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NEW CHESTERIAN (UPPER MISSISSIPPIAN) CRINOIDS
FROM ILLINOIS¹

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ABSTRACT

The genus *Tholocrinus* Kirk is clearly defined and a new genus, *Bicidiocrinus* Strimple, proposed with *Hydreionocrinus wetherbyi* Wachsmuth & Springer as type species. A new genus *Harmostocrinus* Strimple is proposed. *Tholocrinus unionensis* Strimple, n. sp., *T. discus* Strimple, n. sp., *Harmostocrinus porosus* Strimple, n. sp., *Dasciocrinus spinifer* (Wetherby) are reported from the Fraileys Formation (Upper Mississippian). *Harmostocrinus minuspiniferous* Strimple, n. sp., is reported from the Renault Formation, (Upper Mississippian). Possible relationship between *T. discus* and *Lasanocrinus* of Morrowan age is thought to exist and a possible bottom-dwelling habitat is postulated for both. A rough balance between the size of cup and anal sac (representing digestive capacity) and the food-gathering potential of the arms and pinnules is considered, as well as the effect of the position of the anus in relation to the anterior arm.

INTRODUCTION

The following study of Chesterian crinoids is a review of the genus *Tholocrinus* Kirk in which *Hydreionocrinus wetherbyi* Wachsmuth & Springer is removed from the genus and designated as type species of *Bicidiocrinus* Strimple, new genus. *Tholocrinus unionensis* Strimple, n. sp., from the Fraileys Formation of Illinois (Chesterian) shows close affinity with *T. spinosus* (Wood). *T. discus* Strimple, n. sp., from the same formation shows closer affinity with species of *Linocrinus* Kirk, 1938, and may be related to *Lasanocrinus* of Morrowan age. *Dasciocrinus* Kirk is discussed and *D. spinifer* (Wetherby) is reported from the Fraileys Formation. *Harmostocrinus* Strimple, new genus, is proposed with *H. porosus* Strimple, n. sp., from the Fraileys Formation designated as the type species. *H. minuspiniferous* Strimple, n. sp., is from the older Renault Formation.

Discussions with Ron Lewis, while a Master's candidate at The University of Iowa, have been stimulating and helpful in bringing out facets of this study that otherwise might have been overlooked.

The specimens used in this study from the well-known Glen Dean horizon at Sloans Valley, Pulaski County, Kentucky, are housed in the splendid Springer Collection, the Geology Department Repository, The University of Iowa, Iowa City. I first discovered material from the Fraileys Formation during the 1964 Spring Field Trip of the University of Iowa. A large crinoid colony in a roadcut on Illinois Highway 146 east of Anna, Illinois, was found, and excavation of the colony continued for a period of several years. A small slab collected by Al Hartman of Waterloo, Illinois, on a small county road east

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of Waterloo, Illinois, Monroe County, at Walter's Creek led to discovery of another crinoid colony in the Renault Formation. Various associates and I subsequently excavated the colony. The present study is only one report in a long series of researches utilizing these Chesterian faunas.

FOOD GATHERING CAPACITY VS. DIGESTIVE CAPACITY

Several species in the Fraileys Formation crinoid fauna show distinctive features in their arms or anal sacs that indicate a close relationship between the food-gathering and digestive systems in these crinoids. The relationship may just as readily be observed among other late Paleozoic inadunate crinoids. A rough balance is apparently maintained between the food-gathering capacity of most inadunate crinoids and their digestive capacity. Arms and pinnules represent the former, and the cup and anal sac, which together house the stomach and intestine, represent the latter. Increase in arms may be accomplished by additional branchings or by increase in the length of the arms through production of more brachials. Both of these actions also increase the number of pinnules. Additional pinnules may be produced by reduction of the length of individual brachials, by hyperpinnulation (more than one pinnule per brachial), or by change from uniserial arrangement of brachials to a biserial arrangement. Both *Tholocrinus* and *Bicidiocrinus* show a tendency toward shortened biserial arms, whereas *Dasciocrinus* and *Harmostocrinus* have long uniserial arms. The cup houses the stomach and part of the intestine, but much of the intestine is in the anal sac. Capacity of the cup depends largely on the size and shape of the cup, which in *Tholocrinus*, *Bicidiocrinus*, and *Dasciocrinus* is very shallow (i.e., small capacity) but in *Harmostocrinus* is deeper (i.e., larger capacity). The anal sacs of *Tholocrinus* and *Bicidiocrinus* are relatively large and extend above the distal extremities of the arms and the intestine of each apparently recurved, extending up the posterior side and sharply curving down the anterior side to terminate with the anus, which is located about midlength of the crown on the anterior side. In this position any waste expelled by the anus would probably foul the anterior arm. Although the lower portion of the anterior arm remains

subject to pollution, it appears these crinoids attempted to restrict the pollution to a minimal area by holding back on the first bifurcation of the anterior arm and also by producing a lesser number of arms in the anterior ray. In all other rays the arms branch on primibrach 1, but in *Tholocrinus* and *Bicidiocrinus* there are several nonaxillary primibrachs in the anterior ray.

Contemporaneous *Dasciocrinus* met the problem of pollution of the anterior arm and increased length of the intestine by producing a long, cylindrical anal tube with the arms just below the summit of the tube. The anus is therefore located near the uppermost tips of the arms and presumably the waste would be dissipated.

Harmostocrinus has a slightly deeper cup (i.e., more capacity) than the other genera under discussion and the anal sac, though modest in size, is sharply recurved so that the enclosed intestine is in effect longer than the height of the anal sac. Curvature is from posterior to anterior with the arms located above midlength of the anal sac on the anterior side. The only concession to pollution from its own excrement by this genus appears to be a lesser number of arms in the anterior than in other rays.

SYSTEMATIC DESCRIPTIONS

Subclass INADUNATA Wachsmuth & Springer, 1885

Order CLADIDA Moore & Laudon, 1943

Suborder POTERIOCRININA Jaekel, 1918

Superfamily ZEACRINITACEA Bassler & Moodey, 1943

Family ZEACRINITIDAE Bassler & Moodey, 1943

Genus THOLOCRINUS Kirk, 1939

[=*Xystocrinus* Moore & Plummer, 1938]

Type species.—*Hydreionocrinus spinosus* Wood, 1909.

Description.—Dorsal cup low with broad deep basal concavity; arms branch on primibrach 1 in all rays except the anterior which has several nonaxillary primibrachs, equibiserial, numerous endotomous branchings; anal sac extends above arms, terminating platform at distal end of anal sac surrounded by numerous outwardly directed spines; proximal columnals pronouncedly pentagonal.

Discussion.—*Tholocrinus* is well founded with *Hydreionocrinus spinosus* Wood, 1909, as the type species. The holotype of *T. spinosus* is that specimen figured by Wetherby (1881, pl. 9, figs. 1-4) as "*Hydreionocrinus depressus* Troost (Wachsmuth non Wetherby)." The specimen is from the Glen Dean Formation, Chesterian, Sloans Valley, Kentucky. As pointed out by Kirk (1939, p. 469), Wachsmuth did indeed identify such forms as *depressus* and the *lapsus* was followed by Springer (1926, p. 88, 90, p. 26, fig. 1-12) even though the type specimen of *Zeacrinites depressus* (Troost) was in the Springer collection and is obviously a *Zeacrinites* and not congeneric, much less conspecific. Moore and Plummer (1939) proposed a new genus *Xystocrinus* with *Cyathocrinus depressus* Troost as type species, but in illustrations figured *Tholocrinus spinosus* (as *depressus*) following the *lapsus* of Springer.

Kirk (1939, p. 471) ascribed the species *Poteriocrinites* (*Zeacrinus*?) *armiger* Meek & Worthen, 1870, from the "Chester, Pope County, Illinois" and *Hydreionocrinus wetherbyi* Wachsmuth and Springer, 1886, from the Glen Dean Formation of Pulaski County, Kentucky, to *Tholocrinus*. *Tholocrinus wetherbyi* is based on the specimens figured by Wetherby (1881, pl. 9, figs. 7-11) as "var. (?) of *Hydreionocrinus armiger* Meek & Worthen (Wachsmuth non Wetherby)." All the specimens figured by Springer (1926, pl. 25, fig. 4-12a) as *Hydreionocrinus wetherbyi* are from the Glen Dean Formation, Sloan's Valley, save one which is from Grayson Springs, Kentucky. The type of *Tholocrinus armiger* is a dorsal cup with a few closely associated spinose axillary primibrachs *I*. The dorsal cup has a form similar to that of *T. wetherbyi* and may be conspecific. *T. wetherbyi* is taken herein as the type species of *Bicidiocrinus* Strimple, new genus, and differences will be discussed under that genus.

Tholocrinus spinosus may be derived from *Linocrinus* Kirk through modification of the termination of the anal sac and change from uniserial to biserial arms.

The genus *Hydreionocrinus* deKoninck, 1858, has as its type species *H. woodianus* deKoninck, 1858, from upper Lower Carboniferous rocks of Britain. As pointed out by Moore & Plummer (1938), innumerable species of both Early and Late Carboniferous age were assigned to the

genus before the chief diagnostic features were recognized and carefully defined. The cup is low cone shaped with upflared infrabasals, arms are equibiserial with several branches having a distinctive branching (exotomous) in that only the inner two arms of each ray show bifurcation, and the anal sac is mushroomlike with the top composed of a convex central portion of small plates surrounded by outwardly directed spines. These characteristics are so distinctive that the vast majority of species formerly assigned to the genus have subsequently been placed elsewhere and no North American representative of the genus is known. *Telikosocrinus* Strimple, 1951, from the Pitkin Formation, upper Chesterian of Oklahoma, has been assigned to the family Hydreionocrinidae Jaekel, 1918, by Moore, Lane & Strimple (in Moore & Strimple, 1973); however, that genus has endotomous arms and although the distal end of the anal sac is spinose it does not have a platform surrounded by subhorizontal spines. *Hydreionocrinus* does not appear to be very closely related to *Tholocrinus* or to any known genus from North America.

Tholocrinus, *Bicidiocrinus*, and *Linocrinus* are not thought to be closely related to *Zeacrinites* because of the totally different type of anal sac and other factors. *Zeacrinites* has a pyramid-shaped anal sac composed of thick plates, with no visible respiratory slits along the lateral sides of the plates except in the troughlike depressions, which are occupied by the arms and pinnules when they are closed. No effort is made here to segregate the genera because similar problems are incurred when comparing other genera included in the family Zeacrinidae and it is not the purpose of this study to revise the entire family, even though a revision is overdue.

Range.—Upper Mississippian (Chesterian); USA (Kentucky, Illinois). [Namurian El, Eu.]

THOLOCRINUS UNIONENSIS Strimple, new species

Plate 1, figures 1, 3, 4, 6, 9

Description.—Cup bowl shaped with broad, deep, basal invagination; infrabasals and major portion of basals confined to base and basal concavity but distal portions of basals visible in side view, median portion of basals often depressed in the form of long, shallow grooves; three anal plates form a broad *CD* interray; delicate arms partially but not entirely biserial, branching on

primibrach 1 in all rays except anterior where there may be as many as five primibrachs, and branching endotomously as many as three more times; anal sac mushroom shaped with distal platform above the arms and surrounded by outwardly directed spines; proximal columnals pentagonal.

Discussion.—*Tholocrinus unionensis* has a proportionately shallower dorsal cup, with less prominent basal plates in side view than found in *T. spinosus*, type species of the genus. The cup plates are also slightly tumid with sutures well impressed in *T. unionensis*, which is not the case in *T. spinosus*. The cup of *T. unionensis* is taller and the terminal anal sac spines are larger and more prominent than found in the extant *T. discus*. Relationship is thought to be much closer between *T. unionensis* and *T. spinosus* than with *T. discus*, which is more closely aligned with *Linocrinus*.

The spinose platform of *Tholocrinus unionensis* is not as fully developed as that of *T. spinosus* in that pore slits penetrate the edges of platform plates as well as along the bases of the spines. The bases of the spines are rounded and almost none are in contact with each other in *T. unionensis*. Although they are thick elements, there is some widening of the bases and most of the spines are in contact all around the platform of *T. spinosus*. There are no respiratory slits in the platform of *T. spinosus*.

Types.—Holotype SUI 35643, paratypes SUI 35640, 35641, collected by H. L. Strimple, repositied Geology Department Repository, The University of Iowa, Iowa City, Iowa.

Occurrence.—Fraileys Formation, Golconda Group, middle Chesterian (Upper Mississippian), ¼ mile east of intersection of Illinois Hwy. 146 and Interstate Hwy. 57 (NE NW sec. 30, T. 12 S., R. 1 E.), Union County, Illinois.

THOLOCRINUS DISCUS Strimple, new species

Plate 1, figures 2, 5; Plate 2, figures 4, 5

Description.—Dorsal cup very shallow, with infrabasals, basals and proximal ends of radials in shallow basal concavity; radials protruded and forming blunt projections, which are the lowest parts of the cup. Arms apparently 30 in number, narrow, biserial in lower portions, cuneate in upper portions, branching on primibrach 1 in all except the anterior ray where the first bifur-

cation is on primibrach 3, second branching is on or about secundibrach 5 and a third bifurcation takes place in other rays at irregular heights. All axillaries are spinose. The anal sac is recurved, club shaped with a moderately broad termination that appears to be spinose. Some two or three terminating plates develop minute spines; the few exposed lateral plates show keels and pore slits along their lateral sides. Proximal columnals are pentagonal.

Discussion.—The crown of *Tholocrinus discus* is proportionately taller than that of *T. spinosus*. Some segments of the arms remain uniserial (cuneate brachials) and the platform at the summit of the anal sac has few outwardly directed spines. *T. spinosus* differs in having fully biserial arms and numerous outwardly directed spines.

The dorsal cup of *Tholocrinus discus* has a shape more or less like that of *Lasanocrinus* Moore & Plummer, 1940, i.e., the radials are projected downward in midportion and form the lowest part of the cup. The similarity may be due to adaptation to a bottom-dwelling preference in both instances. In my opinion, the presence of a well-developed stem does not obviate the possibility of a bottom-dwelling habitat, particularly when there is a soft bottom. Calceocrinids have well-developed stems, which most crinoid investigators acknowledge were extended along the ocean bottom rather than being upright. Because of the asymmetry of the crowns of calceocrinids there can be no other reasonable interpretation of their living habitat. Calceocrinids are restricted to older Paleozoic strata, but I have at hand a complete crown of an inadunate crinoid from the Permian of southwest Texas which lacks the drastic modification of cup elements exhibited by calceocrinids, yet the arm structure is very nearly identical with them. Aside from the downward-projecting radials of *T. discus*, *T. unionensis* differs in having more prominent anal sac spines.

Measurements of holotype (SUI 35612) in millimeters.—Height of cup 3.0, width in posterior-anterior radius 10.7, from E ray to BC interray 11.7, width of basal concavity (approx.) 5.5, depth 2.0, length of arms 15, width of one ray 8.0, length of anal sac 13.2, width at summit 7.0, width of proximal columnals 1.9.

Types.—Holotype SUI 35612, paratype SUI 35642, collected by H. L. Strimple, repositied

Geology Department Repository, The University of Iowa, Iowa City, Iowa.

Occurrence.—Fraileys Formation, Golconda Group, middle Chesterian (Upper Mississippian), ¼ mile east of intersection of Illinois Hwy. 146 and Interstate Hwy. 57 (NE NW sec. 30, T. 12 S., R. 1 E.), Union County, Illinois.

Genus BICIDIOCRINUS Strimple, new genus

Type species.—*Hydreionocrinus wetherbyi* Wachsmuth & Springer, 1886.

Description.—Dorsal cup moderately low with narrow basal invagination; arms branch on primibrach *I* in all rays, brachials usually but not uniformly in biserial arrangement, branching endotomously; anal sac extends above arms with subhorizontal termination platform composed of six or seven broad-based spines joined at their bases; column round.

Discussion.—*Bicidiocrinus wetherbyi* and *Tholocrinus spinosus*, type species of *Tholocrinus* (see Pl. 1), are both typically from the Glen Dean Formation. *Bicidiocrinus wetherbyi* appears to be less advanced in having a narrow basal invagination, relatively high cup, brachials not always in equibiserial arrangement, individual arms broader and branching less than in *Tholocrinus* and terminating spine plates of anal sac joined at bases. *Bicidiocrinus* is more advanced in having axillary primibrachs *I* in all rays and a round stem. *Tholocrinus* has several nonaxillary primibrachs in *A* ray and a pentagonal stem. The arms of *Tholocrinus* are smaller, and bifurcate more frequently than in *Bicidiocrinus*, the dorsal cup is very shallow, with a broad, deep, basal invagination and the stem is pentagonal. In addition, the termination of the anal sac of *Tholocrinus* is a subhorizontal platform composed of small polygonal plates surrounded by numerous short spines. *Bicidiocrinus* appears to be related to *Dasciocrinus* but differs in that the latter has much longer, more primitive arms (cuneate brachials) and a lesser number of terminating anal sac spines. The sac spines join at their base in both genera.

Paianocrinus Strimple, 1961, is closely related to *Bicidiocrinus* but differs in having a more cone-shaped cup and uniserial arms. There are six spinose plates at the termination of the anal sac in *Paianocrinus* and they are joined at their base as in *Bicidiocrinus*.

Range.—Upper Mississippian (Chesterian); USA (Kentucky). [Namurian E1, Eu.]

Superfamily PIRASOCRINACEA Moore & Laudon, 1943

Family PIRASOCRINIDAE Moore & Laudon, 1943

Genus DASCIOCRINUS Kirk, 1939

Type species.—*Cyathocrinus floralis* Yandell & Shumard, 1847.

Diagnosis.—Crown elongated, subcylindrical. Cup low, saucer shaped with small basal concavity; infrabasals small, basals medium, radials large, three anal plates. Anal sac taller than arms, terminating with subhorizontal spinose plates joined at their bases, anus just below termination. Arms uniserial, long, rounded, branching about three times, primibrach *I* axillary in all rays.

Discussion.—The original illustration of *Cyathocrinus floralis* Yandell & Shumard (1847, pl. 1, fig. 1), type species of the genus *Dasciocrinus*, shows the dorsal cup to be low, bowl shaped. The specimen figured by Springer (1926, pl. 16, fig. 8), also from Grayson Springs, Kentucky, was apparently selected by Kirk (1939, p. 472) for his generic diagnosis, wherein the cup was reported as "depressed turbinate, with invaginated base." Actually the cup does not appear to be turbinate, or cone shaped (that is, with straight lateral sides expanding evenly from the basal plane), but has slightly curved lateral sides that might be better termed saucer shaped. The cup is quite small when compared to the length of the arms.

Owen & Shumard (1852, p. 91) described a form as *Poteriocrinus spinosus* from "archimedial layers of the carboniferous limestone of Kaskaskia, Illinois" with the notation "It occurs also in a similar geological position in Grayson Co., Kentucky, where it was discovered by Dr. L. P. Yandell, whose fine collection of crinoids contains a very perfect specimen of this interesting species." Inasmuch as the crown reported by Yandell and Shumard (1847, p. 24) as "One [encrinite], plate figure 1, we name provisionally, *Cyathocrinus floralis* ——" was "provisionally" named without description it seems possible that Shumard, the junior author in both instances, considered the Grayson Springs specimen to be an undescribed species and so proposed another

name. The description by Owen & Shumard (*op. cit.*, p. 92) of the anal sac of *Dasciocrinus spinosus* reads: "Proboscis long and slender, surmounted by three plates of conical figure, joined together at their bases." Springer (1926, pl. 16, fig. 9, 9a) illustrated a specimen of "*florealis*" from Grayson Springs, Kentucky, in which four spines joined together at their bases and surmounted the termination of the anal sac.

Dasciocrinus spinosus has a lesser number of secundibrachs than *D. floralis* and the two forms do not appear to be conspecific. There has been no explanation of the change in the spelling of the name *floralis* which did not appear as "*florealis*" until a catalogue listing by Shumard (1885, p. 217). Kirk (1939, p. 217) correctly listed the original spelling in the synonymy but accepted the change to "*florealis*," which has been perpetrated to date as an erroneous spelling.

Dasciocrinus spinifer (Wetherby) (1880, p. 157) is reported from "Pulaski County, Kentucky, Kaskaskia (Chester) Group" (probably Glen Dean Formation). Second bifurcation of the arms appears to be with axillary secundibrachs 6-8, which is a lesser number than found in either *D. floralis* or *D. spinosus*. The holotype is not well enough preserved to compare dorsal cups.

Pachylocrinus cachensis Weller (1920, p. 343) was not assigned to *Dasciocrinus* by Kirk (1939) but is listed under the genus by Bassler & Moodey (1943, p. 404). The species is typically from the Paint Creek Formation (Lower Chesterian), Cache River Bluffs, Johnson County, and Monroe County, Illinois. Although somewhat older than other species of the genus, *P. cachensis* has the second bifurcation with secundibrach 6-8.

Dasciocrinus aulicus Strimple (1963) has more robust spines than found in other species and the second bifurcation is usually with secundibrach 6. The species is from the Fayetteville Formation (Chesterian), near Afton, Craig County, Oklahoma.

Dasciocrinus has terminal spines at the distal end of the anal sac, which are joined at the base, as in *Bicidiocrinus*; however, they are not as large or prominent as found in that genus. *Bicidiocrinus* has biserial arms, whereas *Dasciocrinus* has cuneate brachials. The two genera are thought to be closely related.

Dasciocrinus is not considered here to be in the direct lineage of *Tholocrinus*, but is thought to have evolved from the Pachylocrinidae and to have close affinity with the Pirasocrinidae. Strimple (1963), suggested that *Perimestocrinus* Moore & Plummer, 1938, might be descended from *Dasciocrinus*. The species described as *Stenopecrinus rugosus* Strimple, 1961, from the Wapanucka Formation (Morrowan) of Oklahoma and referred to *Anchicrinus rugosus* (Strimple) by Moore & Strimple (1973), appears to be closely related to *Dasciocrinus aulicus* Strimple, 1963, from the Fayetteville Formation (Chesterian) of Oklahoma. *Linocrinus* sp. is known to be associated with *Dasciocrinus aulicus*, but has not previously been reported as occurring in the Fayetteville Shale.

In *Dasciocrinus floralis* (Yandell & Shumard) the anus is located just below the summit of the anal sac, which demonstrates that the intestine is not recurved (see Springer, 1926, pl. 16, fig. 9). Conversely, *Linocrinus arboreus* (Worthen), as illustrated by Springer (1926, pl. 16, fig. 6), has a recurved anal sac with the anus at mid-length on the anterior side, and *Tholocrinus spinosus* Wood, illustrated as "*Hydreionocrinus wetherbyi* (Hall from Troost)" by Springer (1926, p. 26, fig. 10) has an hourglass-shaped anal sac with the anus located at midheight on the anterior side, indicating a recurved intestine. A straight anal sac with the anus at the distal end is primitive on the one hand (as exemplified by the Ordovician genus *Eustenocrinus*), but is advanced on the other hand as demonstrated by the Missourian (Upper Pennsylvanian) genus *Aesiocrinus*. *Dasciocrinus* is thought to have evolved from stock having recurved anal sacs and is therefore more advanced in that regard than contemporaneous genera.

Range.—Upper Mississippian (Chesterian), USA. [Bollandian (P2)—Namurian (E1), Eu.]

DASCIOCRINUS SPINIFER (Wetherby, 1880)

Plate 2, figures 1, 2

Scaphiocrinus spinifer Wetherby, 1880, p. 157, pl. 5, fig. 5.
Dasciocrinus spinifer (Wetherby) Kirk, 1939, p. 472.

Diagnosis.—See previous discussion for the genus.

Discussion.—The single small specimen presented here is for the purpose of recording the occurrence of the genus in the Fraileys Formation. Preservation of the crown is not adequate

for careful comparisons but the specimen appears to be close to *Dasciocrinus spinifer*.

Hypotype.—SUI 35644, collected by H. L. Strimple, repositied Geology Department Repository, The University of Iowa, Iowa City, Iowa.

Occurrence.—Fraileys Formation, Golconda Group, middle Chesterian (middle Upper Mississippian), ¼ mile east of intersection of Illinois Hwy. 146 and Interstate Hwy. 57 (NE NW sec. 30, T. 12 S., R. 1 E.), Union County, Illinois.

Superfamily TEXACRINACEA Strimple, 1961

Family STAPHYLOCRINIDAE Moore & Strimple, 1973

Crown tall, slender; cup bowl shaped with basal concavity or exceptionally with fused infra-basal circlet gently convex and visible from side; arm facets plenary; uniserial arms 20 to 80 or more; one to three anals in cup.

Genera.—*Staphylocrinus* Burdick & Strimple, 1969 (U.Miss.); *Agnostocrinus* Webster & Lane, 1967 (L.Perm.); *Abrotocrinus* Miller & Gurley, 1890 (L.Miss.); *Dinotocrinus* Kirk, 1941 (L.Miss.-U.Miss.); *Exochocrinus* Burdick & Strimple, 1969 (U.Miss.); *Hylodecrinus* Kirk, 1941 (L.Miss.); *Microcaracrinus* Strimple & Watkins, 1969 (M.Penn.-L.Perm.); *Harmostocrinus* Strimple, new genus (U.Miss.).

Range.—Lower Mississippian (Lower Carboniferous)-Lower Permian; USA.

Genus HARMOSTOCRINUS Strimple, new genus

Type species.—*Harmostocrinus porosus* Strimple, new species.

Description.—Crown tall, slender; cup bowl shaped with shallow, broad basal concavity; infra-basals form planate pentagonal disk extending beyond pentagonal columnal cicatrix; basals large, extending out of basal concavity to form appreciable portion of lateral cup walls; radials moderately large, facets plenary; low ridges pass from plate to plate in the basal and radial circlets accentuated by pronounced depressions at plate corners; three anal plates in normal (primitive) arrangement in broad posterior interradius. Arms uniserial, branching on primibrach *I* in all rays and once again isotomously high in the arms

except in the anterior ray where there are only two arms, brachials cuneate, pinnulate. Anal sac cylindrical, recurved with subvertical spines at summit and arms about one-fourth the way down the anterior side. Proximal columnals pentagonal becoming round distalward.

Discussion.—Close relationship is apparently with *Abrotocrinus* which has more numerous arms than *Harmostocrinus* and the anterior ray does not bifurcate close to the cup if at all. The anal sac of *Abrotocrinus* reaches about midheight of the arms where subvertical spines are found and the sac is recurved with the anus located at midheight of the sac on the anterior side. It appears the anterior ray delayed branching until it was past the position of the anus. The anal sac of *Harmostocrinus* is very similar to that of *Abrotocrinus* except that the anal opening is slightly higher on the anterior side. It is interesting to note that although *Harmostocrinus* equalized the branching of arms at the cup level it still suppressed the second branching in the anterior ray where the anus is situated.

Range.—Upper Mississippian (Lower Chesterian-Upper Chesterian), USA [Cravenian (P1)-Namurian (E1), Eu.]

HARMOSTOCRINUS POROSUS Strimple, new species

Plate 2, figure 3; Plate 3, figures 1-5, 8

Diagnosis.—Characters of genus.

Discussion.—Surface of cup plates covered by minute granules. Axillary primibrachs *I* are constricted in midsection; anterior (*A*), right posterior (*C*) and left posterior (*D*) are longer than those in the other two rays. Sutures between radials and primibrach *I* are gaping. Arms are narrow, rounded and in young specimens the long pinnule-bearing side is projected as a blunt spine which is subdued in maturity. Brachials of young specimens are constricted in midsection and pinnules are quite large. The anterior side of the anal sac is preserved in one paratype and is composed of several series of small polygonal plates with respiratory slits along their lateral sides. The distal termination is marked by long, slender, subvertical spines. A large anus is located about one-fifth the distance down the anterior side.

Measurements in millimeters.—Measurements of *Harmostocrinus porosus* specimens follow.

	(SUI 35615) Young paratype	(SUI 35618) Large paratype	(SUI 35613) Holotype
Length of crown	24.0	73.0	33.0
Height of cup	2.2	8.0*	3.2
Width of cup	5.0	25.0*	9.5
Width of infra- basal disc	—	—	2.5
Width of proximal columnal	0.7	—	1.0

* Distorted.

Types.—Holotype SUI 35613, paratypes SUI 35614-35618, collected by H. L. Strimple, deposited Geology Department Repository, The University of Iowa, Iowa City, Iowa.

Occurrence.—Upper Fraileys Formation, Golconda Group, Chesterian (Upper Mississippian): ¼ mile east of intersection of Illinois Hwy. 146 and Interstate Hwy. 57 (NE NW sec. 30, T. 12 S., R. 1 E.), Union County, Illinois.

HARMOSTOCRINUS MINUSPINIFEROUS Strimple,
new species
Plate 3, figures 6, 7

Diagnosis.—Like *Harmostocrinus porosus* except that the arms are stouter, pinnules are larger, and brachials are decidedly spinose.

Discussion.—Young specimens of *Harmosto-*

crinus porosus from the stratigraphically younger Fraileys Formation are very similar to mature specimens of *H. minuspiniferous*, although the spinose nature of the brachials is not quite as pronounced. In maturity the arms of *H. porosus* are narrower and decidedly less spinose than those of *H. minuspiniferous*. The cup plate ridges are more pronounced in *H. minuspiniferous* than those found in mature *H. porosus*.

There are only two arms in the anterior ray (see Pl. 3, fig. 6), whereas there are four arms in other rays. This follows the pattern previously discussed wherein the anterior ray develops a lesser number of arms and/or branches higher in an effort to minimize the effects of pollution from fecal waste expelled by the anus when the anus is located low on the anterior side of an anal sac of medium height.

Measurements of holotype in millimeters.—Length of crown 52.0, height of dorsal cup 4.2, average width 9.3.

Holotype.—SUI 36293, collected by Amel Priest, deposited Geology Department Repository, The University of Iowa, Iowa City, Iowa.

Occurrence.—Renault Formation, Gasperian Stage, Lower Chesterian (Upper Mississippian), road cut at Walters Creek east of Waterloo, Monroe County, Illinois.

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EXPLANATION OF PLATES

PLATE 1

All figures magnified $\times 1.7$.

- FIGURE
1,3,4,6,9. *Tholocrinus unionensis* Strimple, n. sp., Fraileys Formation, Union County, Illinois.—1,9. Paratype crown, SUI 35640, viewed from B ray and from base.—3,6. Holotype crown, SUI 35643, viewed from AB interray and from opposite side.—4. Paratype crown, SUI 35641, viewed from CD interray.
- 2,5. *Tholocrinus discus* Strimple, n. sp., Fraileys Formation, Union County, Illinois, paratype crown, SUI 35642, viewed from D ray and from opposite side.
- 7,11. *Bicidiocrinus wetherbyi* (Wachsmuth & Springer), Glen Dean Formation, Pulaski County, Kentucky, hypotype crown, SUI 35737, viewed obliquely showing anal sac termination with spines joined at base and viewed from A ray.
- 8,10,12-14. *Tholocrinus spinosus* (Wood), Glen Dean Formation, Pulaski County, Kentucky.—8,10,14. Hypotype crown, SUI 35639, viewed from summit to show anal sac terminating platform, from base, and from CD interray.—12,13. Hypotype crown, SUI 35638, viewed from EA interray and from summit.
- crown, SUI 35644, viewed from side and from opposite side (C ray) showing spinose anal sac termination, Fraileys Formation, Union County, Illinois, $\times 2$.
3. *Harmostocrinus porosus* Strimple, n. sp. Paratype crown, SUI 35616, viewed from anterior and showing anal sac, anal opening and column (see also Pl. 3, fig. 3), Fraileys Formation, Union County, Illinois, $\times 3$.
- 4,5. *Tholocrinus discus* Strimple, n. sp. Holotype crown, SUI 35612, viewed from summit showing termination of anal sac and oblique side view with CD interray below, Fraileys Formation, Union County, Illinois, $\times 1.7$.

PLATE 3

All figures magnified $\times 1.7$.

FIGURE

- 1-5,8. *Harmostocrinus porosus* Strimple, n. sp., Fraileys Formation, Union County, Illinois.—1-2. Paratype crown, SUI 35614, viewed from A ray and CD interray.—3. Paratype crown, SUI 35616, viewed from anterior showing anal sac, anal opening, and proximal section of column (see also Pl. 2, fig. 3).—4,5. Holotype crown, SUI 35613, viewed from CD interray and base.—8. Large paratype crown, SUI 35618, viewed from C ray.
- 6,7. *Harmostocrinus minuspiniferous* Strimple, n. sp., Renault Formation, Monroe County, Illinois, holotype crown, SUI 36293, viewed from A ray and CD interray.

PLATE 2

FIGURE

- 1,2. *Dasciocrinus spinifer* (Wetherby). Hypotype



1



2



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