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## Edrioasteroids (Echinodermata) of the Maquoketa Formation of Iowa

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B. M. BELL, H. L. STRIMPLE, and C. O. LEVORSON (New York State Museum, Albany, NY). Edrioasteroids (Echinodermata) of the Maquoketa Formation of Iowa. *Proc. Iowa Acad. Sci.* 83(1): 23-27, 1976. Two specimens of edrioasteroids have been found in the Maquoketa Formation, Richmond Group, Upper Ordovician of Iowa. This occurrence extends the geographic range of both genera, *Isorophus* Foerste (1917) and *Edriophus* Bell

(1975) into Iowa which is the westernmost occurrence of these genera formerly recorded only east of Illinois. *Isorophus* was found in a horizon essentially barren of fossils but *Edriophus* is coexistent with more common echinoderms of the Maquoketa, including the crinoid genera *Carabocrinus* and *Porocrinus*. INDEX DESCRIPTORS: *Isorophus*, *Edriophus*, Maquoketa Formation, Winneshie County.

Edrioasteroids are extremely rare in Middle and Upper Ordovician rocks of Iowa and surrounding areas with only two specimens represented in the large collections of echinoderms under study, both of which are from the Maquoketa Formation. *Isorophus cincinnatiensis* is from a horizon 8 to 12 feet above the *Isotelus* zone of the Elgin Member, or in midsection of Bed 2 of Parker, Dorheim and Campbell (1959). This horizon is essentially barren of fossils other than rare parts of *Calymene* and fragments of an unidentified orthocone cephalopod. *Edriophus levis* on the other hand is from a highly fossiliferous horizon including crinoids (*Carabocrinus*, *Porocrinus*, and others), a few feet below midportion of the Fort Atkinson Member (Bed 11 of Parker, Dorheim and Campbell, 1959.)

Both species are attached to rock matrix, possibly "hard ground." It might be thought that additional specimens have been overlooked because of their small size and unusual mode of living and preservation, and many probably are; however, all of the collectors involved in the present undertaking are very aware of edrioasteroids and other similarly attached echinoderms (eg. cyclocystoids). Holdfasts including *Lichenocrinus* have been recovered but appear to have a preference for small elevations on the sea bottom such as a brachiopod shell or an orthocone shell.

The two genera, *Isorophus* and *Edriophus*, have previously been reported only east of Illinois which makes this the westernmost occurrence of the genera.

### SYSTEMATIC PALEONTOLOGY

Class EDRIOASTEROIDEA Billings, 1858

Order ISOROPHIDA Bell, 1976

Suborder ISOROPHINA Bell, 1976

Family ISOROPHIDAE Bell, 1976

Genus ISOROPHUS Foerste, 1917

Type Species: *Isorophus cincinnatiensis* Roemer, 1851

Diagnosis: Isorophidae with; ambulacra curved, I-IV counterclockwise, V clockwise; ambulacral coverplates form a double, alternating biseries; ambulacra of moderate width in proportion to thecal diameter, with gradual distal taper; interambulacral plates of moderate size, squamose and imbricate.

Discussion: A comprehensive synonymy and revised description of Foerste's genus is given in Bell, 1976. The Isorophidae are characterized by: domal thecae with plated oral and nonplated aboral surface;

ambulacra in which the food grooves are enclosed between a uniseries of trough-shaped floorplates and multiple biseries of movable coverplates which roof the food groove; ambulacra devoid of passageways to interior of the theca; each ambulacral tunnel connected only by its proximal opening into the central lumen of the oral frame; oral area of non-movable coverplates which hide the oral frame; oral area with four large primary orals, two pairs of lateral shared coverplates, one large hydropore oral and several secondary orals; oral frame, which encompasses the proximal end of the gut, formed by the enlarged proximal plate of each of the five ambulacra, commonly in conjunction with inward extensions from the overlying oral covering plates; hydropore structure in the right posterior part of the oral area, adjacent to the proximal posterior edge of ambulacrum V; hydropore opens along junctions between the edges of the relatively few plates which form the structure; hydropore unit forms a low hump in the right posterior part of the central oral rise with which it is semi-confluent; interambulacra formed by squamose and imbricate plates; anal structure valvular, with two circlets of triangular plates; margin of oral surface a peripheral rim in which the plates of the more proximal circlets are geniculate.

The Isorophidae are most easily separated from the only other family of Isorophina by their simple multiple biseries of ambulacral coverplates, which contrasts with the cyclic coverplate series found in the Agelacrinitidae Chapman (1860). All Isorophina are set apart from the Lebetodiscina Bell (1976) by the absence in the Isorophina of coverplate passageways into the theca along the length of the ambulacra and by the presence of a valvular anal structure; the Lebetodiscina are characterized by ambulacral coverplate passageways and an anal periproct. Isorophina differ from members of the suborder Cyathocystina Bell (1976), which have a somewhat similar anal structure and also have ambulacra without passageways, in that the latter have only a single, not multiple, biseries of ambulacral coverplates. The order Isorophida is most quickly differentiated from the order Edrioasterida by the structure of the ambulacra, because Edrioasterida have biserial floorplates with sutural passageways connecting the ambulacral tunnel with the thecal cavity.

The highly curved ambulacra of *Isorophus*, which distally became concentric with the proximal margin of the peripheral rim, readily separate this genus from the closely related genera of Isorophidae, *Isorophusella* Bassler, 1935, *Hemicystites* Hall, 1852 and *Rectitriordo* Bell, 1976, which have straight or nearly straight ambulacra. *Curvitriordo* Bell, 1976, the only remaining genus placed in the Isorophidae at this time, is distinguished by having a triple biseries of ambulacral coverplates, versus the double biseries of *Isorophus*.

Range and Occurrence: Species belonging to the genus *Isorophus* as described in Bell, 1976, have been reported from the Maysville and Richmond Groups, Upper Ordovician of Indiana, Ohio, and Tennessee. The occurrence of the specimen described here extends the range

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into the Maquoketa Formation, Richmond Group, Cincinnati Series, Upper Ordovician of Iowa.

*Isorophus cincinnatiensis* Roemer, 1851  
Text-figure 1, plate 1, figs. 1, 2.

**Diagnosis:** An *Isorophus* with: moderate to large thecal diameter, commonly between 20 and 25 mm; five or more secondary orals; primary ambulacral coverplates distinctly larger externally than secondaries; secondaries rarely reach adradial suture line externally; interambulacral of moderate size in proportion to thecal diameter.

**Discussion:** A complete synonymy and revised description of *Isorophus cincinnatiensis* (Roemer) is given in Bell, 1976. This species is separated from the others included in the genus by the relatively large size of the adult theca, and the relatively small size of the secondary coverplates of the ambulacral series. In other species the secondary coverplates commonly reach the adradial suture line, externally, especially in the proximal parts of the ambulacra, because these plates approach the size of the primaries.

**Specimen:** University of Iowa specimen number SUI 38969, Elgin Member, Maquoketa Formation, Richmond Group, Cincinnati Series, Upper Ordovician. Road cut on east side of SE 1/4 sec. 2, T. 96 N, R. 8 W., Winneshiek County, Iowa. Collected by A. J. Gerk.

The specimen measures 14.2 mm axial by 12.9 mm transverse diameter and shows the entire oral surface of the theca, which was attached directly to a firm substrate that may have been a hardground. However, the theca is not well preserved and plate boundaries are mostly questionable. As commonly happens with edriasteroids, the theca has collapsed against the substrate. The oral-ambulacral structures, supported by underlying floorplates, form abnormally high ridges, and the proximal margin of the peripheral rim is sharply elevated above the interambulacral areas, because the larger rim plates are geniculate and remain upright with their bases resting on the substrate. The anal valve is also raised, forming a conical mound. The theca has slumped laterally and this has expanded the left half of the rim and compressed the right side by stacking the rim plates almost vertically. The right posterior half of the theca has been partially dissolved. Secondary dolomite marks the location of some plate boundaries, and irregularly covers the remainder of the right posterior half of the theca, as well as nearly all of the peripheral rim. The plates of the oral area have been largely obliterated, but the general shape of the central oral rise is retained. The hydropore structure cannot be recognized. Ambulacral coverplates are preserved in parts of ambulacra I-IV, although these elements have been somewhat disrupted by lateral shifting during thecal collapse. Sutures are clear only in the proximal part of III. Plate boundaries are also tentatively identified in the distal part of III and proximal part of IV. (Text fig. 1). First appearances suggest the coverplates are well preserved in the distal part of ambulacrum II. However, close inspection reveals multiple fracturing of these plates which make impossible the separation of plate boundaries from cracks. Interambulacral plates are preserved in interambulacra 1, 2, and 3 and plate outlines are suggested by the form of the secondary dolomite in 4 and 5. The anal valve is also marked by secondary dolomite, although the plates have been completely dissolved. Anal plate boundaries are tentative. Plates of the peripheral rim are best preserved along interambulacrum 3, but they are nearly hidden in plate 1, fig. 1 because of the vertical state of the rim.

Enough diagnostic characters are preserved to allow placement of the specimen in *Isorophus cincinnatiensis*, although only with some doubt. Ambulacra III and IV are well enough preserved to conclusively show that the specimen belongs to the suborder Isorophina and thus the only Ordovician family, the Isorophidae. The presence of what appears to be a valvular anal structure also supports this conclusion. The ambulacral disposition narrows the choice to either *Isorophus* or *Curviriordo*, and

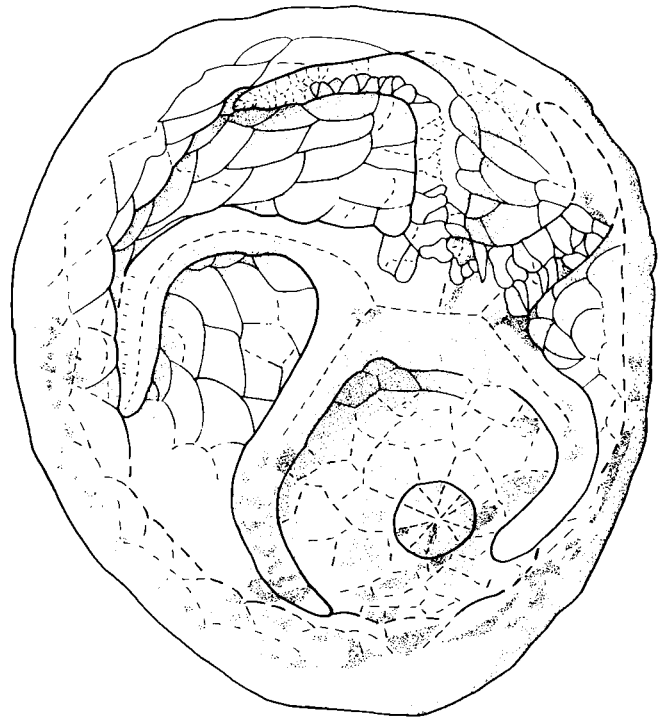


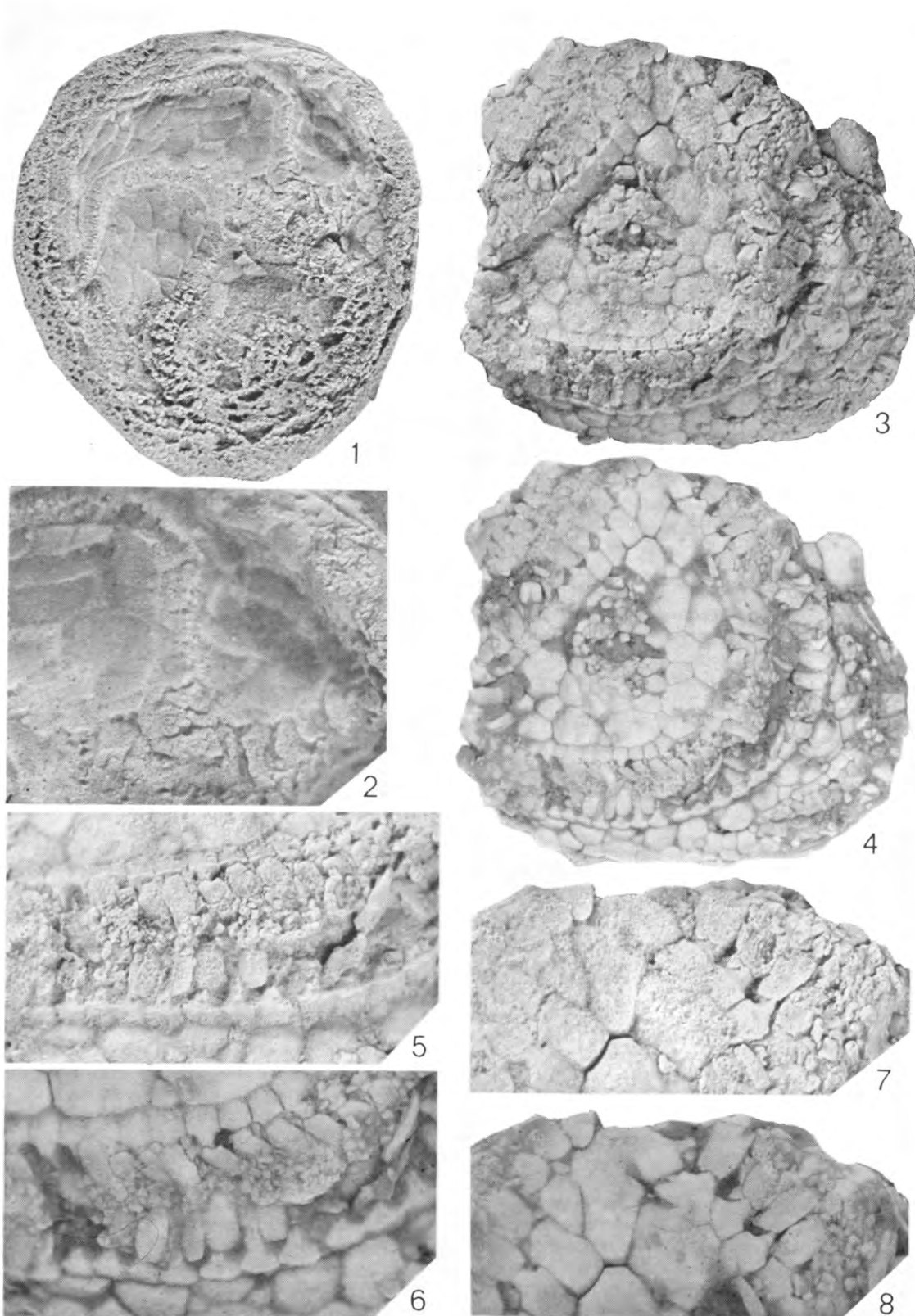
Figure 1.  
*Isorophus cincinnatiensis* (Roemer), 1851.  
SUI 38969. Oral surface. See plate 1, figure 1.

the coverplates in the proximal part of ambulacrum III with little doubt show a double biseries, which excludes *Curviriordo*. The moderate sized interambulacral of this specimen excludes its placement in one of the three species now recognized as belonging to *Isorophus* (see Bell, 1976), i.e. *I. warrenensis* (James), 1883 which has relatively large interambulacral. The moderately large size of the theca excludes the small *I. austini* (Foerste), 1914. The moderate length of the ambulacra of this specimen suggest it is not a full grown adult and thus supports the conclusion that this individual belongs to a relatively large species. All observable features thus bespeak *I. cincinnatiensis*. It is not impossible that better preserved specimens will reveal traits which would place this individual in a new species, because of the rather poor preservation of the individual. But, there is no evidence to support this possibility.

Plate 1

- 1-2. *Isorophus cincinnatiensis* (Roemer), 1851.  
SUI 38969. Specimen whitened with ammonium chloride.
  1. Oral surface, X5.
  2. Oral area and proximal parts of ambulacra II-IV, X10.
- 3-8. *Edriophus levis* ? (Bather), 1914.  
SUI 80011.
  3. Oral surface, whitened with ammonium chloride, X2.5.
  4. Oral surface, in methal alcohol, (X2.5).
  5. Hydropore structure, whitened with ammonium chloride, X5.
  6. Hydropore structure, in methal alcohol, X5.
  7. Distal section of ambulacrum V, whitened with ammonium chloride, X5.
  8. Distal section of ambulacrum V, in methal alcohol, X5.

EDRIOASTEROIDS



Range and Occurrence: *Isorophus cincinnatiensis* ranges from the Middle Ordovician Trenton Group through the Richmond Group of Indiana, Ohio, and Tennessee (Bell, 1976). This specimen extends the occurrence of the species into the Richmondian Maquoketa Formation of Iowa.

Order EDRIOASTERIDA Bell, 1976  
 Family EDRIOASTERIDAE Bather, 1898  
 Genus EDRIOPHUS Bell, 1976  
 Type Species: *Edrioaster levis* Bather, 1914

Diagnosis: An Edrioasteridae with: globoid theca with invaginated base; oral plates similar to and continuous with ambulacral coverplates; right posterior plate of hydropore structure apparently fused to proximal posterior floorplate of ambulacrum V; ambulacra curved, I-V clockwise; ambulacral coverplates form a single alternating biseries, each coverplate perradially elevated.

Discussion: A complete synonymy and description of *Edriophus* and the type species *Edriophus levis* (Bather) are given in Bell, 1976. Edrioasterid species are characterized by: globoid theca with an invaginated base, plates of oral surface extend past ambitus to form a basal invagination which surrounds a small nonplated aboral surface, distal margin of the oral surface a flexible membranous collar, imbedded with minute platelets, collar extended down to and was attached to the substrate; oral frame formed by ten compound plates which include numerous ambulacral floorplates and five modified proximal interambulacral; hydropore structure located in the posterior part of the oral area, formed by two plates; hydropore opening elongate perpendicular to the suture line and penetrating both plates; ambulacra formed by: 1) biserial floorplates with sutural passageways all along the length of the ambulacra, passageways extend from the ambulacral tunnel into the thecal cavity; and 2) by biserial coverplates which rest on top of the floorplates and leave the adradial part of each floorplate exposed on the oral surface. The globoid theca with invaginated base and the biserial, partly exposed floorplates which have sutural passageways are both readily observable features which together allow rapid differentiation of edrioasterid species from those belonging to the Isorophida which have domal, discoidal or clavate thecae and uniserial ambulacral floorplates which are entirely hidden from view and do not have sutural passageways.

*Edriophus* is one of only three genera in the family Edrioasteridae, the only family in the order Edrioasterida. It is easily recognized by the clockwise curvature of all five ambulacra, in contrast with *Dinocystis* Bather, 1898, in which the ambulacra all curve counterclockwise and *Edrioaster* Billings, 1858, with ambulacra I-IV counterclockwise and V clockwise. A complete synonymy and description of *Edriophus* and the type species *Edriophus levis* (Bather) are given in Bell, 1976.

*Edriophus levis* (Bather), 1914  
 Text-figure 2, plate 1, figs. 3-8.

Diagnosis: An *Edriophus* with: theca large, adults commonly 40 mm in diameter; approximately ten oral covering plates, with four central orals apparently larger than other orals; orals raised perradially to form a small ridge along the oral midlines; oral frame formed by five compound interradial oral frame plates, partly exposed externally, and five compound radial frame plates which lie in part below the interradials; radials in contact around the inner edge of the frame rim; ambulacral coverplates are perradially elevated to form a distinct perradial ridge; proximal side of perradial end of each coverplate produced proximally as a small lobe; interambulacral large, polygonal, tessellate; periproct formed by several irregular circlets of plates, central elements larger, elongate; thecal plates smooth.

Discussion: Only one species other than *Edriophus levis* has been

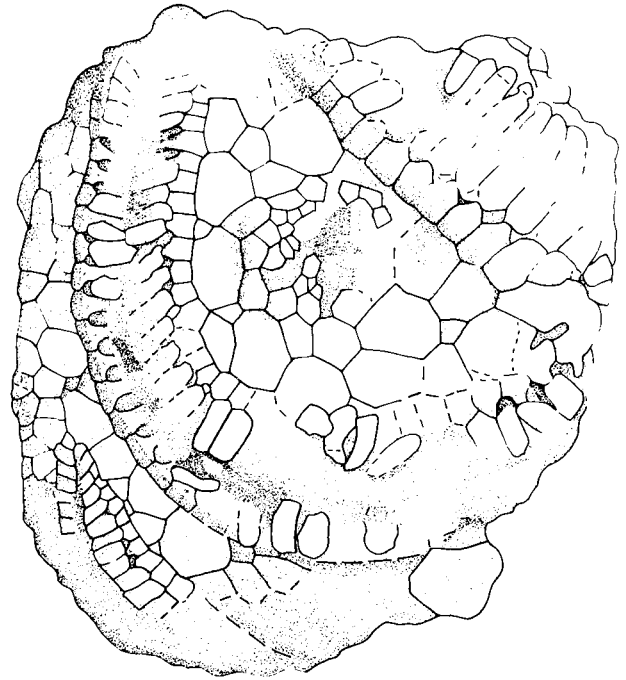


Figure 2.  
*Edriophus levis* ? (Bather), 1914.  
 SUI 80011. Oral surface. See plate 1, figure 3-4.

assigned to the genus, *E. saratogensis* (Ruedemann), 1912, and the assignment is only with question because there are few specimens and these are not well preserved. ?*E. saratogensis* is believed to be a small species with adult thecal diameters from 10 to 17 mm. Thecal plates may be finely pustulose in that species.

Specimen: University of Iowa specimen number SUI 80011, Fort Atkinson member, Maquoketa Formation, Richmond Group, Cincinnati Series, Upper Ordovician. Road cut on south edge of Fort Atkinson, at the North Center line, Section 10, T. 96 N., R. 9 W., Winneshiek County, Iowa. Collected by C. O. Leverson.

The specimen measures 25 mm axial by 28.5 mm transverse diameter and preserves about one-third of the supra-ambital part of the oral surface. It includes the proximal part of ambulacrum I, most of ambulacrum V and a small distal segment of ambulacrum IV. Interambulacrum 5 is nearly complete and a few plates from interambulacra 1 and 4 remain. The interambulacral component of the posterior interradial plate of the oral frame is also preserved. Adjacent to its right posterior margin is the hydropore oral plate. None of the rest of the upper side of the oral surface remains. The reverse side of the specimen shows only a few disarticulated plates.

The ambulacral segments preserve both coverplates and floorplates. Coverplates form a single biseries, although they are mostly collapsed down into the ambulacral groove and have shifted laterally somewhat, so they no longer exactly overlie the floorplates as in non-deformed specimens. Moreover, the adradial corners of these plates have been broken in many places, which gives the appearance of small accessory plates along their zone of contact with the underlying floorplates. The perradial parts of the coverplates are nowhere well enough preserved to confirm or reject the notion that there exists the central coverplate ridge which is characteristic of *E. levis*.

The ambulacral floorplates are preserved in various states. As is typical of *E. levis*, the adradial section of each floorplate is exposed on the oral surface. The upper surface of this adradial part slopes downward from the adradial ends of the coverplates to the adradial suture line, which is the junction of the floorplates with the interambulacral plates. As with the coverplates, the floorplates are in a biseries with contiguous plates on opposite sides of the perradial suture alternately disposed. The partial disruption of the coverplates exposes parts of the floorplates normally hidden from external view along the upper lateral edges of the ambulacral tunnel. Large passageways extend from the ambulacral tunnel down into the theca along the sutures between contiguous floorplates. The upper ends of these passageways seem a bit larger than those of other specimens of *E. levis*, but this may be preservational and of no significance. There is also a small shallow pit formed in the upper lateral surface of each floorplate. The pit lies just perradial to the contact line between the adradial end of the overlying coverplate and the underlying floorplate. The pits are approximately in line with the adradial edges of the upper ends of the large subjacent floorplate passageways. These small pits, located along the zone of articulation of the coverplates with the floorplates and thus presumably related to articulation, have not been observed before.

The hydropore is a slit-like opening which penetrates two plates: 1) the large interambulacral part of the posterior interradial plate of the oral frame; and 2) an adjacent modified interambulacral which is fused to at least the proximal posterior floorplate of ambulacrum V. The opening is unequally shared by the two plates, with about two-thirds of the opening cut through the anterior one. Remnants of a raised rim around the opening are preserved. The posterior hydropore plate appears to have been pushed slightly out of line with the anterior plate.

Interambulacral plates are large, thick, polygonal and tessellate. One of the interambulacrals, in the left proximal part of interambulacrum 5, suggests that their exterior surface may have been nodose.

Part of the anal periproct is preserved in interambulacrum 5, slightly offset to the left of center.

The limited nature of the specimen precludes confident identification. The biserial ambulacral floorplates with sutural passageways, the polygonal biserial coverplates, and the hydropore which penetrates plate stereom establish that the specimen belongs to the family Edrioasteridae of the order Edrioasterida. The ambulacral curvature of I, IV, and V curving clockwise, excludes two of the three genera known to belong to the Edrioasteridae, *i.e.*, *Dinocystis* with all counterclockwise ambulacra and *Edrioaster* with I-IV counterclockwise and V clockwise. Whereas the direction of curvature of ambulacra II and III is unknown in this specimen, there is no evidence to suggest it was not clockwise, and thus the specimen is thought to belong to the genus *Edriophus* with all 5 ambulacra clockwise. Moreover, the posterior hydropore plate is fused to at least the proximal most floorplate of the posterior side of ambulacrum V, another feature previously observed only in *Edriophus*.

The specimen also seems to agree in most aspects with the features of *Edriophus levis*. The only other described species, *E. saratogensis*, is small and poorly known. Among those features preserved, three are not in agreement with known features of *E. levis*: 1) the presence of a small pit centered on each floorplate along its articulation zone with the overlying coverplate; 2) the somewhat unusually large upper openings of the floorplate passageways; and 3) the questionable possibility of nodose prosopon. However, the first may occur in *E. levis* and merely have been overlooked previously, and the last two may be entirely preservational. The specimen is therefore thought to be an *E. levis*, but some question must remain.

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