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THE EDRIOASTEROID *LEPIDODISCUS SQUAMOSUS* (MEEK & WORTHEN)

TIMEISCHYTES, A NEW GENUS OF HEMICYSTITID EDRIOASTEROID FROM THE MIDDLE DEVONIAN FOUR MILE DAM LIMESTONE OF MICHIGAN

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THE EDRIOASTEROID *LEPIDODISCUS SQUAMOSUS* (MEEK & WORTHEN)

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ABSTRACT—A specimen of *Lepidodiscus squamosus* (Meek & Worthen) believed to be the holotype has been found at the Museum of Paleontology of the University of Michigan. Because *L. squamosus* is the type species of *Lepidodiscus*, this specimen is of particular interest. Certain details can now be added to Meek & Worthen's original description. The ambulacral plates are more numerous than shown by Meek & Worthen in their drawing published in 1873, five years after the species was described. In some parts of the ambulacra the plates are irregular, but in most parts they are arranged in cycles of six, of which two plates do not extend to the outside edge of the ambulacrum. The peripheral plates are set at a steep angle, imbricating, and not fused into a ring, as in other species presently assigned to *Lepidodiscus*. The peristome covering plates form a bulge in the right posterior region, and they have collapsed along a line. This feature is similar to that pointed out by Hecker in 1940 in *Lepidodiscus ephraemovianus* (Bogolubov). The position of the structure corresponds to that of the hydropore in *Edrioaster bigsbyi* (Billings), and the bulge may contain some kind of hydropore.

INTRODUCTION

DISCOVERY of a specimen of *Lepidodiscus squamosus* (Meek & Worthen) which we believe to be the holotype permits a restudy of the species. Insofar as we know, this is the only specimen ever found of *L. squamosus*, the type species of *Lepidodiscus*. Although poorly preserved, it clearly shows certain characteristics different from those in edrioasteroids now assigned to other species of *Lepidodiscus*.

At least 10 years ago, and perhaps as long as 30 years ago, an exhibit of echinoderms was set up in the Hall of Evolution in the Museum of Paleontology at the University of Michigan. Two edrioasteroids were included in this exhibit. The one which is the subject of this paper was accompanied by a label reading:

LEPIDODISCUS SQUAMOSUS
MEEK AND WARTHIN
SILURIAN
5420 CRAWFORDSVILLE, IND.

In the course of our study of edrioasteroids, we examined this specimen. To our knowledge, we were the first to open the case housing the exhibit since it was prepared. The reference to Silurian age is puzzling, since no Silurian strata are exposed near Crawfordsville, Indiana. The famous collecting locality there is an outcrop of Mississippian Edwardsville formation. The co-author of the species is Worthen, not Warthin as given on the label.

Since a catalogue number accompanied the specimen, we checked the catalogue card in the Museum of Paleontology, and found the following information:

5420 Agelacrinus (Lepidodiscus) squamosus M & W.
Niagara
Crawfordsville, Ind.
Rominger

It contains no indication that the cataloguer recognized this specimen as a type.

The entry "Rominger" indicates that this edrioasteroid was part of Dr. Carl Ludwig Rominger's extensive fossil collection. Most of his specimens are now in the Museum of Paleontology. In 1864, when Dr. Rominger was Assistant Curator in the Museum of Geology, Zoology, and Botany of the University of Michigan, he deposited most of his large collection of fossils from Europe in the Museum.

In his history of the Museum of Paleontology, L. B. Kellum states (1956, p. 1492–1493):

> On June 27, 1865, the Regents received a communication from Winchell "in relation to the enlargement and improvement of the Museum and the employment of Dr. C. Rominger as Curator of the Museum of Geology, Zoology and Botany, to be charged with the duty of laboring for the increase and preservation of the collections in this department" . . . A sum of $300 was appropriated "for the purpose of

> employing Dr. Rominger to make collections in Natural History, for the use of the Museum . . . ." With this sum he made twelve collections, comprising 320 species of fossils from Ordovician, Silurian, Devonian, and Mississipian strata in Indiana, New York, Michigan, and Ontario. Nevertheless, in September, 1866, the Committee on the Museum recommended that his salary as Assistant Curator of the Museum be discontinued.

Thus, it appears quite likely that the specimen of *Lepidodiscus squamosus* was collected in 1865 by Dr. Rominger, and was loaned to Meek and Worthen three years later for description. Nevertheless, in 1881 Rominger had the specimen in his possession and definitely regarded it as his property. In the Museum of Paleontology there is a bound journal written in Dr. Rominger's German script. One section of this journal is entitled "Petrefactorum Catalogus / Merz 1881," and includes the following entry on page 37: "Agelacrinus squammosus [sic] / Subcarb. Crawfordsville . . . 1 Stk." (Dr. Rominger often wrote partly in German and partly in English, and "Stk." undoubtedly is the abbreviation of the German "Stück," meaning "specimen"). In the same journal, under the section headed "Catalogue of Collection deposited in the University Museum as a loan with the view of selling it to the Museum if the necessary funds are appropriated for the purpose," Rominger listed on page 215, "Agelacrinus squamosus M. & Worthen / Crawfordsville . . . 1 Stk."

Negotiations for the purchase of Rominger's European collection by the University began in 1864, when he first deposited it at the Museum. During succeeding years, Rominger added numerous specimens from Michigan and nearby states to his collection. On January 1, 1888, the University started renting Rominger's collection for $125 per half year. At last, in December of 1891, after nearly 28 years of negotiation and delay, the University purchased the fossils for $5,000. We assume that the edrioasteroid here described came into the possession of the University in this transaction.

It is also of interest that Rominger, in his "Petrefactorum Catalogus," listed many other echinoderms from "Subcarb. Crawfordsville." They include numerous specimens of 27 identified species, in addition to several unidentified species. Of these, many are catalogued in the Museum of Paleontology, including the holotypes of the rare echinoids *Lepidesthes coreyi* and *Oligoporus coreyi* described by Meek & Worthen (1868*b*, p. 525; 1870, p. 34), and a hypotype of the crinoid *Onychocrinus exculptus* Lyon & Casseday figured by Meek & Worthen (1873, pl. 14, fig. 4). Regarding the last, Rominger wrote in his "Petrefactorum Catalogus": "original exemplar figured by Worthen."

Although Meek & Worthen in their several publications do not mention Rominger as the collector of specimens they described, it appears that Rominger loaned some of his choice echinoderms to them for study and description. Of course, it is possible that Meek or Worthen obtained the specimens which they described from another source, and traded them to Dr. Rominger for specimens in his collection. In those days, excellent specimens from one locality were swapped for those from another to build up a large collection, and holotypes commanded little respect except as prime trading material.

Meek & Worthen (1870, p. 34) say in their original description of *Oligoporus coreyi*, "The specimen from which the description was made out belongs to Mr. Corey, of Crawfordsville, Ind., to whom we have dedicated the species." If we knew how the holotype of *Oligoporus coreyi* came into Rominger's possession, perhaps we would know more of the history of the holotype of *Lepidodiscus squamosus*.

The photography of this poorly preserved

EXPLANATION OF PLATE 119

FIGS. *1–3*—*Lepidodiscus squamosus* (Meek & Worthen). Holotype, UMMP No. 5420. *1*, natural size, coated with ammonium chloride. *2*, enlarged, photographed when submersed in xylol to show the plates. *3*, reproduction of Meek & Worthen's figure (1873, pl. 16, fig. 1) in their orientation, slightly reduced to correspond to their measurement (1873, p. 514).

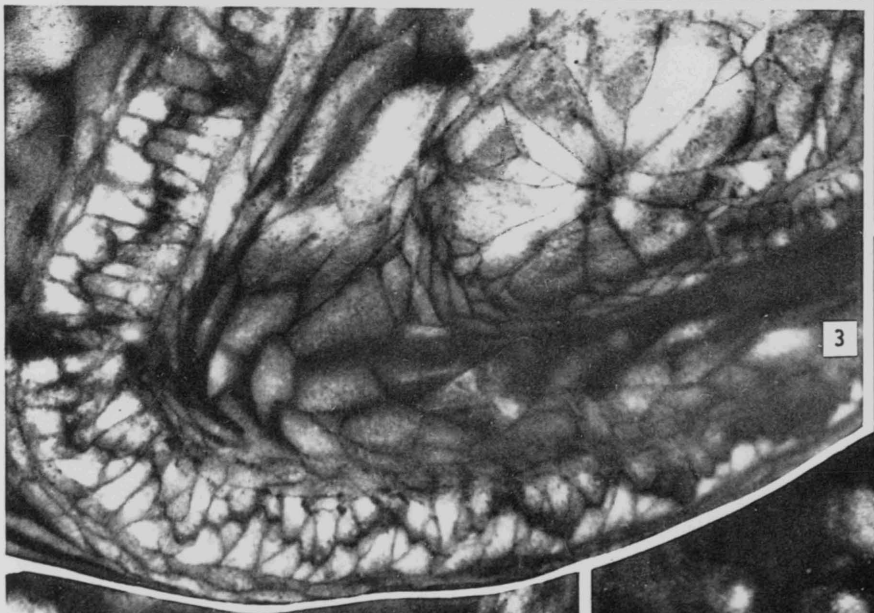
1

2

3


1


2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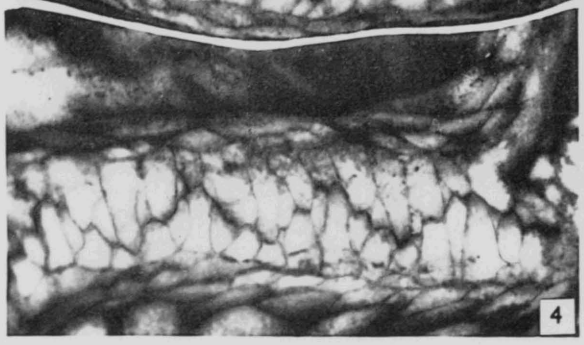
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5


6

specimen presented many problems. Because the plates were worn in many parts of the ambulacra, a coating of sublimate hid many significant details. We found, after several trials, that the best results were achieved with the specimen immersed in xylol. Because of the sharp contrast between the color of the plates and the color of the matrix, it was necessary to use a film of very low contrast to show the complete specimen to advantage. However, film of greater contrast was used to show details of the ambulacral plates.

We greatly appreciate the efforts of Dr. Porter M. Kier of the United States National Museum, Dr. Carlton Condit of the Illinois State Museum, and Dr. Charles Collinson of the Illinois State Geological Survey for searching through the collections at their institutions for specimens of *Lepidodiscus squamosus*.

SYSTEMATICS

Phylum ECHINODERMA
Subphylum PELMATOZOA
Class EDRIOASTEROIDEA Billings, 1858

There has been some confusion in literature on the origin of the name of this class. The first reference we have found that proposes such a designation is by Billings, 1858, p. 85, who wrote:

> I have placed *E.* (*Edrioaster*) *Bigsbyi* in the order Asteriadae, because its structure appears to me to be more like that of the Star-fishes than that of the Cystideae. None of the Cystideae have ambulacra whose pores penetrate through the covering of the body, and therefore all such genera as *Edrioaster*, *Agelacrinites* and *Hemicystites*, belong to a very different division of the Echinodermata. When we know more of their structure it is probable that they will be arranged as a sub-order, for which the name *Edrioasteridae* would be appropriate, as it would suggest their sessile condition on the one hand, and on the other their affinity to the Asteriadae.

Family AGELACRINITIDAE Clarke, 1901

S. A. Miller (1877, p. 65) used "Order Agelacrinidae" to include *Agelacrinus*, *Edrioaster*, and *Hemicystites*. Later (1889, p. 216) he used "Order Agelacrinoidea" for the families "Agelacrinidae" and "Hemicystidae." In 1899 (p. 57) Jaekel claimed authorship of this spelling, writing "Fam. Agelacrinidae m." Bather (1900*a*, p. 207) and others, including Piveteau (1953, p. 651), also used the family name "Agelacrinidae." Miller's "Agelacrinidae" and "Agelacrinoidea" were based on the stem of the much used but erroneous change in the spelling of *Agelacrinites* to *Agelacrinus*. The correct name of the genus is that which Vanuxem (1842, p. 158) originally proposed—*Agelacrinites*. Because Miller's names are not based on the correct generic stem, he cannot be regarded as the author of the suprageneric taxon.

In 1901 on page 183 and again on page 198, J. M. Clarke referred to the "family Agelacrinitidae." He also called attention to the erroneous spelling of *Agelacrinites*. In 1935 (p. 2) R. S. Bassler, evidently unaware of Clarke's correct family name, proposed "Agelacrinitidae, new name." we believe Clarke was the first to use the correct stem and is the author of the family.

The family is used here as emended by Bassler (1935, p. 2) and further restricted by him (1936, p. 15) to include *Agelacrinites*, *Cooperidiscus*, *Discocystis*, *Isorophus*, *Isorophusella*, *Lepidodiscus*, *Thresherodiscus*, and *Ulrichidiscus*. The family, as now restricted, includes edrioasteroids with a single row of

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EXPLANATION OF PLATE 120

All figures ×10, retouched

FIGS. *1–6*—*Lepidodiscus squamosus* (Meek & Worthen). Holotype, UMMP No. 5420. *1*, central part of ambulacrum III, showing fairly regular cyclic arrangement of ambulacral plates. *2*, distal part of ambulacrum V. *3*, proximal and central parts of ambulacrum I, the anal pyramid, and (at the right) the end of ambulacrum V, showing the small interambulacral plates bordering the ambulacra and anal pyramid. *4*, proximal part of ambulacrum IV. *5*, proximal part of ambulacrum III; note the irregularity of plates where the ambulacrum recurves. *6*, recurved part of ambulacrum II, showing insertion of several plates in addition to the normal cycle at the bend.

flooring plates in each ambulacrum and numerous covering plates of the peristome.

Genera are distinguished by the presence of branching in the ambulacra, the curvature of the ambulacra, the width of the ambulacra, and the mosaic or imbricating character of the interambulacral plates.

Genus LEPIDODISCUS Meek & Worthen, 1868*a*

Type species.—By monotypy, *Agelacrinites* (*Lepidodiscus*) *squamosus* Meek & Worthen, 1868*a*, p. 357.

The generic name was first used by Meek & Worthen (1868*a*, p. 357) for a subgenus of *Agelacrinites*. They compared their species with *Agelacrinites hamiltonensis* Vanuxem, the type species, and noted that, whereas *A. hamiltonensis* had ambulacra IV and V curved to the right and mosaic interambulacral plates, their species had only ambulacrum V curved to the right and imbricating interambulacral plates. They concluded (1868a, p. 358):

> It therefore certainly seems to us doubtful whether species differing in two such important characters as these are strictly congeneric. If they are not, then a new generic name should be applied to our species, and the others agreeing with it in these characters, in which case we would propose to designate this group of species under the name *Lepidodiscus* . . . . At least we should think they ought to be separated subgenerically.

As now employed, the genus *Lepidodiscus* includes, in addition to the type species, *L. alpenensis* Bassler, 1936, *L. beecheri* (Clarke, 1901), *L. buttsi* (Clarke, 1901), *L. ephraemovianus* (Bogolubov, 1926), *L. lebouri* Sladen, 1879, and *L. milleri* Sharman & Newton, 1892. These species have long, curved ambulacra, of which ambulacra I–IV curve to the left and ambulacrum V to the right, and numerous, strongly imbricating interambulacrals. The genus ranges from Middle Devonian to Mississippian.

LEPIDODISCUS SQUAMOSUS (Meek & Worthen, 1868*a*)

Pl. 119, figs. 1–3; pl. 120, figs. 1–6; text-fig. 1

Agelacrinites (*Lepidodiscus*) *squamosus* MEEK & WORTHEN, 1868*a*, p. 357–358; 1873, p. 513–515, pl. 16, fig. 1.

Lepidodiscus squamosus CLARKE, 1901, p. 184, 188–193, 198. BASSLER, 1935, p. 8; 1936, p. 20, pl. 1, fig. 17; 1938, p. 123. BASSLER & MOODEY, 1943, p. 207. SHIMER & SHROCK, 1944, p. 131, pl. 49, fig. 21.

Agelacrinus squamosus MILLER, 1889, p. 222.

Agelacriniles squamosus JAEKEL, 1899, p. 51.

THE SPECIMEN

There are several reasons for considering this specimen to be the holotype. In 1873 (p. 514), Meek & Worthen repeated their previous (1868*a*, p. 357) statement, "The only specimen of this species we have seen is somewhat crushed and distorted. . . ." No other specimen has been mentioned in literature since that time.

Meek & Worthen (1868*a*, p. 357; 1873, p. 514) give the greatest diameter of the specimen they describe as 1.70 inches; this is the size of UMMP No. 5420. Their figure (1873, pl. 16, fig. 1, here reproduced as pl. 119, fig. 3) shows the right anterior part of the specimen broken off; the right anterior part is missing in UMMP No. 5420. The figure also shows ambulacrum IV broken off before it completely recurves; ambulacrum IV in UMMP No. 5420 is broken off at the corresponding place. Their figure further shows the distal parts of ambulacra I, II, and III lying on or near the periphery; these ambulacra in UMMP No. 5420 extend to the periphery. In several other details, Meek & Worthen's figure matches our specimen, as in the shape of the ambulacra, the position of the analy pyramid at the left side of the posterior interambulacrum, and the termination of ambulacrum V just below the anal pyramid.

In a few details, Meek & Worthen's figure of the type differs from UMMP No. 5420. In the anterior region, lying between the distal part of ambulacrum III and the periphery, they show a continuation of ambulacrum IV. In UMMP No. 5420 no trace of ambulacrum IV is exposed at the surface in this part of the specimen; instead, there are only upturned peripheral plates, but the broken edge of the specimen shows a cross section of ambulacrum IV, suggesting that the peripheral plates in this region were compressed and shoved over the top of the distal part of the ambulacrum. Meek & Worthen show ambulacrum I terminating at about the midventral part of the periphery. In UMMP No. 5420 ambulacrum I

extends farther, and terminates below the recurved part of ambulacrum V. In addition, in Meek & Worthen's figure the center lines of ambulacra I and II extend separately into the peristomial region, but in our specimen these lines join at the left side of the peristomial region.

In view of the crushed and distorted nature of UMMP No. 5420, it would be surprising, indeed, if an artist produced a photographic likeness. We are convinced, by the many points in which our specimen, UMMP No. 5420, agrees with the drawing given by Meek & Worthen, that it is the holotype.

Dr. Charles Collinson searched for specimens of *Lepidodiscus squamosus* at the Illinois State Geological Survey, Dr. Carleton Condit at the Illinois State Museum, and Dr. Porter M. Kier at the United States National Museum, but none could be found. We believe this is the only known specimen of the species.

The specimen is incomplete, as mentioned above. Furthermore, its upper surface was evidently displaced toward the left posterior edge. At this place, ambulacra I, II, and III lie along the periphery, as seen in an oral view, but the peripheral plates are still preserved under the edge, where they are hidden in this view.

The matrix is a very dark limestone with numerous pelmatozoan columnals and fragments. We did not attempt to remove it to uncover the aboral surface of the specimen because of the fragile nature of the parts exposed on the oral side. Although we spent many hours in cleaning the specimen, we removed very little matrix. Most of our work consisted of uncovering the small plates along the edges of the ambulacra.

AMBULACRA

The general curvature of the ambulacra is given by Meek & Worthen (1868a, p. 357; 1873, p. 513, 514). To their description should be added that a short distance from the peristomial region ambulacra I, II, III, and IV curve to the right before strongly recurving to the left, and that ambulacrum V curves to the left before strongly recurving to the right.

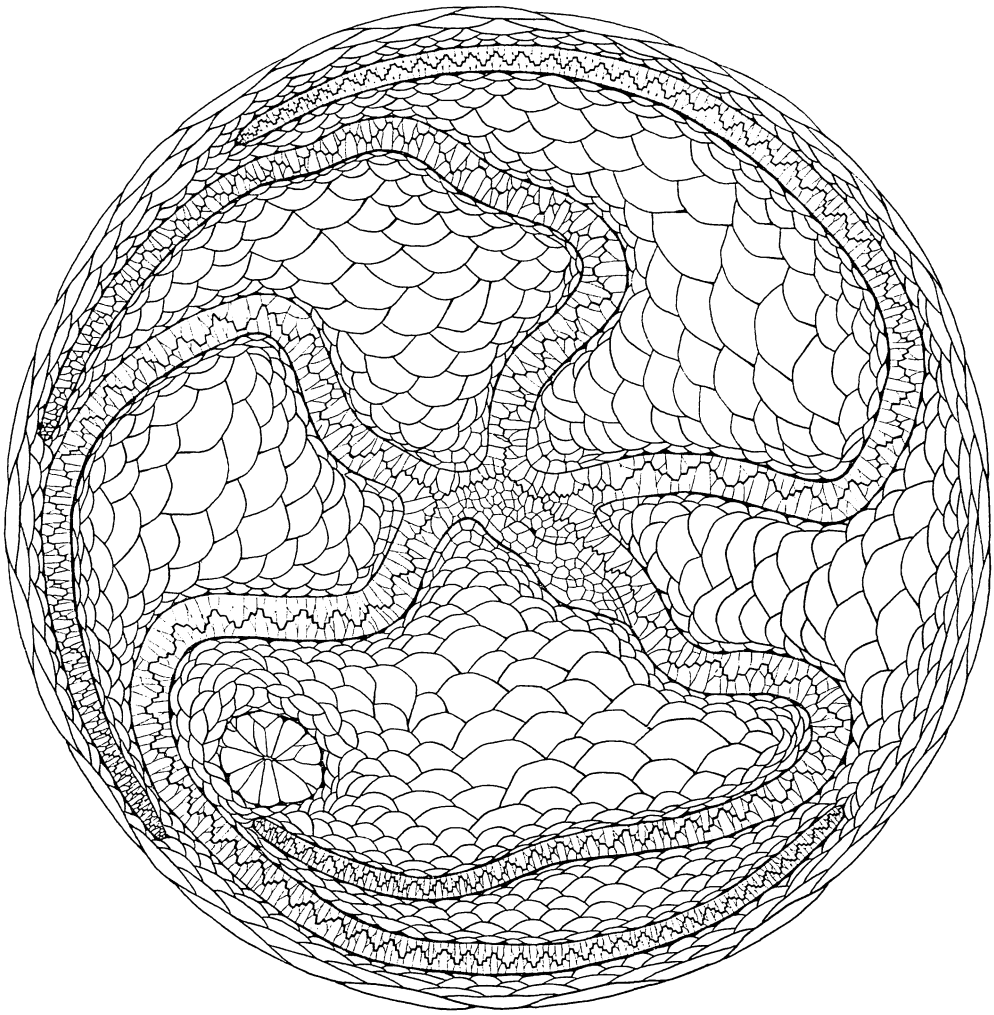
In no part of the specimen are the flooring plates exposed to show their shape or arrangement. At the broken end of ambulacrum IV the flooring plates are thick and lie rather close to the covering plates.

AMBULACRAL COVERING PLATES

Meek & Worthen (1868*a*, p. 357; 1873, p. 514) describe the ambulacra: ". . . each composed of two zigzag rows of very small pieces, with some irregular ones apparently not belonging properly to either row."

As can be seen in the photographs (pl. 119, fig. 2; pl. 120, figs. 1–6), the conspicuous feature of the arrangement of ambulacral covering plates is a prominent zigzag central line dividing those of one side from those on the other. This zigzag line begins near the peristomial region and extends to the end of each long arm. Each limb of the major zigzag line is itself conspicuously serrate. In contrast to the covering plates of the peripstome and the nearby parts of the ambulacra, some which have their edges serrate at the central line (see text-fig. 1 and pl. 119, fig. 2), the other plates in the ambulacra are not serrate at the central line (pl. 120, figs. 1–6). Instead, each angle in the central line meets a line dividing two of the ambulacral plates on one side or the other, so that each plate is angular but not indented. In other words, each angle of the central line is formed on one side by the acuminate end of one plate and on the other side by the edges of two plates.

In some parts of each ambulacrum the covering plates are somewhat irregular, but throughout most of the ambulacrum, particularly the distal half, they are regularly cyclic. The plates on each side of the zigzag central line occur in cycles of six, with few exceptions (pl. 120, fig. 1). In each cycle, the first, second, fourth, and sixth plates extend from the central line to the outside edge of the ambulacrum. The first is short and quadrate; the second is intermediate in length and irregularly hexagonal, its outer part subquadrate and its inner part acuminate; the fourth plate, the longest in the cycle, is subquadrate except that the inner corners are beveled; and the sixth plate is a mirror image of the second. The third plate is subrhombic, inserted between the second and fourth plates, with its inner apex forming a serration on the central line of the ambulacrum. The fifth plate is a mirror image of the third, lying on the opposite side



TEXT-FIG. *1*—Hypothetical reconstruction of *Lepidodiscus squamosus* (Meek & Worthen) based on the holotype and only known specimen. The small plates at the peripheral edge, lying on the nearly vertical face of the large peripheral plates, have not been indicated.

of the long fourth plate. In most cycles, the subrhombic third and fifth plates do not extend to the outside edge of the ambulacrum, but terminate along the side of the fourth plate. The plates on the other side of the ambulacrum are arranged in similar cycles but offset by half a cycle, so that the first plate on one side lies directly opposite to the fourth plate on the other side.

In the proximal part of each ambulacrum and at the place where it rather abruptly recurves, extra plates are irregularly inserted in the cycles (pl. 120, figs. 3,5,6).

Meek & Worthen (1868*a*, p. 357; 1873, p. 514) also state that the ambulacra are "apparently not provided with *open* ambulacral furrows, the rows of minute plates on each side, apparently closing up and interlocking. There appear, however, to be pores arranged along them in a zigzag row between the plates." There is no evidence that the plates interlocked, if by that term is meant that the free movement of plates was constrained. Instead, the plates of one side abut against those of the other side, fitting evenly against them and leaving no interstices. We can

discern no pores along the central lines of the ambulacra.

This pattern of plates may be unique. Insofar as known, in other species presently assigned to *Lepidodiscus* the ambulacral plates are more nearly alike, and, with few exceptions, vary only in a gradual decrease in size toward the distal end of the ambulacrum. In these species, the acuminate ends of the plates on one side alternate with those on the other side, forming a serrate central line the length of the ambulacrum. It may be mentioned here, however, that *Discocystis laudoni* Bassler, as shown in the original figures (1936, pl. 3, figs. 7–8), also has a prominent zigzag line along each ambulacrum, but precise details of its plate pattern are not known.

INTERAMBULACRAL PLATES

Meek & Worthen (1868*a*, p. 357; 1873, p. 514) state:

> Disc composed of large, thin, irregular, strongly squamose or imbricating plates, the imbrication being inward from the periphery, that is, the inner edge of each plate laps upon the outer edge of the next. . . . Ovarian ? pyramid . . . forming a depressed cone, around the base of which there are numerous small, short, but comparatively wide imbricating disc plates.

Some of the interambulacral plates are worn and a few are missing. As can be seen in the photograph (pl. 119, fig. 2) and as indicated in the restoration (text-fig. 1), the plates are distinctly imbricating, overlapping toward the center with three exceptions. First, small imbricating plates lap up to both the inner and outer edges of the ambulacra (pl. 120, figs. 2–5); those along the inner edges of the ambulacra reverse the general direction of imbrication. Second, the interambulacral plates in the region of the anal pyramid are small and overlap toward the center of the pyramid (pl. 120, fig. 3). Third, the interambulacral plates near the peristomial region are small and nearly mosaic, imbricating very little if at all (pl. 119, fig. 2).

The interambulacral plates are very large in the center of each interambulacrum and decrease abruptly towards the edges of the ambulacra and towards the anal pyramid. Those in the distal region differ very little from the plates in the peripheral ring. The only difference we can point out is that the plates in the peripheral ring are set at a much steeper angle, being nearly vertical, whereas the interambulacral plates are nearly horizontal.

ANAL PYRAMID

Meek & Worthen (1868*a*, p. 357; 1873, p. 514) state that the anal pyramid in *Lepidodiscus squamosus*, which they refer to as the "ovarian ? pyramid," is "closed by ten pieces, apparently imbricating laterally, and forming a depressed cone."

There are more than ten plates in the anal pyramid, and they are not arranged in the regularity shown in Meek & Worthen's figure. In addition to a few very small plates at the periphery of the pyramid, which are inserted between the outer edges of the large plates, there appear to be 15 plates in the anal pyramid of the holotype (pl. 120, fig. 3; text-fig. 1). Of these, only 11 extend into the central part of the pyramid. It is not known whether the number, size, shape, and arrangement of the plates vary within the species.

PERIPHERAL PLATES

Clarke (1901, p. 193) considered the nature of peripheral plates to be an important generic character, together with the nature of the interambulacrals and the length and width of the ambulacra. He diagnosed *Lepidodiscus* (in which he included *L. squamosus* and *L. alleganius*, the latter subsequently made the type species of *Cooperidiscus* by Bassler in 1936) as having "peripheral band very narrow or extinguished, composed of large and small plates; the latter few, the former projecting on the aboral surface." He contrasted it with *Agelacrinites*, in which the "peripheral band [is] composed of large plates with very small ones at the margin," and with *Discocystis*, in which the "peripheral band [is] composed of a few large plates with no fine ones outside of them."

Other workers have paid little attention to the peripheral plates in classification of edrioasteroids. They have regarded the nature of the covering plates of the peristome, the curvature of the ambulacra, and the interambulacral plates as diagnostic.

In contrast to other species assigned to *Lepidodiscus*, the type species does not have the peripheral plates fused to form a ring.

The plates lying outside the distal parts of the ambulacra are set at a steep angle, nearly vertical. The peripheral plates are very large, with the exception of the outermost plates, which are small and arranged in several rows. In the holotype the small plates are worn and, where preserved, more or less hidden by over-hanging adjacent large plates. In the left posterior region of the holotype, where the distal parts of ambulacra I, II, and III have been displaced over the edge of the peripheral plates, the latter are hidden in an oral view and are turned outward and upward toward the edges of the abulacra.

PERISTOMIAL REGION

The covering plates of the peristome appear to be smaller than those of the ambulacra. It is possible, however, that some of the plates are cracked and that some of the cracks have been interpreted as junctions between plates.

The center line of ambulacrum III continues into the peristomial region as a serrate line, and from its end one serrate line extends to the left to the junction of the center lines of ambulacra I and II, and another extends to the right to the junction of the center lines of ambulacra IV and V. Dr. August Foerste noted this arrangement in many edrioasteroids of the family Agelacrinitidae and (1914, p. 412) proposed a trimerous origin of the ambulacral system in the family. *Lepidodiscus squamosus* is an excellent example of a trimerous arrangement and "pseudo-pentamerism," as termed by Dr. Foerste. Some of the covering plates along the three lines have serrate edges. As already pointed out, this is a sharp contrast to the ambulacral covering plates, which are so arranged that the plates meet the central zigzag line without indentations.

The peristomial region (pl. 119, fig. 2; text-fig. 1) is strongly asymmetrical. The left half is very narrow, about the same width as the proximal part of one of the ambulacra. The right half, however, has a doubly lobate bulge projecting into the posterior ambulacrum. Many of the plates along a line parallel to the edge of this bulge are crushed in, suggesting that some hollow structure existed in the edrioasteroid below the covering plates. A similar structure has been reported in *Lepidodiscus ephraemovianus* (Bogolubov) by Hecker (1940, p. 99; 1941, p. 321) and pointed out again by Regnéll (1950, p. 5), who referred to it as "a bulging into the anal interambulacrum of the oral field suggesting the presence of some wider opening, according to the interpretation of Hecker."

The presence of a hydropore in edrioasteroids was first reported by F. A. Bather in 1900, in Part III of *A Treatise on Zoology*, edited by E. Ray Lankester. In his description of the class Edrioasteroidea, Bather wrote (1900*a*, p. 205), "Hydropore (usually, if not always, present) between mouth and anus." In Fig. VI, no. 1, he illustrated *Ediroaster bigsbyi* in a drawing, in which the hydropore was labeled "M" and identified in the explanation of the figure as a "madreporite." Because *A Treatise on Zoology* became a widely quoted text, many subsequent writers on the Edrioasteriodea have stated that edrioasteroids are characterized by a hydropore. Although this may be true, the existence of a distinct opening that can be interpreted as a hydropore has only been established in the genus *Edrioaster*.

In the same year that Part III of the *Treatise* was issued (but later, since it contains a reference to the *Treatise*), Bather published an article on "*Edrioaster Buchianus* Forbes sp.," in which he states (1900*b*, p. 198), "In the posterior interradius was a madreporite or hydropore-plate, the inner surface of which formed a semicircular projection for the attachment of the upper end of the stone-canal." Later Bather (1914*a*, p. 118) republished his figure of *Edrioaster bigsbyi* from Lankester's *Treatise* but labeled the structure "water-pore," and stated on the same page, "In the posterior interradius, two large interradials, adjoining the peristome, are traversed by an elongate hydropore." Evidently, Bather considered "hydropore," "madreporite," and "water-pore" to be synonyms.

Bather (1915*b*, p. 266) states that in the Agelacrinitidae "An external hydropore has not yet been detected, but it is conceivable that the hydrocircus [ring canal] opened into the oral vestibule, and that it may have been connnected with some canal passing up in the posterior interradius."

Edrioasteroids so preserved that the peristomial cavity can be viewed from the aboral side are extremely rare. Some specimens of

Carneyella pileus (Hall) in this condition have been studied by Foerste (1914, p. 427–429). He reports and figures (1914, p. 429; pl. 1, fig. 5*a*; pl. 2, figs. 3–4) "a peculiar margined depression along the proximal part of the right hand margin of the right posterior ray (No. 5), as viewed from below," and states, "This impression involves the two proximal covering plates on the left side of the right posterior ray, where adjoining the right margin of the posterior peristomial plate, as seen from above. Possibly a duct passed by this path, but its presence could not be verified with confidence."

Bather (1915*b*, p. 266) concluded, "If, as Dr. Foerste suggests, 'a duct passed by this path,' then the duct in question would most naturally be the hydropore-canal."

Foerste's description further indicates the possibility that the hydropore in *C. pileus* may have been an elongate slit between plates in the right posterior part of the peristomial region. Of these plates, he says (1914, p. 415):

> This differentiation [in form of the first covering plate of ambulacrum V] is connected with the form of the posterior peristomial plate, and consists in a slight elevation of the basal margin of the covering plate, corresponding to a much more marked raising of the lower right-hand margin of the posterior peristomial plate (P). Usually the first covering plate of the right posterior ray (No. 5) fits snugly against the upper part of the right hand margin of the posterior peristomial plate, often having a convex outline where adjoining the latter, but posteriorly these two plates do not fit as closely to the anterior outline of the immediately adjacent interambulacral plate (X). This suggests the possibility of the exit of some duct at the angle between these three plates (P, X, and 5). No aperture actually penetrating a plate has been noted.

As shown in one of Foerste's figures of *Carneyella pileus* (1914, pl. 1, fig. 5*a*), his plate "X" seems to be part of the peristomial region, since it lies wholly within the boundary formed by a continuation of the line along the rear edge of the posterior peristomial plate to the rear edge of the first covering plate of ambulacrum V.

Although *Carneyella* belongs to the family Hemicystitidae, it is of particular interest that a structure resembling a passageway for a stone canal is present in the peristomial region and that the form of the plates overlying it suggests an opening between them. The cavity in *C. pileus* lies below the plates in the right posterior part of the peristomial region which are not paired by plates on the left; thus, the cavity is covered by plates which enlarge the right posterior area and cause the peristomial region to be asymmetrical.

It may likewise be said of *Lepidodiscus squamosus* that the additional plates in the right posterior part make the peristomial region asymmetrical. The crushing in of the plates in this part strongly suggests that this unpaired structure was underlain by a hollow duct. No opening that could be termed a distinct hydropore was observed, although the plates are caved in and distorted so that even a large hydropore might not have been preserved.

Such an important part of the edrioasteroid's anatomy as the water-vascular system must have existed in all species. The distinct opening in *Edrioaster bigsbyi* is, in our opinion, rightly interpreted as a hydropore. We believe that the water-vascular system of other edrioasteroids also had some sort of opening for intake of water.

If numerous edrioasteriods could be obtained in each species, one might learn more about their internal structures by serial sections. Unfortunately, only one specimen of *Lepidodiscus squamosus* is known.

The evidence and observations just mentioned are meagre and inconclusive. We can only postulate the following:

1. Each edrioasteroid had some kind of water-vascular system, with an external opening, or hydropore, for intake of water.
2. In *Edrioaster* (family Edrioasteridae) the conspicuous opening shared by two adjacent plates in the posterior ambulacrum, near the right posterior edge of the peristomial region, is a hydropore.
3. In *Carneyella* (family Hemicystitidae) the hydropore is an inconspicuous gap between covering plates in the right posterior part of the peristomial region.
4. In *Lepidodiscus* (family Agelacrinitidae) the hydropore is probably a narrow gap between covering plates in the right posterior part of the peristomial region.

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JOURNAL OF PALEONTOLOGY, V. 32, NO. 5, P. 933–936, PL. 121, 1 TEXT-FIG., SEPTEMBER 1958

TIMEISCHYTES, A NEW GENUS OF HEMICYSTITID EDRIOASTEROID FROM THE MIDDLE DEVONIAN FOUR MILE DAM LIMESTONE OF MICHIGAN

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ABSTRACT—A very small and unusual edrioasteroid from the Dock Street clay member of the Four Mile Dam limestone (Middle Devonian) is classified as a new genus and species, *Timeischytes megapinacotus*. Although it appears to be closely related to *Hemicystites*, its inclusion in the Hemicystitidae requires an emendation of the family. The new species has two features unknown in other edrioasteroids. The anal pyramid is very large and touches the peristomial region, and each interambulacrum, with the exception of the posterior, is covered by one large plate.

INTRODUCTION

IN 1955, while cleaning some invertebrates from the Dock Street clay member of the Four Mile Dam limestone, the senior author noticed a small edrioasteriod attached to a bryozoan colony encrusting a coral. In 1958 in the course of investigating the edrioasteroid fauna of the Middle Devonian rocks of Michigan, we examined this specimen in detail. Preliminary cleaning revealed some very unusual characteristics.

A search was started for additional specimens in the collections of the Museum of Paleontology. Each of hundreds of fossils from this member was examined with a hand lens. The efforts were rewarded. Mr. Rex M. Peterson, an assistant at the Museum, found a second specimen. Curiously, this specimen, like the first, is attached to a bryozoan colony encrusting a coral. The label accompanying the second specimen indicates that it was found by Mr. Leon O. Pettyes, of Alpena, Michigan, who presented several invertebrates to the Museum of Paleontology on August 24, 1926. Evidently, the edrioasteroid had not been noticed until our search was made.

The first specimen, which we have designated as the holotype, is from an exposure of the Dock Street clay member of the Four Mile Dam limestone in the abandoned quarry of the Thunder Bay Quarries Company, now owned by the Huron Portland Cement Company of Alpena. This quarry is on the eastern side of Alpena, Michigan, in the SE ¼ sec. 14, T. 31 N., R. 8 E. The type section of the Dock Street clay member is exposed in this quarry, and is not known in other outcrops. Undoubtedly, the second specimen was also obtained from this locality.

The two specimens are catalogued and deposited in the Museum of Paleontology of the University of Michigan.

SYSTEMATIC DESCRIPTION

Phylum ECHINODERMA
Class EDRIOASTEROIDEA Billings, 1858
Family HEMICYSTITIDAE Bassler, 1936

Although the new edrioasteriod described in this paper appears to be closely related to *Hemicystites* Hall, particularly in the arrangement of plates in the peristomial region, its inclusion in the Hemicystitidae requires an emendation in the family description.

Bassler (1936, p. 4) originally described the Hemicystitidae as follows: "Theca composed of thin plates with an oral surface of five ambulacra separated by interambulacrals and attached by the greater part of the aboral surface permanently or temporarily to some outside object. Oral covering plates three, one large plate next to the anal area with two smaller adjacent ones."

He also characterized the Agelacrinitidae (1936, p. 15) as having a "theca as in the Hemicystitidae except that the plates covering the oral area are small, numerous, and without any definite order."

According to our analysis, the peristome in *Hemicystites* and related genera now included in the Hemicystitidae is covered by four plates. In addition to the three mentioned by Dr. Bassler, they include a fourth in the right posterior region. This plate was

described and figured in *Carneyella pileus* by Dr. Foerste (1914, p. 429; pl. 1, fig. 5a), who referred to it as plate "X" and classified it as part of the posterior interambulacrum. Foerste's account of this plate is quoted in the previous article under the center heading of "Peristomial region."

The new edrioasteriod has more than four plates covering the peristome. Unlike the Agelacrinitidae, however, it has the covering plates arranged in a definite pattern. The plate corresponding to Foerste's plate "X" in *Carneyella pileus* is large, conspicuous,and seems to be a definite part of the peristomial region.

To accommodate the new genus, we believe the description of the family Hemicystitidae should be emended to read as follows:

> Attached edrioasteroids with sacklike, cylindrical, or discoidal thecae composed of distinct plates. Peristome covered by four or more plates, of which four have a definite arrangement. Three meet in the center of the peristomial region; of these, one lies over the posterocentral part of the peristome, and the other two in the left anterior and right anterior positions, one on each side of ambulacrum III. The fourth, unpaired, lies in the right posterior part of the peristomial region. Proximally, ambulacrum V is constricted where it extends along the right side of this plate. Floor plates of ambulacra uniserial.

TIMEISCHYTES, n. gen.

Type species.—Timeischytes megapinacotus, n. sp.

Description.—Attached, discoidal. Ambulacra short, straight, broad. Ambulacra I and II joined together at the left side of the peristomial region, and ambulacra IV and V at the right side. Peristome covered by more than four plates. Posterior half of peristome covered by several plates, of which one is central and the unpaired plate lies in the right posterior corner. Ambulacrum V extending along the right edge of the latter, not symmetrical to ambulacrum I. Interambulacra with very few plates. Peripheral ring large, shaped like the frustrum of a cone, composed of a few large, thick plates with numerous small, scalelike plates on their distal surfaces and edges.

Remarks.—The new genus is very similar to *Hemicystites*, from which it differs in having several plates in the posterior half of the peristomial region instead of only two. It also has fewer interambulacral plates.

We have not considered the size of the anal pyramid, the number of plates in the anal pyramid, the exact number of plates in the interambulacra, nor the small size of the new edrioasterioid to be generically significant.

The name of this genus is an anagram of *Hemicystites*, a genus which it closely resembles; it is also based on the Greek τιμηεις ("precious, prized, costly"), in view of the efforts expended in finding the paratype, and χυτος, m. ("a mound"), referring to its shape.

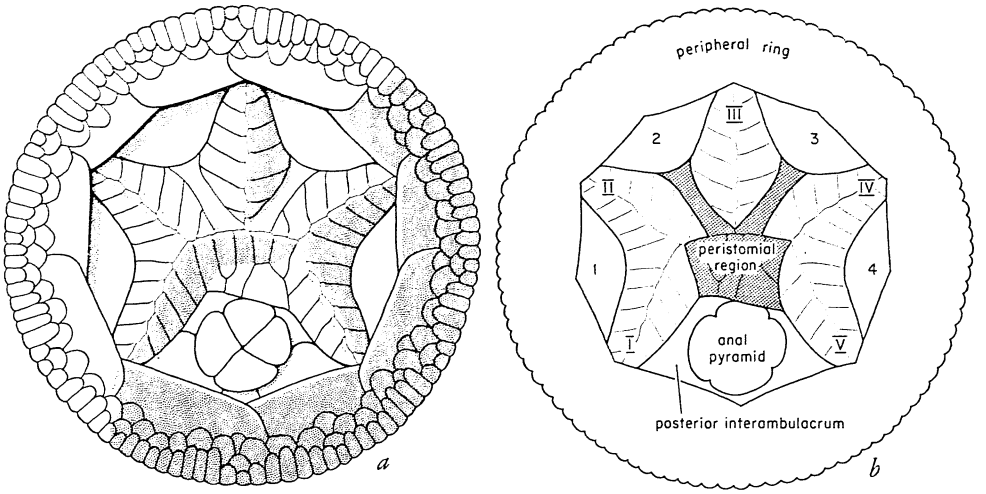
TIMEISCHYTES MEGAPINACOTUS, n. sp.
Pl. 121, figs. 1–6; text-fig. 1

Theca.—Very small, discoidal, attached. Peripheral ring wide. Ambulacra and peristomial region very large in relation to the interambulacra, together forming a modified, dilated pentacle within the peripheral ring. Anal pyramid large. Plates of the theca slightly granular, none highly ornamented but a few faint ridges on some interambulacrals.

Ambulacra.—Each ambulacrum short, straight, very broad proximally, tapering rather abruptly. Distal end subround, tangent to the peripheral ring or extending a little way under its edge. Ambulacra not sharply differentiated from the peristomial region. Ambulacrum I confluent with II, and ambulacrum IV with V. Center lines of I and II joined to the left end of the transverse center line of the broad peristomial region; these of IV and V joined to the right end. Center line of III extending posteriorly a short distance to the center of the peristomial region.

Ambulacral covering plates arched or vaulted upward toward the center line of the ambulacrum at an angle of about 30 degrees. Upper edges of plates turned slightly upward and beveled to form a narrow, more or less flat surface along each side of the center line.

Each ambulacrum covered by four or five plates on one side more or less alternating with four or five on the other side. Each covering plate subquadrate, with the following exceptions: on the anterior sides of II and IV, the proximal plate subtriangular and much smaller than the adjacent plate; the two posterior plates of III very small, subtriangular; the plate shared by I and II and the similar plate shared by IV



TEXT-FIG. 1—*Timeischytes megapinacotus*, n. sp. *a*, reconstruction in oral view, based on the holotype and paratype; The proximal plates of ambulacra II–IV are drawn to agree with those of the holotype. *b*, labeled diagram of parts of the theca. The left posterior, left anterior, right anterior, and right posterior interambulacra are designated 1–4. The left posterior, left, anterior, right, and right posterior ambulacra are designated I–V, in accordance with common practise of numbering the ambulacra in a clockwise (solar) direction around the posterior interambulacrum.

and V large, subquadrate except for their acuminate inner ends; and terminal plates in each ambulacrum subtriangular. The proximal plate on the right side of I extending to the posterior interambulacrum, its right edge terminating anteriorly at the junction of the center lines of I and II. On the anterior sides of II and IV, the proximal one or two plates truncated by the peristomial region, not extending to the interambulacrum. On each side of III, the proximal one or two plates similarly truncated by the peristomial region (text-fig. 1). The proximal plate on the left side of V abutting against the right posterior (unpaired) peristome covering plate, not in contact with the posterior interambulacrum.

Interambulacra.—Interambulacra 1–4 each covered by one large sublunate or sublinguiform plate. Proximally, the plates of interambulacra 2 and 3 with a slightly smaller radius of curvature than those of 1 and 4 (pl. 121, fig. 5).

Posterior interambulacrum about half covered by the circular anal pyramid. Five plates around the anal pyramid (pl. 121, fig. 5): a small subtriangular plate at the right anterior side of the pyramid; a slightly larger plate at the left anterior; two large, subtrapezoidal, anteriorly acuminate plates, one at the left posterior and the other at the right posterior side; and a small subquadrate, narrow plate at the posterior.

Peristomial region.—Region broad, large, not distinctly differentiated from the ambulacra, divided into anterior and posterior parts by a long transverse center line extending from the junction of the center lines of ambulacra I and II at its left end to that of the center lines of IV and V at its right end. The two limbs of this transverse line forming an angle of about 160 degrees. Center line from ambulacrum III extending a short distance posteriorly to its junction with the center of the transverse line, forming an angle of about 100 degrees with each of its limbs.

Anterior part of the peristome covered by two large, elongate, subpentagonal plates, one situated on each side of ambulacrum III in an interambulacral postion. Each of these plates with its posterior side along the transverse center line, its two long, slanting sides nearly parallel, and its distal side abutting against the large interambulacral plate. The juncture of the two plates in this part of the peristome very short, along the extension of the center line of ambulacrum III.

Posterior part of the peristome asymmetrical, covered by six plates. Of these, only three extend to the posterior interambu-

lacrum. Plate over the posterocentral part of the peristome elongate, its anterior end abutting against the middle of the transverse center line and in contact with both anterior convering plates of the peristome; posterior half of this plate offset slightly toward the left. To the left of this plate, a smaller subtriangular to spatulate plate in contact with the transverse center line but not extending to the posterior interambulacrum. Between this plate and the proximal covering plate of ambulacrum I, an elongate subpentagonal plate in contact anteriorly with the transverse line and posteriorly with the interambulacrum; the posterior part of this plate in contact with the posterocentral covering plate of the peristome. The unpaired right posterior covering plate very large, subtrapezoidal, the only peristome covering plate not in contact with the transverse center line; its posterior border very long adjacent to the anal pyramid, its left border adjacent to the posterocentral covering plate, its anterior border in contact with a small plate of the peristome, and its right border in contact with three plates, one of the peristome and two of ambulacrum V. The other two plates of the region small, subquadrate, located to the right of the posterocentral plate and in front of the large unpaired plate.

Anal pyramid.—Very large, subcircular, quatrefoliated, in contact with the unpaired plate of the peristome. The four plates about equal, meeting in the center of the pyramid, their junctures forming an ×.

Peripheral ring.—Wide, shaped like the frustrum of a cone, its sides set at angles of about 35 degrees. Composed of about ten large, thick plates, slightly overlapping at their junctions but forming a rigid structure, and numerous smaller, thin plates on their distal surfaces and edges. Where smaller plates are missing, the large plates can be seen to extend to or nearly to the base of the theca.

Dimensions.—Holotype about 4.5 mm. in diameter; paratype about 4 mm.

Remarks.—The only two specimens that have been found are each attached to bryozoa that are encrusting a coral, *Depasophyllum adnetum* Grabau. This occurrence suggests that the larval edrioasteroids may have selected corals for attachment in order that they might avoid the accumulation of sediment, toxicity from decaying matter, or competition for food on the sea floor. The porous and uneven surface of the bryozoan colony may have offered favorable conditions for attachment to the larval edrioasteroid.

This edrioasteriod is unique in having the anal pyramid in contact with the peristomial region and in having four of the interambulacra each covered by a single plate.

We have considered the possibility that these specimens are immature, and that the adults may have differed in some characteristics. However, the plates in the specimens are well formed, with distinct boundaries and junctions, very unlike the plates in immature edrioasteroids we have studied. We believe, despite their very small size, that the edrioasteroids described above are fully developed adults.

The trivial name of the species is derived from Greek μεγας ("large, great") and πίναξ, m. ("plate, platter"), and refers to the form of the interambulacral plates.

Types.—Holotype, UMMP No. 35392. Paratype, UMMP No. 35428.

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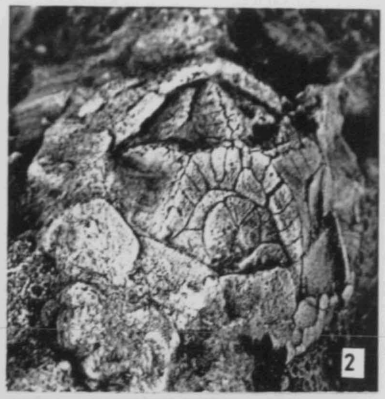
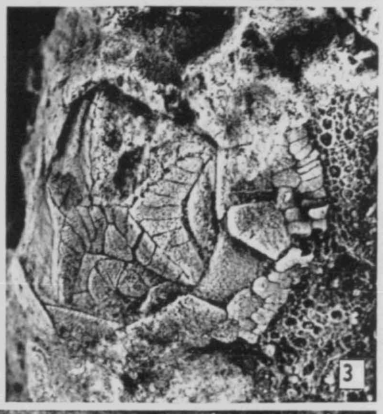
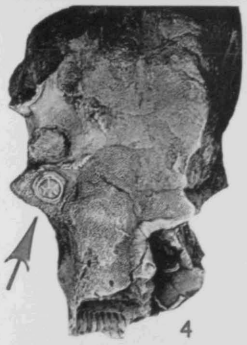
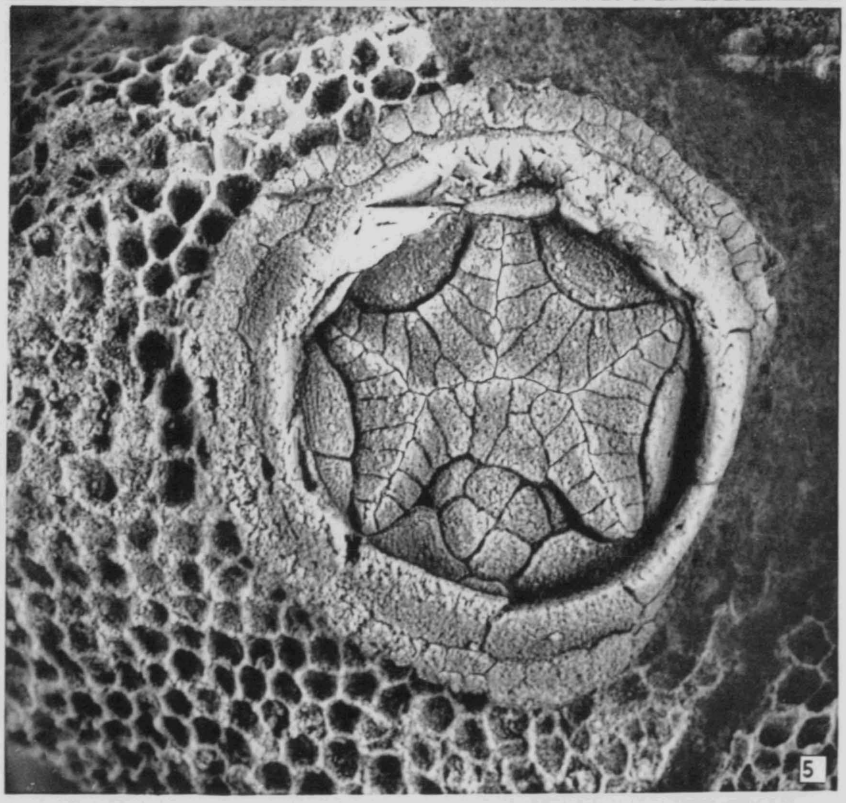
EXPLANATION OF PLATE 121

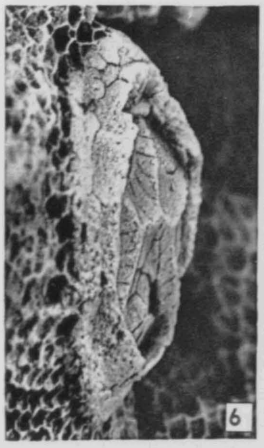
FIGS. *1–6*—*Timeischytes megapinacotus*, n. sp. *1–3*, holotype, UMMP No. 35392; the left side of the specimen, including interambulacrum 1 and parts of ambulacra I and II, were covered by matrix; when this matrix was removed, the plates were plainly visible when the specimen was wet, but are obscured by the very thin coating of sublimate used for the photographs. *1*, oral view, ×20; *2*, inclined posterior view, ×10; and *3*, inclined right view, ×10. *4–6*, paratype, UMMP No. 35428, an excellent specimen but with the proximal edge of the peripheral ring broken in the anterior region. *4*, oral view of the specimen (in the left central part of the picture, above the arrow) attached to a bryozoan colony encrusting a coral, *Depasophyllum adnetum* Grabau, ×1; *5*, oral view, ×20; and *6*, inclined left view, ×12½.

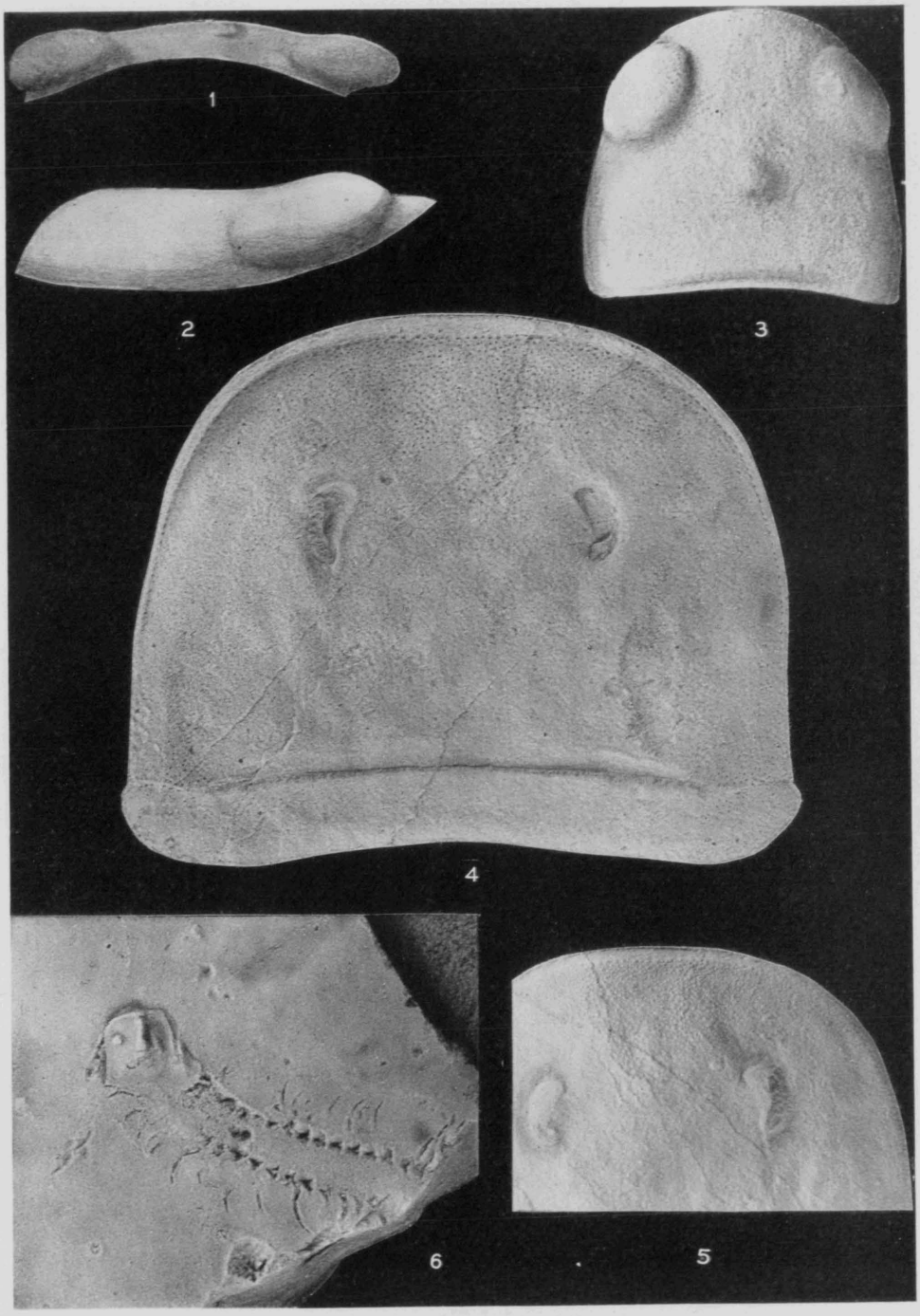








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