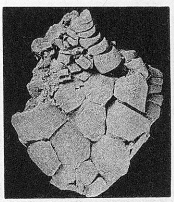
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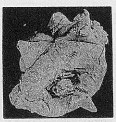
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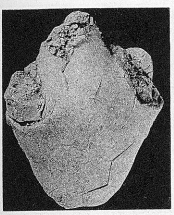
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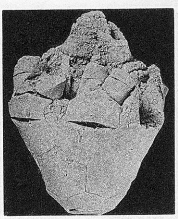
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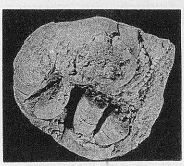
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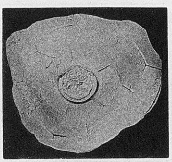
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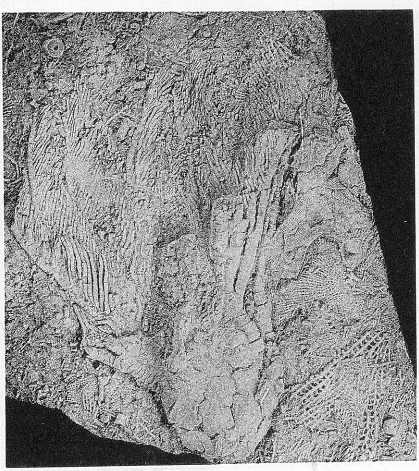
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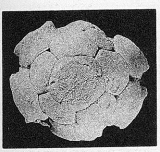
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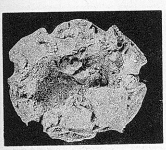
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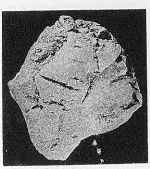
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ZEACRINITIDAE AND SCYTALOCRINIDAE

PLATE 3

[All figures are natural size.]

Figures

1-3. *Phanocrinus parvaramus* Sutton & Winkler. *1*, Posterior view of well-preserved specimen showing posterior interradius; hypotype, locality 15, IU 5724. *2*, Basal view; hypotype, locality 15, IU 5724, *3*, Anterior view displaying two rami in anterior ray; hypotype, locality 15, IU 5724.

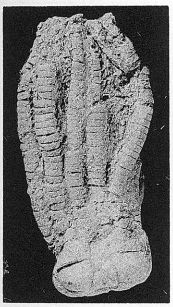
4-6. *Eupachycrinus germanus* Miller. *4*, View of posterior interradius; hypotype, locality 23, IU 5738. *5*, Anterior view showing two rami in anterior ray; hypotype, locality 23, IU 5738. *6*, Basal view; hypotype, locality 23, IU 5738.

7-9. *Phanocrinus compactus* Sutton & Winkler. *7*, View of posterior interradius; hypotype, locality 12, IU 5723. *8*, Basal view; note smooth dorsal cup displaying inconspicuous plate sutures; hypotype, locality 12, IU 5723. *9*, Anterior view showing single arm in anterior ray; hypotype, locality 12, IU 5723.

10-12. *Eupachycrinus spartarius* Miller. *10*, View showing posterior interradius; hypotype, locality 23, IU 5739. *11*, Basal view; hypotype, locality 23, IU 5739. *12*, Anterior view showing two rami in anterior ray; hypotype, locality 23, IU 5739.

13-15. *Phanocrinus* cf. *P. formosus* (Worthen). *13*, Ventral view displaying uniserial arm attached to matrix above dorsal cup; hypotype, locality 15, IU 5935. *14*. View of posterior interradius; hypotype, locality 15, IU 5935. *15*. Basal view showing infrabasal disk extending beyond column attachment hypotype, locality 15, lU 5935.

16-18. *Eupachycrinus boydii* Meek & Worthen. *16*, Posterior view; hypotype, locality 12, IU 5722. *17*, Basal view; hypotype, locality 12, IU 5722. *18*, Anterior view displaying two rami in anterior ray; hypotype, locality 12, IU 5722.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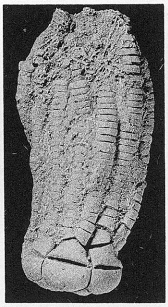
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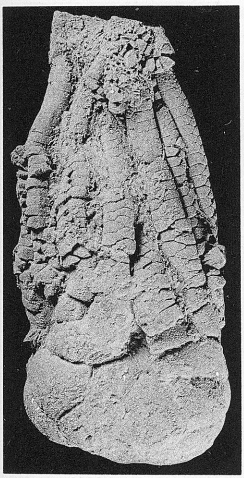
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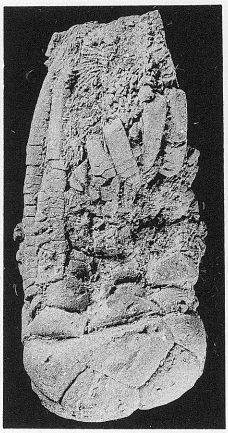
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PHANOCRINUS AND EUPACHYCRINUS

PLATE 4

[All figures are natural size except figure 12, which is X 2/3.]

Figures 1, 2. *Agassizoerinus* cf, *A. conicus* Owen & Shumard. *1*, Lateral view of infrabasal cone; hypotype,locality 19, IU 5736. *2*, Ventral view of infrabasal cone showing sutures on articulating surface and small depression representing lower part of body cavity; hypotype, locality 19, IU 5736.

3, 4. *Agassizocrinus dactyliformis* Shumard. 3, Probably left posterolateral view of silicifieddorsalcup; hypotype, locality 19, IU 5737. ~, Ventral view of dorsal cup; hypotype, locality 19, IU 5737.

5-8. *Pterotocrinus bifurcatus* Wetherby. *5*, Ventral (top) and lateral views of narrow-bladedspecimen directly comparable to wing plates of holotype; hypotype, locality 9, IU 5929b. *6*, Ventral (top) and lateral views of broad-bladed form; hypotype, locality 11, IU 5926. *7*, Ventral (top) and lateral views of form having awl-shaped bifurcations that have been broken in distal parts; hypotype, locality 9, 117 5929a. *8*, Ventral (top) and lateral views showing small angle of bifurcation and awl-shaped distal blades; hypotype, locality 12, IU 5928.

9, 10. *Pterotocrinmy bifurcatus* variants. *9*, Ventral (upper) and lateral views of multiple bifurcations at distal end of blade; figured specimen, locality 8, IU 5917c. *10*, Ventral (upper) and lateral views of multiple bifurcations at distal end of blade; figured specimen, locality 8, IU 5917b.

11, 12. *Onychocrinus pulaskiensis* Miller & Gurley. *11*, Upper part of incomplete crown showingspinose axillary brachials; hypotype, locality 1, AMNH 26076. *12*, Specimen having poorly displayed spinose axillary brachials; hypotype, locality 1, AMNH 26198.


1


2


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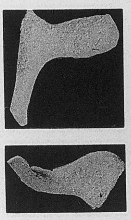
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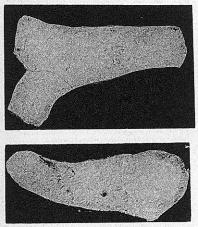
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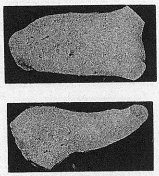
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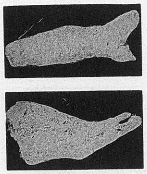
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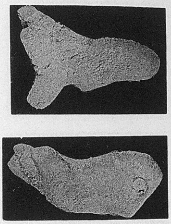
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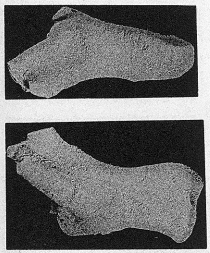
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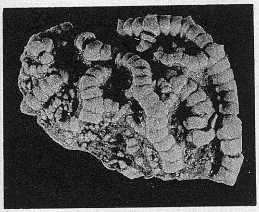
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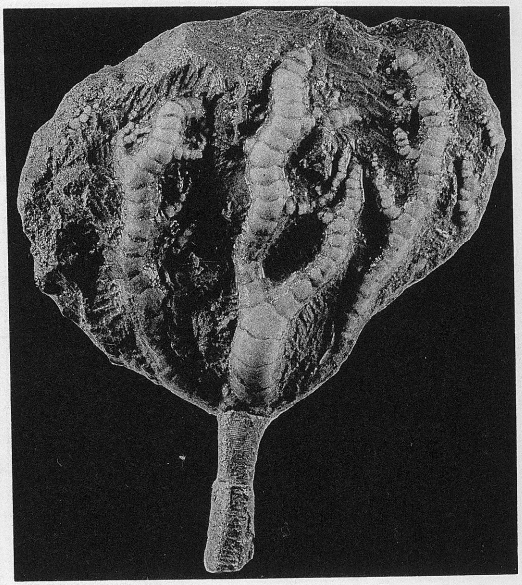

12

AGASSIZOCRINUS, PTEROTOCRINUS, AND ONYCHOCRINUS

PLATE 5

[All figures are natural size.]

Figure 1-3. *Pterotocrinus* sp. A. *1*, Lateral view of dorsal cup showing facet for reception of wing plate; figured specimen, locality 6, IU 5735. *2*, Basal view showing two basals, quadrangular anal plate, and convex upper surface of radials; figured specimen, locality 6, IU 5735. *3*, Ventral view showing five facets for reception of wing plates; figured specimen, locality 6, IU 5735.

4-6. *Pterotocrinus* sp. B. *4*, Ventral (upper) and lateral views; figured specimen, locality 13, IU 6038. *5*, Ventral (upper) and lateral views; figured specimen, locality 8, IU 6056. *6*, Ventral (upper) and lateral views; figured specimen, locality 6, IU 6534.

7-9. *Pterotocrinus acutus* Wetherby. *7*, Lateral views of growth series of wing plates exhibiting little curvature of blades; hypotypes, locality 12, IU 5741. *9*, Lateral views of growth series of wing plates displaying curvature of blades; hypotype, locality 12, IU 5741,

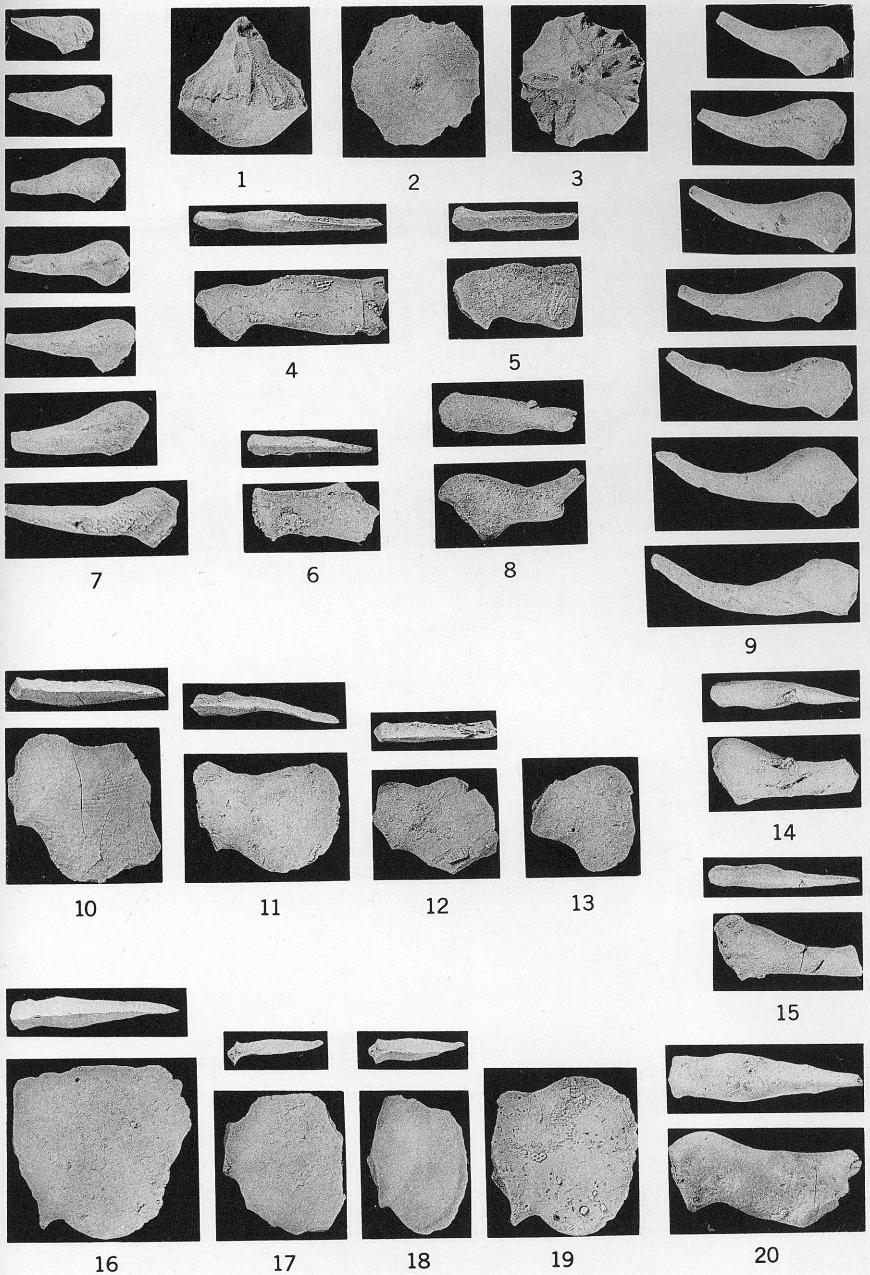
8. *Pterotocrinus acutus* variant. *8*, Ventral (top) and lateral views of specimen showing two awl-shaped distal points, one above the other, in lateral view; figured specimen, locality 8, IU 5917a.

10-13. *Pterotocrinus vannus* Sutton. *10*, Ventral (top) and lateral views of downward-expanding blade; petiole is longer than in *P. depressus* Lyon & Casseday; hypotype, locality 12, IU 5742b. *11*, Ventral (top) and lateral views of typical specimen having moderately flaring distal blade; hypotype, locality 23, IU 5749a. *12*, Ventral and lateral views of form having shorter base and distally broken blade; hypotype, locality 12, IU 5742a. *13*, Lateral view of short, broadly flaring distal blade; hypotype, locality 23, IU 5749c.

14, 15. *Pterotocrinus spatulatus* Wetherby. *14*, Ventral (top) and lateral views; blade is broken distally; hypotype, locality 22, IU 5931b. *15*, Ventral (top) and lateral views; hypotype, locality 22, IU 5931a.

16-19. *Pterotocrinus depressus* Lyon & Casseday. *16*, Ventral (top) and lateral views of wing plate having base almost equal to height of blade; hypotype, locality 23, IU 5750g. *17*, Ventral (top) and lateral views of blade expanding upward and downward from small base; distal edge is broken; hypotype, locality 12, IU 5744a. *18*, Ventral (top) and lateral views of short blade; hypotype, locality 12, IU 5744h. *19*, Lateral view of almost complete wing plate; hypotype, locality 23, IU 57501.

20. *Pterotocrinus* sp. C. *20*, Ventral (top) and lateral views showing relatively uniform height of blade and greatest thickening in ventral view about one-third distance from base; figured specimen, locality 23, IU 5760.



PTEROTOCRINUS

DISTRIBUTION OF GLEN DEAN CRINOID SPECIES BY LOCALITY

BULLETIN 34 TABLE 1

Species	Locality																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Agassizocrinus cf. *A. conicus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—
A. dactyliformis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—
A. sp. (infrabasal cones)	—	—	X	X	—	—	—	X	—	—	X	X	X	—	X	—	X	X	X	—	X	—	X
Aphelecrinus bayensis	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—
A. oweni	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
A. randolphensis	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
A. sp. (undescribed fragments)	—	—	—	—	—	—	X	—	—	—	—	—	?	—	—	—	X	—	—	—	—	—	—
Eupachycrinus boydii	—	—	—	—	—	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—
E. germanus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X
E. spartarius	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X
Hypselocrinus campanulus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—
Onychocrinus pulaskiensis	X	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	X
Phacelocrinus longidactylus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—
Phanocrinus compactus	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—
P. cf. *P. formosus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—
P. parvaramus	—	—	—	—	—	—	—	X	X	—	—	—	—	—	X	—	—	—	X	—	—	—	—
P. sp. (cups)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	X	X	X	X	—	X
Pterotocrinus acutus	—	—	—	X	—	—	—	X	—	X	X	X	—	—	X	X	—	—	—	—	X	X	X
P. bifurcatus	—	—	—	X	—	—	—	X	X	—	X	X	X	—	—	—	—	—	—	—	—	—	X
P. depressus	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	X	—	—	X	X
P. spatulatus	—	—	—	—	—	—	—	—	X	X	X	—	—	—	—	—	—	—	—	—	—	—	X
P. vannus	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	X
P. sp. A	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P. sp. B	—	—	—	—	—	X	—	X	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—
P. sp. C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X
P. sp. (unidentified wing plates)	—	—	—	—	X	X	—	—	—	—	X	—	—	—	—	—	—	X	—	—	—	—	—
Tholocrinus spinosus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	X
T. sp. (spines)	—	—	—	—	—	—	—	X	—	—	X	X	—	X	—	—	—	—	—	—	—	—	—
Zeacrinites doverensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—
Z. trapeziatus	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—
Z. wortheni	—	—	—	—	—	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—
Z. sp. A	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—
Z. sp. B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—
Z. sp. C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—
Z. sp. D	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—
Z. sp. E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—
Z. sp. (undescribed fragments)	—	X	—	—	—	—	—	X	—	—	—	X	X	—	—	—	—	—	—	—	—	—	—

MORPHOLOGIC DATA ON INFRABASAL CONES OF *AGASSIZOCRINUS* OWEN & SHUMARD

BULLETIN 34 TABLE 6

[Linear measurements in millimeters]

Character	Museum No. and locality										
	IU 5945e, loc. 18	IU 5945g, loc. 18	IU 5946a, loc. 17	IU 5946d, loc. 17	IU 5947a, loc. 19	IU 5947b, loc. 19	IU 5950a, loc. 12	IU 5950b, loc. 12	IU 6955, loc. 4	IU 6956, loc. 4	IU 6957, loc. 3	IU 6958 loc. 3
Maximum height	5.5	6	7.5	8	7?	8	9	6.5	6.5	7	8	7.5?
Height of articulating facet	1	2	2	1.5	2	2	1.5	1	1.5	1.5	1.5	2
Height of external cone	4.5	4	5.5	6.5	5?	6	7.5	5.5	5	5.5	6.5	5.5?
Diameter	7-7.5	10-10.5	10.5-11	10.5	9.5-10	9.5-10.5	12	9	8-8.5	10-11	10.5	10.5-11.5
Shape of cone	Pointed, medium	Rounded, low-wide	Rounded, medium	Rounded, medium	Rounded, low-wide	Pointed, medium	Rounded, medium	Rounded, low-wide	Pointed, low-wide	Rounded, low-wide	Rounded, medium	Rounded, low-wide
Slope of facets	Moderate outward	Steep outward	Moderate outward	Moderate outward	Moderate outward	Moderate outward	Moderate outward	Moderate outward	Moderate outward	Moderate outward	Moderate outward	Moderate outward
Ornamentation of facets	Obscured	Obscured	Weathered	Deeply impressed bifurcating grooves, radiating outward	Obscured	Obscured by silicification	Obscured, radiating grooves	Obscured	Obscured, radiating grooves	None?	Bifurcating radiating grooves	Obscured, bifurcating radiating grooves
Body cavity:	—	—	—	—	Obscured	Small, well defined	Very small	Very small	Obscured	Very small	Obscured	Small, well defined
Diameter	1+	3.5	2	1.5-2	—	1.5	1.5	2	1	1.5	—	2
Depth	—	2	—	1.5	—	1.5	—	—	—	—	—	—
Stem	No trace	Obscured	Obscured	No trace	Obscured	No trace	No trace	—	Obscured	No trace	No trace	Obscured
Sutures	Not visible	Not visible	Not visible	Not visible	Faintly visible on sides of cone	Present on sides of cone, obscured by silicification	Not visible	Visible on facets	Not visible	Not visible	Clearly visible on sides of cone	One visible on facets