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FREST, T. J. and H. L. STRIMPLE (Department of Geology, The University of Iowa, Iowa City, Iowa 52242). *Praepholidocidaris*, a new Echinoid from the Pella Formation (Mississippian) of Iowa.

Praepholidocidaris pellaensis, n. gen., n. sp., is described from basal Chesterian rocks in the vicinity of Oskaloosa and Givin, Mahaska County, Iowa. The new genus is characterized by its small number of ambulacral and interambulacral plate columns, adorally expanded ambulacra, unequal ambulacrals with perforate primary spines, and interambulacrals with primary spines only on adradial plate columns. Age relationships of the Pella Formation and the paleoecology of its echinoderm fauna are reviewed. It is concluded that the echinoderms represent an opportunistic assemblage and the bulk of the echinoderm fauna supports assignment of unit C of the formation to the *Talarocrinus* Zone (of Horowitz and Strimple, 1974), basal Chesterian.

INDEX DESCRIPTORS: Late Mississippian; Chesterian; *Talarocrinus* Zone; Pella Formation; Mahaska County, Iowa; Echinodermata; Echinoidea; Echinocystitidae; *Praepholidocidaris pellaensis; Pholidocidaris;* paleoecology.

The prolifically fossiliferous Mississippian Pella Formation has been a subject of paleontological investigations for more than a century (Hall, 1858). However relatively little modern work has been done on the invertebrates, and some groups have been almost totally neglected. This is particularly true of the Echinodermata: though long known as a source of exceptionally preserved blastoids other echinoderm classes with the exception of the Edrioasteroidea (Strimple, 1968; Bell, 1976) and two crinoids (Strimple, 1974) have not been previously reported. Collecting in recent years has yielded a variety of crinoids, edrioasteroids, and starfish as well as the echinoid described below: these will be the subject of future reports. Unlike the rather ubiquitous blastoids (*Pentremites conoideus, Diploblastus glaber*) nearly all of the other echinoderms have been found only at a single locality, the abandoned county quarry, north of Oskaloosa, Iowa, although a single echinoid was collected at the Banzee quarry, near Givin, Iowa (detailed localities cited below). Most of the echinoderms are restricted to a single thin layer in the upper third of the formation. None of the echinoids were found in place though crinoids and blastoids have been recovered *in situ*. The majority of specimens are loose on dump piles where shale discarded from the echinoderm-bearing layer happened to have been the last material discarded: hence the distribution of the echinoderms as collected is extremely spotty.

Most of the crinoids occur as crowns, often retaining part of the column, despite the poorly indurated nature of the enclosing rock, which in places approaches a mudstone. Many blastoids retain the brachioles and covering plates, and several of the echinoids and starfish have spines still articulated, probably indicating an autochthonous assemblage. In most echinoids the interambulacral plates have shifted and become telescoped or are otherwise disrupted; this is likely due to sediment compaction around originally intact specimens. The crinoid fauna is peculiar in that it is dominated in terms of abundance by the flexible *Taxocrinus shumardianus* whereas the majority of species are inadunates. The camerates are mostly simple types *(Dichocrinus, Camptocrinus, Talarocrinus)*. For many crinoid species few adult or very young individuals are encountered, and most (excluding the flexibles) have not been recovered even as isolated plates outside of the echinoderm zone though *Praepholidocidaris*, blastoids, edrioasteroids, and stems do occur at other levels in the Pella. The fauna seems to represent an opportunistic assemblage that was able to populate a small area of the Pella-age sea bottom for an extremely short period of time, perhaps during an interval of slightly decreased sedimentation, but was abruptly wiped out by an influx of mud. Sedimentation rate was most likely the determinant factor in establishing faunal composition and in the eventual termination of the assemblage since other invertebrates, especially brachiopods and corals, could have provided hard substrates for those species which were sessile. There is little deviation from typical abundance of these groups in the echinoderm layer (in fact some are commoner than at other levels); however holdfasts and the certainly sessile edrioasteroids are more than usually common, but are still rather rare as compared to the number of crowns recovered. The lithology of the echinoderm zone, rarity of many-plated camerates *(e.g. Batocrinus)*, abundance of flexibles, and presence of free-living genera such as *Camptocrinus* indicate that the echinoderms were either broadly tolerant species or were adapted to soft bottoms. The latter alternative is most probable: the commonest edrioasteroid *(Lepidodiscus laudoni;* see Bell, 1976, pp. 557-567) has a claveate theca with the oral face in the adult elevated considerably above the original point of attachment of the theca. It seems likely that the majority of the Pella crinoids, as well as the echinoid and starfish, were effectively eleutherozoic *(sensu* Kirk, 1911) due to the nature of the substrate and probable comparatively high rate of sediment accumulation.

Precise age relationships of the Pella are uncertain. The history of the formation has been reviewed by Rexroad and Furnish (1964), who also provide a section of the Oskaloosa exposure (their text-figure 1). On the basis of the conodont fauna these authors place the formation within the *Gnathodus bilineatus – Cavusgnathus characta* Assemblage Zone and correlate it with the Ste. Genevieve (Rexroad and Furnish, p. 669). Series assignment of the Ste. Genevieve has been either to the Meramecan, the Valmeyeran, a separate series between the Valmeyeran and Chesterian (*e.g.* Swann, 1963), or the Chesterian. On this point Rexroad and Furnish *(op. cit.)* comment that "the Ste. Genevieve conodont fauna is sharply different from the conodonts of the underlying formations of the Valmeyer series but is closely similar to, if not identical with, the conodonts of the overlying Chester series" (p. 669). With regard to the Pella echinoderm zone (included in unit C of Rexroad and Furnish, *op. cit.)* we prefer the Chesterian assignment for the formation. *Talarocrinus*, a common constituent of Chesterian faunas, is present in the Pella while *Platycrinites* appears to be unrepresented even by stems.

Other echinoderms present in the Pella *(i.e. Taxocrinus shumardianus, Diploblastus glaber)* could support either a Late Meramecan or Early Chesterian age for the top of the formation. On the whole the preponderance of species indicates the likelihood of Early Chesterian age *(Talarocrinus* Zone as defined by Horowitz and Strimple, *op. cit.*, pp. 207, 213) for unit C of the Pella.

PALEOECOLOGY

Praepholidocidaris (new genus) was an integral member of the Pella echinoderm fauna. Despite the generally fragile nature of echinoid tests it is represented by over thirty specimens. The occurrence is unusual in that the echinoids were not found in a "nest" but are scattered sparsely

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throughout the echinoderm-bearing layer. Other echinoids are virtually absent: a few plates and spines of an archaeocidarid were the only other echinoid remains encountered despite intensive search. The seeming paucity of echinoid species supports the inference of an opportunistic assemblage. *Praepholidocidaris* seems to have been more tolerant of silty conditions than many of the Pella species: isolated plates and spines have been observed at other levels in the Pella and as mentioned above it is one of the few species to be found outside of the Oskaloosa locality. Probably this greater ecological tolerance is related more to the echinoid's feeding habits than its motility. The echinoid's feeding system, unlike that of crinoids, is not prone to fouling by fine sediment particles. Like many Paleozoic echinoids the rather short and acicular spines of *Praepholidocidaris* may have functioned more as protection than as a means of locomotion. Durham (*in* Durham *et al.*, 1966) has interpreted the living position of similarly shaped (depressed, with flat oral surface) lepidocentrids to be with the oral surface submerged in the substrate and only the apical surface projecting above the sea floor. The suggestion is plausible although it is also likely that echinoids living on a fine mud bottom would need to retain some ability to adjust their position unless the sedimentation rate were extremely low. The closely related genus *Pholidocidaris* has primary spines on all the interambulacral plates of the oral surface: *Praepholidocidaris* interambulacrals bear primary spines only on those plate columns bordering the ambulacra. These spines in Echinocystitoida typically are the longest and most sturdy set and have the best developed articulation; hence the primaries are most likely to have served a locomotory function in addition to being protective. The small number of oral face interambulacrals with primaries in *Praepholidocidaris* may indicate that the genus was less active than *Pholidocidaris*.

PHYLOGENETIC RELATIONS

Praepholidocidaris is morphologically similar to *Pholidocidaris* in several respects. The test shape of *Praepholidocidaris pellaensis* (new genus) appears to be identical to that of *Pholidocidaris irregularis,* the type species of *Pholidocidaris*. Like the latter *Praepholidocidaris* has ambulacra that are adorally much wider and are composed of larger plates. In both genera the adapical adradial interambulacrals are larger than the other interambulacrals while all adoral interambulacrals are of similar size. Overall the spines and plates of both genera strongly resemble each other. Differences in numbers of ambulacral and interambulacral plate columns, the presence of primary spines on at least some ambulacrals of *Praepholidocidaris,* and the lack of primary spines on the median interambulacral plate columns on both test surfaces in *Praepholidocidaris* readily distinguish the two. These differences are detailed below, and only a few points concerning taxonomic and phylogenetic implications of the genus need to be discussed here.

The close relationship between *Praepholidocidaris* and *Pholidocidaris* necessitates discussion of the latter at some length in the systematic description. Our concept of *Pholidocidaris* is derived largely from the work of R. T. Jackson, who in two papers (Jackson, 1912, 1929) described or reviewed essentially all the known material of the genus. The more recent treatment of the genus in the echinoid section of the Treatise on Invertebrate Paleontology by Kier (1966) is largely derivative but Kier's format for generic descriptions, and the phylogenetic assumptions on which it is based, are accepted and followed herein. In an earlier paper Kier (1965) ascribed five species to *Pholidocidaris,* although other fragmentary material consisting only of isolated elements, not described to the specific level, has also been placed in the genus by other authors. Abandonment of this practice is advocated herein (next paragraph). Of the nominate species only three (*P. irregularis, P. tenuis,* and *P. tournacensis)* are represented by good material: otherwise unspecified references to *Pholidocidaris* in this paper relate to these three species collectively.

The finding of a genus which when dissociated would yield plates and spines virtually indistinguishable from those of *Pholidocidaris* suggests that the acription of such material to a definite genus, as was commonly done in the past, is unjustified unless a very large number of isolated parts, allowing a virtual reconstruction in full, is available. This point has been made previously by Kier (1958, p. 11) in connection with the Archaeocidaridae. Erection by Kier *(op. cit.)* of the Mississippian genus *Polytaxicidaris,* which differs from *Archaeocidaris* almost solely in the number of ambulacral columns, has made it untenable to refer isolated archaeocidarid interambulacrals to *Archaeocidaris;* the majority of nominal species are based only on such material. According to Kier (1965, p. 456) only 8 of the 42 "species" of *Archaeocidaris* are recognizable on these grounds. Subsequent description by Kier of another *Polytaxicidaris* (Kier, *op. cit.)* strengthens the argument, and an undescribed Pennsylvanian echinoid in the University of Iowa collections that is apparently also referable to *Polytaxicidaris* greatly increases the range overlap of the two genera. The widespread geographic distribution of *Pholidocidaris* (sensu lato) makes it probable that the same situation could recur unless echinoid taxonomists exercise more parsimony. Paleozoic echinoids are rare fossils, and evolutionary trends within the Paleozoic are still poorly understood (Kier, *op cit.,* p. 437): consequently even fragmentary material may be of interest. The fact that significant contributions to our knowledge of Paleozoic echinoids can be made while following Kier's suggestion in regard to taxonomy has been demonstrated by Hoare and Sturgeon (1976).

Among the evolutionary trends within the Echinocystitoida delineated by Kier *(op. cit.)* may be noted the following:

1. Adoral expansion of ambulacra.
2. Increase in number of ambulacral columns in some families (including the Echinocystitidae).
3. Development of regularity in shape of interambulacral plates.
4. Flattening of the test.
5. Increase in the number of plates.
6. Increase in the size of the test.
7. Differentiation of spines and development of tubercles.

In all of these respects *Pholidocidaris* is a relatively advanced genus, which is not altogether surprising in view of its stratigraphic occurrence (Mississippian). The monotypic *Praepholidocidaris,* though younger than most *Pholidocidaris* species, is oddly primitive. Its shape and ambulacral development are close to those of *Pholidocidaris* but the number of plate columns, both ambulacral and interambulacral, is less, and the primary tubercles, while evolutionarily advanced in structure, are fewer in number on the interambulacrals. Since little evidence contradicts Kier's evolutionary scheme it is likely that much older species of *Praepholidocidaris* remain to be discovered.

SYSTEMATIC DESCRIPTION

Class ECHINOIDEA Leske, 1778

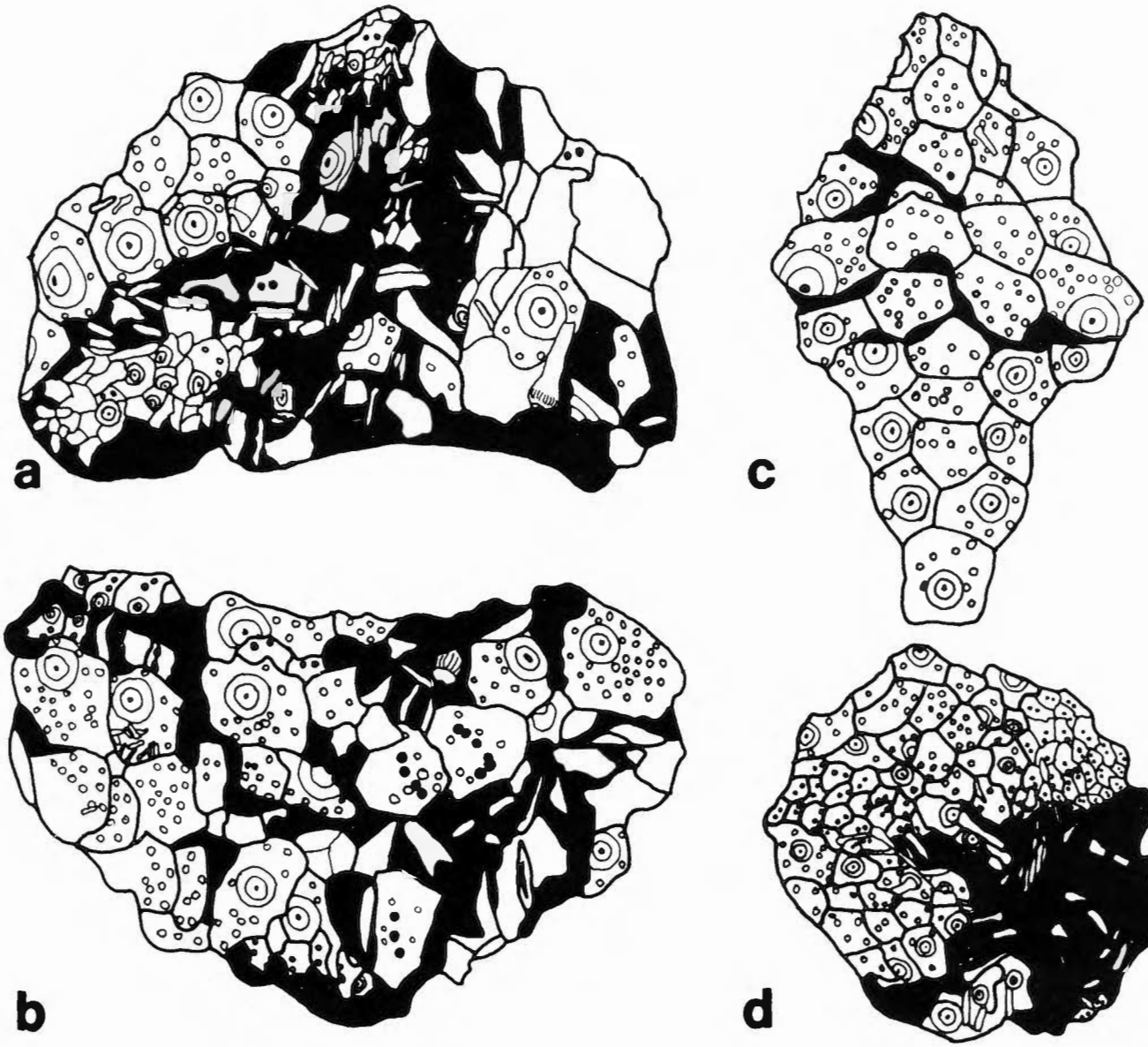
Subclass PERISCHOECHINOIDEA M'Coy, 1849

Order ECHINOCYSTITOIDA Jackson, 1912

Diagnosis. — Perischoechinoidea with strongly imbricate plates; ambulacral plates beveling under interambulacra, imbricating adorally; interambulacral plates reaching peristome, imbricating adapically; genital plates present, perignathic girdle absent (after Kier, *in* Durham *et al.*, 1966, p. U301).

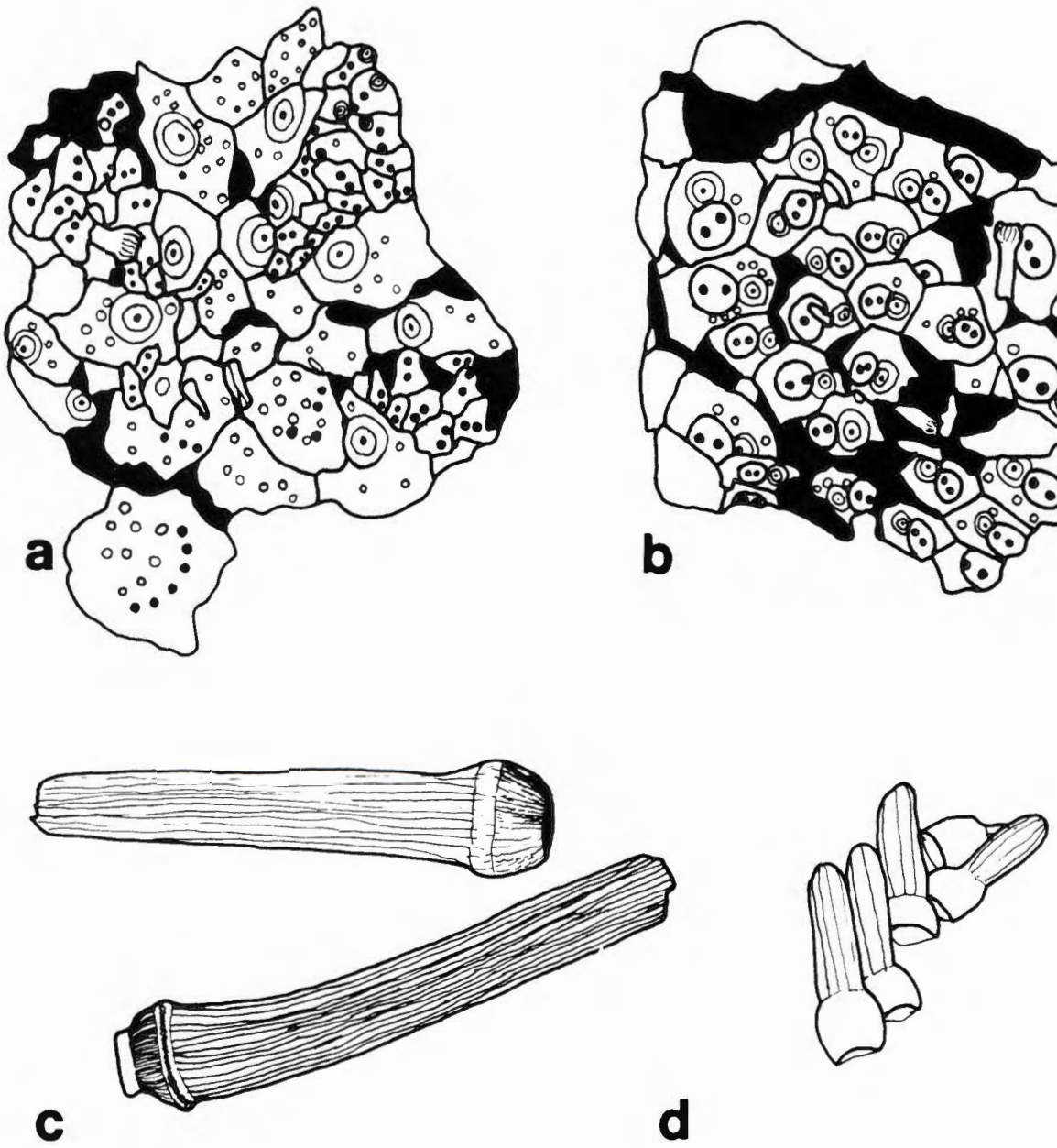
Family ECHINOCYSTITIDAE Gregory, 1897

Diagnosis. — Echinocystitoida with ambulacra enlarged adorally in Mississippian and younger genera; more than two columns in each ambulacrum (after Kier *in* Durham *et al.*, 1966, p. 301).



Text-Figure 1. Camera lucida sketches of plates of *Praepholidocidaris pellaensis*, n.g., n. sp. Black areas indicate matrix or places where plate arrangement cannot be deciphered.
a. Adoral surface of holotype (SUI 39491) showing interambulacral plates and tubercles. Compare with Plate 2, figure 6. b. Adapical surface of holotype. Note genitals, interambulacral plates, secondary spines, and brace. See also Plate 2, figure 7. c. Interambulacrum showing plate arrangement. Adoral portion at bottom. SUI 39482: for comparison with Plate 1, figure 3 & 4. d. Apical surface of small entire paratype (SUI 39485), showing ambulacral plate arrangement and spines; compare with Plate 2, figure 4.

Remarks. — In the Treatise (Kier, *in* Durham *et al*., 1966, p. U308) *Pholidocidaris* is included in the Lepidocentridae, a family characterized by invariable possession of only two columns of plates per ambulacrum (*op. cit*., p. U304). This is probably an oversight because the ambulacra of *Pholidocidaris* are well known and the genus has been associated with the other genera of the Echinocystitidae since at least the time of Jackson (1912). Kier (1965, text-figure 9 and in passing) earlier accepted the echinocystitid assignment of the genus. The Mississippian members of both families can have similar test shapes and comparable distribution of primary spine tubercules (*e.g. Perischodromus*), and two Mississippian lepidocentrids (*Hyattechinus* and *Perischodromus*) do display a similar trend to adoral enlargement of the ambulacra. However the much greater ambulacral expansion adorally in such Mississippian echinocystitds as *Proterocidaris* and *Pholidocidaris* is distinctive. Enlargement of ambulacra obviously is rendered more easily possible in echinoids which possess a large number of plate columns in each ambulacrum. Both *Pholidocidaris* and *Praepholidocidaris* are accepted as members of the Echinocystitidae in the present paper. In order to facilitate discussion of *Praepholidocidaris* (new genus) a generic description of *Pholidocidaris* follows. The holotype of the type species of the genus (*P. irregularis*) is illustrated on Plate 1, figures 1 & 2.



Text-Figure 2. Camera lucida sketches of *Praepholidocidaris pellaensis*, n. gen., n. sp. Black areas represent matrix or are indecipherable. a. Paratype SUI 39490 showing apical system, X 5. b. Adoral surface of SUI 39502 showing large adoral ambulacrals, peripodia and peripores, and ambulacral plate tubercles, X 3. c. Two large primary spines showing straight and curved shafts, X 7.5. d. Cluster of secondary spines from holotype (SUI 39491) illustrating morphology, X 20.

Genus PHOLIDOCIDARIS Meek & Worthen, 1869

Type Species. — *Pholidocidaris irregularis* (Meek & Worthen).

Diagnosis. — Ambulacra adorally much more developed than aborally; five or more commonly, six or more columns of plates per ambulacrum, imbricating adorally; adoral ambulacral plates larger than adapical, with distinct peripodia on adoral plates only; ambulacrals with secondary tubercles only: interambulacrals imbricating adapically, six or more columns per interambulacrum; adapically adradial plates much larger than other interambulacrals; adorally all interambulacral plates of same size; single large perforate primary tubercle on adapical and all adoral interambulacral plates; secondary tubercles, probably imperforate, on other plates: basal terrace and scrobicule present but scrobicular ring and parapet lacking around primary tubercles with scrobicular circle and low boss but no scrobicule or basal terrace. Primary spines stout, straight, enlarged at base, longitudinally striated, terete.

Remarks. — The above generic diagnosis is taken largely from Kier (*op. cit.*, p. U308), supplemented in some details from the more extended diagnosis and descriptions in Jackson (1912, pp. 433-442; 1929, pp. 64-67). As defined above the genus includes the following species: *P. irregularis* (Meek & Worthen), *P. tenuis* Tornquist, *P. tournacensis* Jackson; all are from the Mississippian (Lower Carboniferous) of England, Ireland, Germany, Belgium, and the United States. The following species are very imperfectly known, could belong to *Praepholidocidaris, Pholidocidaris,* or other genera, and should probably not be retained in a definite genus: *P. acuaria* (Whidborne) [only Devonian species], *P. anceps* (Austin) [see Mortensen (1935), pp. 74-75], *P. gaudryi* Julian, *P.* sp. Jackson (1912, p. 440), *P.* sp. Jackson (1929, p. 67), *P.* sp. Schmidt (1930, p. 72).

Genus PRAEPHOLIDOCIDARIS, new genus

Type species. — *Praepholidocidaris pellaensis,* new species.

Diagnosis. — Ambulacra adorally much more developed than aborally; typically four columns of plates per ambulacrum, imbricating adorally; adoral ambulacral plates much larger than adapical, with peripodia only on adoral ambulacrals; all ambulacrals with both perforate primary and occasional imperforate secondary tubercles; four columns of plates in each interambulacrum; interambulacrals imbricating adapically; adradial plate columns on both surfaces of test slightly larger than plates of median columns, with single perforate primary tubercles developed as in *Pholidocidaris;* all interambulacrals with nonperforate secondary tubercles much like those of *Pholidocidaris.* Primary spines include both straight and proximally curved types, otherwise similar to those of *P. irregularis.*

Horizon. — Pella Formation, basal Chesterian (Mississippian), Iowa.

Remarks. — Differences between *Praepholidocidaris* and *Pholidocidaris* have been outlined above and require little additional comment. Since the former genus is at present monotypic assessments of the relationships between the two necessarily have limited value. The generic characters as a whole indicate that *Praepholidocidaris* is archaic in some respects as compared to other Mississippian echinoids, particularly *Pholidocidaris,* despite its apparent Chesterian age. The pattern of spination of the interambulacrals is strikingly reminiscent of the lepidocentrid *Perischodromus* (see Jackson, 1912, p. 401) and is most closely paralleled among the Echinocystitidae in *Proterocidaris.* The presence of peripodia and primary spines on the ambulacrals are probably advanced characters; but the restriction of primaries to only the adradial interambulacrals is decidedly primitive. Several of the more unusual aspects of the genus' morphology that run counter to the general trends of evolution within the Echinocystitoida are noteworthy in that they are paralleled most closely among contemporary Echinoidea by the cidaroids. Among these may be mentioned the small number of ambulacral and interambulacral columns and the extremely depressed test shape. As compared to *Pholidocidaris* the interambulacral plates are more nearly equal in area in all columns and the amount of imbrication (as judged from the proportion of plate area without secondary tubercles) is reduced. It is thus possible that *Praepholidocidaris* represents a specialized offshoot from the Echinocystitoida that is evolutionarily convergent in some ways with the early Cidaroidea rather than a persistent member of the ancestral stock which gave rise to *Pholidocidaris,* but present evidence is hardly conclusive.

PRAEPHOLIDOCIDARIS PELLAENSIS, new species

Plate 1, figures 3-9; Plate 2; Text-figures 1 & 2

Diagnosis. — Same as that of genus.

Material. — About thirty specimens, mostly fragmented flattened tests with plates disarranged, preserved in a soft shaley matrix.

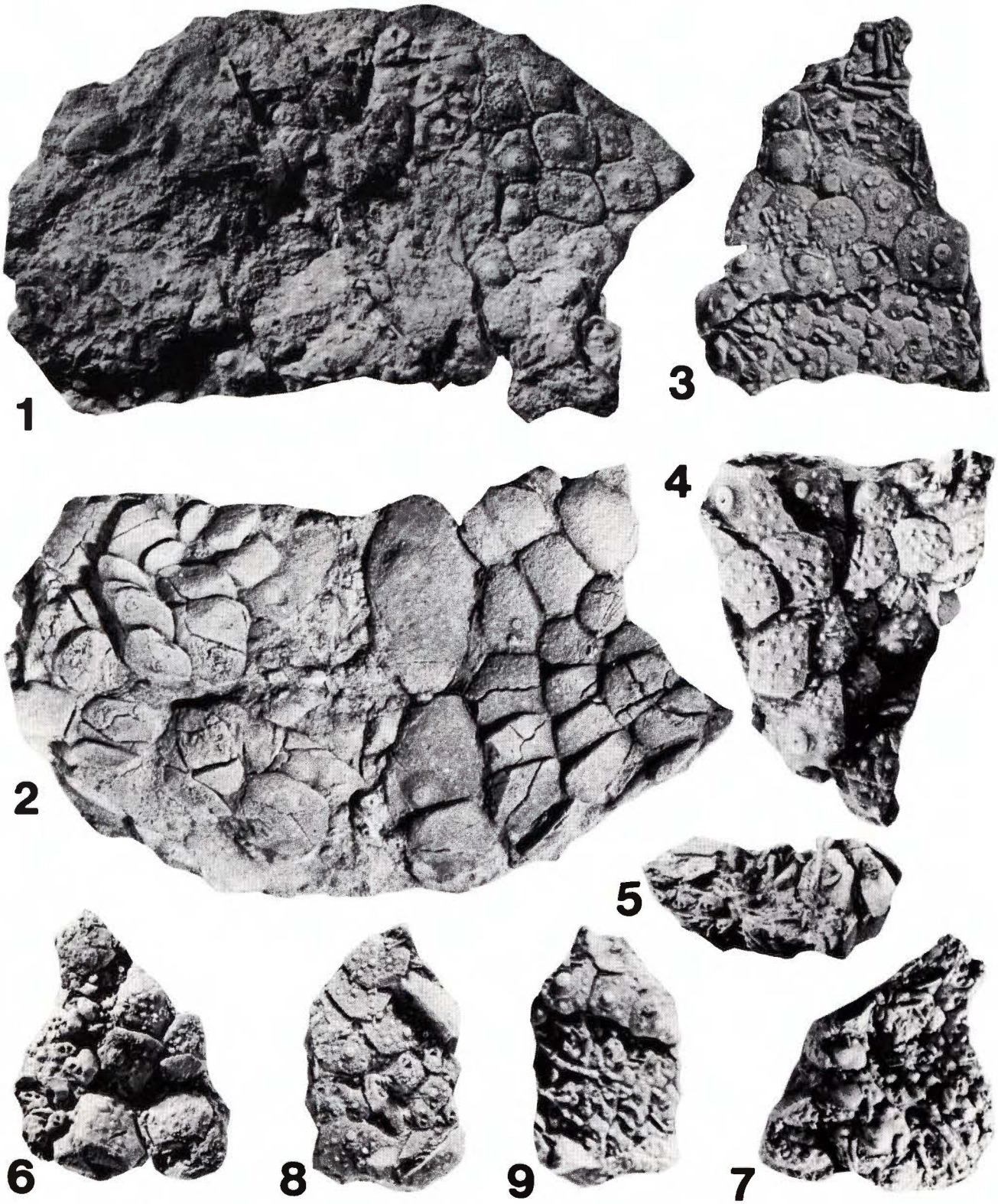
Description. — Shape: although all specimens are probably somewhat flattened, the original shape can be inferred from relatively complete specimens (*e.g.* SUI 39485; text figure 1d, Plate 2, figures 4 & 5). Test much wider than high, discoidal, with flat oral surface and gently rounded apical surface; profile probably similar to those of *Pholidocidaris* and *Perischodromus* (Kier, 1965, text-figure 5), outlined as viewed from above rounded.

Size: small, widest measured interambulacrum width 12.7 mm at ambitus, largest ambulacrum measured 5.0 mm at ambitus; estimated diameter or largest specimen 30 mm. Isolated adapical face interambulacrals indicate a maximum diameter of about 50 mm.

Apical system: some genitals preserved in holotype (SUI 39491; Text-figure 1b, Plate 2, figure 7); a more complete example is illustrated as Text-figure 2a (SUI 39490). Genitals large: one plate (presumably including madreporite) larger than others, with six large pores which tend to be occluded by secondary calcite, no madreporite pores obvious; remaining genitals with about 60% of area of largest, three to four large pores on each arranged in an arc with apex directed adapically. All genitals with numerous secondary spine tubercles, large pores tending to be disposed in crescent on adapical half of plate. Some small plates with secondary spine tubercles near center of Text-figure 2a are though to be oculars; they are non-porous and approximately one third the size of the genitals. Oculars and genitals thick, outer surface broadly convex.

Interambulacra: four columns of thick plates in each area, imbricating adapically (Plate 2, figure 4; Text-figure 1d), laterally from center to adradials. Plate shape and origin of columns as indicated in Text-figure 1c, a nearly complete interambulacrum lacking only the most adapical plate (see also Plate 1, figures 3 & 4). Interambulacrals of adapical surface forming an almost equialteral triangle, rapidly reaching full complement of columns; adoral interambulacrals forming elongate triangle with concave lateral edges, fourth column appearing immediately before ambitus. Adradial interambulacrals only with primary tubercles, all interambulacrals with numerous secondaries. A scrobicular ring of tubercles is most noticeable in young individuals (Plate 1, figures 3, 9; Plate 2, figures 1, 5) but less distinct on largest specimens (Plate 2, figures 6, 7). Adradial plates only slightly larger than more central ones, at most 1½ times length of central interambulacrals. Interambulacrals of both faces about equal in area, moderately imbricate, mostly hexagonal in shape, but adradials with adambulacral sutures scalloped, extending partly over first ambulacral columns. Tubercle morphology as in generic description.

Plate 1. Echinoids from Iowa and Illinois. 1. Adoral surface of holotype of *Pholidocidaris irregularis* (Meek & Worthen), Field Museum UC 10522, Hamilton or Nauvoo, Illinois, X 1.5. Note large ambulacral plates with peripodia, small interambulacrals each bearing a primary spine tubercle. 2. Adapical surface of *Pholidocidaris irregularis* (Meek & Worthen), holotype, showing small ambulacrals near center of figure and large scale-like interambulacrals; only enlarged adradial plates with primary tubercles. 3. Adoral portion of two ambulacra and interambulacrum of *Praepholidocidaris pellaensis,* n. gen., n. sp., showing large hexagonal ambulacrals, ambulacral spines, and interambulacral plate arrangement. Paratype SUI 39489, X 5.5. 4. Adapical surface of same specimen as 3 to show interambulacral plate arrangement and secondary spines; note size of plates, tubercle morphology, and weak scrobicular ring of secondaries on this and preceeding figure. X 5.2 5. Side view of lantern showing outer surfaces of demipyramids. SUI 39484, X 5.6. 6 & 7. Adapical and adoral sides respectively of *Praepholidocidaris pellaensis,* SUI 39487, showing size and shape of ambulacrals, relative widths and shape of ambulacrum on each side. X 6.7. 8 & 9. Adapical and adoral views of another paratype (SUI 39488). This specimen shows good secondary spines on adapical face and primary ambulacral spines in place, scrobicular ring on interambulacral primary tubercles of adoral face. X 4.7.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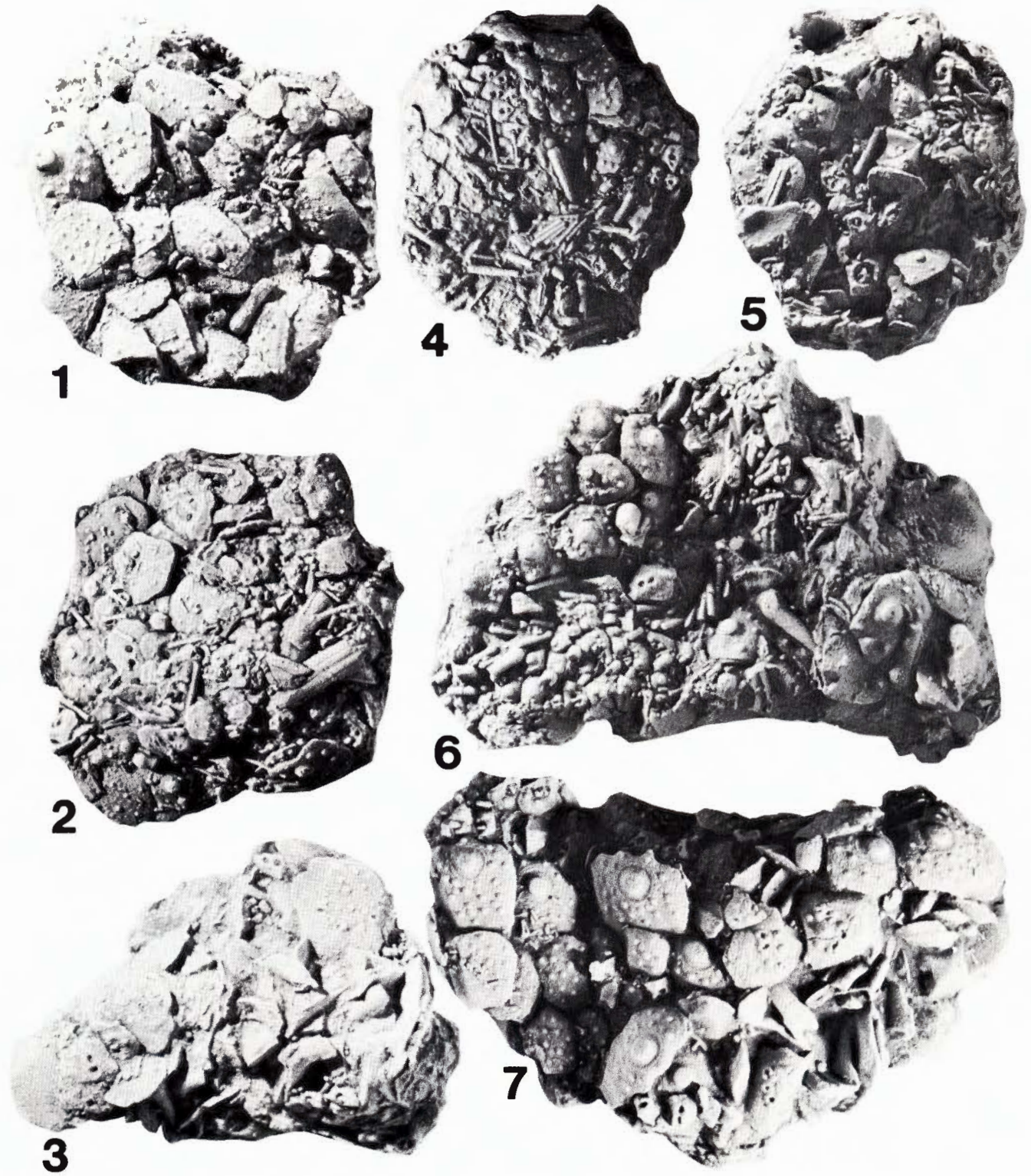

Plate 2. Praepholidocidaris pellaensis, n. gen., n. sp. 1. Adapical surface of moderate-sized whole specimen, showing edges of disrupted interambulacral plates. SUI 39483, X 5.3. 2. View of adoral surface of same specimen. Note grooved tooth, ambulacral peripodia, and primary spines. X 5.3. 3. Fragment of large specimen showing lantern as viewed from above. Large genital plate (possibly madreporite) at rop of figure. X 5.5.4. Adapical face of a small whole specimen illustrating imbrication of ambulacral and interambulacral plate columns, plate tubercles, and primary spines in place on both plate types. Peristome obscured by spines. X 4.3. 5. Oral face of same specimen as (4) above

Ambulacra: four columns of unequal plates in each ray on both faces, ambulacra much wider on aboral face, petaloid in shape with maximum width reached at a point less than half radial distance to ambitus (Plate 1, figure 7); ambulacra of adapical face narrow, gradually increasing in width approaching ambitus but less than half greatest adoral width at ambitus. Adoral ambulacrum of one specimen (Text-figure 2b) may have five columns. Most ambulacrals regularly hexagonal in shape (Plate 1, figures 3, 9) but some adapical plates diamond-shaped (Plate 2, figure 4). Adoral ambulacrals larger in average size than adapical (compare Plate 1, figures 6 & 7, 8 & 9); adoral plates also with pore-pairs surrounded by deep peripodia (text-figure 2b; Plate 2, figure 5) and bearing both primary and secondary spines. Adapical plates with primary spines and probably secondaries also; peripodia not developed. Ambulacrals beveling orally, laterally beveling under interambulacra, thick. Columns adjacent to interambulacra laterally elongate and larger on both faces. Pore pairs eccentric, not oblique, situated closer to side of plate facing nearest interambulacrum. Ambulacrals near peristome and adjacent to apical system rapidly decreasing in size; origins of columns not seen but all four are present very close to test apices.

Peristome: not well preserved on available material, likely very small; interambulacra not reaching peristome.

Spines: primaries of two types, straight and curved (Text-figure 2c; Plate 2, figures 4 & 6); longitudinally finely striate, 40-50 striations on largest spines. Primaries with swollen bases: well-developed milled ring and collar, knurled annulus; shaft tapering, rather stout; cross section round; longest interambulacral primary observed (incomplete) 11.5 mm long. Ambulacral primaries smaller (Plate 2, figures 2, 4, 6) only straight type observed, otherwise similar to interambulacral primaries; longest observed spine (complete) 8.0 mm long. Secondaries very small, stout tapering abruptly, bases swollen, shaft ornamented by a few longitudinal striae (Test-figure 2d; Plate 1, figure 4; Plate 2, figure 7). Ambulacral secondaries slightly smaller, more terete (Plate 1, figure 9), otherwise like their interambulacral counterparts.

Lantern: incompletely known, represented by demipyramids (Plate 1, figure 5; Plate 2, figure 3), a single brace on the holotype (Plate 2, figure 7), and a tooth (Plate 2, figure 2). Lantern small, similar to that of *Pholidocidaris* in morphology, with wide-angled demipyramids each with deep foramen magnum; teeth wide, grooved on outer surface.

Types. — All type specimens in the Repository of the Geology Department, The University of Iowa. Holotype SUI 39491; figured paratypes SUI 39483-39490, 39501-39502; unfigured paratypes SUI 39483, 39492-39500.

Horizon and localities. — Pella Formation, Mississippian (basal Chesterian), abandoned county quarry N. of Oskaloosa, near center of N. line of section 30, T. 76 N., R. 15 W., Oskaloosa 7½′ quadrangle; inactive quarry NE of Givin, SW ¼ NW ¼ sec. 12, T. 74 N., R. 16 W., Eddyville 7½′ quadrangle, Mahaska County, Iowa.

Remarks. — The close similarities between *Praepholidocidaris* and *Pholidocidaris,* plus the small test size, originally led us to believe that the Pella specimens might be immature *Pholidocidaris;* however, comparisons with the two juveniles of the type species of *Pholidocidaris* described by Jackson (1912, pp. 436-437), both within the size range of *Praepholidocidaris,* revealed numerous differences.

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showing large ambulacrals with pore pairs surrounded by raised peripodia. Plates somewhat jumbled. X 4.3. 6. Holotype (SUI 39491); adoral surface of large specimen, showing well-preserved ambulacrals with both primary and secondary spines, most of adoral half of one interambulacrum. X 4.5. 7. Adapical surface of holotype illustrating plate arrangement of adapical half of an ambulacrum (left half of figure), several perforate genital plates (right half), exposed portion of a brace, and numerous tiny secondary spines. X 4.5.

Pholidocidaris, like many other echinoids, acquires its distinctive characteristics at an early stage of growth. Many of the differences between the two genera have been noted previously, but a few supplemental comparisons can be appended. Adradial interambulacrals in *Pholidocidaris* are two to three times the length of the median column plates, and the interambulacrals of the adapical face are distinctly large in size. The genitals of *Pholidocidaris* have six to ten genital pores and are proportionately smaller than those of *Praepholidocidaris.* Additionally, the poorly known oculars of *Pholidocidaris* may be perforate (Jackson, 1912, p. 435).

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