A NEW SILURIAN OPHIUROID FROM THE WEST OF IRELAND

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Abstract

Silurian echinoderms from Ireland are poorly known; hitherto, only three nominal species have been described, all crinoids and all from the Telychian (Upper Llandovery, Lower Silurian) Kilbride Formation in County Galway. A new species from this formation, *Crepidosoma doylei,* is the first recorded Irish Silurian ophiuroid (brittle star). The new species is described from five articulated specimens; all are mouldic and none retains a counterpart. The disc and immediately adjacent arm lateral ossicles of the new species differ in shape from those of the type species in that these ossicles are comparatively flat rather than angular or ridged, and the series is marked by a well-defined channelway that appears to have extended from within the disc for the full length of the free arm. Ambital framework ossicles are smooth, and not S- or Z-shaped and ridged as in the type species. The new specimens of *C. doylei* were recovered from distal storm deposits that are thought to be deep-water equivalents of Benthic Assemblage Zone 5 (*Clorinda* Community).

Keywords: Kilbride Formation, Llandovery, systematics, Benthic Assemblage Zone 5, *Crepidosoma*

Introduction

The Silurian echinoderms of the British Isles are diverse (Lewis *et al*. 2007; Donovan *et al*. 2009-2012a) and there are several sites worthy of the appellation *Konservat Lagerstätte* (Donovan *et al*. 2012b), whereas a paucity of echinoderms has been recorded from the Silurian rocks of Ireland. Only three species have been described hitherto, all crinoids and all from the Telychian (Upper Llandovery) Kilbride Formation of western Ireland: the myelodactylid disparid *Myelodactylus hibernicus* Donovan and Sevastopulo, 1989; the flexible cladid *Cryptanisocrinus kilbridensis* Donovan *et al*., 1992; and the large columnal morphospecies *Segmentocolumnus* (col.) *clarksoni* Donovan and Harper, 2003. The first two of these species are only known from single specimens that are external moulds without counterparts. We are thus loathe to term the Kilbride Formation an echinoderm *Lagerstätte* as it palls in comparison with truly echinoderm-rich horizons from the British Isles (and elsewhere), most notably with the 70+ nominal species known from the Much Wenlock Limestone Formation of the Dudley district, West Midlands of England (Donovan *et al*. 2008, table 2). This scarcity in terms of diversity still remains evident when comparisons are drawn with more modest sites, such as the Telychian North Esk Inlier, Midlothian, south-west Scotland (see relevant papers in Clarkson *et al*. 2007), and the rarity of specimens renders the search for new Irish Silurian echinoderms all the more exciting and potentially rewarding. Herein, we describe *Crepidosoma doylei* sp. nov., the first ophiuroid recorded from the Silurian of Ireland. These specimens were preserved in deep-water, distal storm deposits from a remote, mountainous area of the borderlands between counties Galway and Mayo.

Geological setting

Highly fossiliferous Silurian rocks crop out in the Galway-Mayo borderlands in western Ireland, the most western of the Lower Palaeozoic inliers of the Midland Valley of Scotland and Ireland (Clarkson and Harper 2016). On the Kilbride peninsula, in the eastern outcrops of the region, the Upper Llandovery marine rocks expose diverse, changing assemblages of benthic (invertebrate) animal communities developed against a sustained marine transgression (Williams and Harper 1988) and already known for their locally abundant crinoid faunas (see above). The lowest parts of the sequence consist of shallow-water communities in coarse-grained siliciclastics dominated by bivalve and gastropod associations along with vertical burrows (possibly representing *Skolithos* ichnofacies). Shell-beds packed with the rhynchonellide brachiopod *Eocoelia* are developed stratigraphically higher in the succession (Doyle *et al*. 1991), while in the middle part, diverse coral faunas are preserved by thin volcaniclastic surge deposits interbedded within green siltstones. Other faunas are developed at around the same level, some with large crinoids (Donovan and Harper 2003) and others in which large, coarse-ribbed brachiopods related to *Dolerorthis* are common. At a number of horizons, the rich faunas were actually suffocated by the volcaniclastics, which are now exposed as spectacular mass mortality surfaces (Harper *et al*. 1995). The top of the upper Llandovery sequence is dominated by deeper-water associations with the brachiopod *Clorinda,* together with small horn corals and trilobites, which pass upwards into red mudstones containing a micromorphic fauna of brachiopods, the marginal *Clorinda* community (Doyle *et al*. 1990), surviving in more oligotrophic conditions. Between 10 to 20km further to the west, age-equivalent rocks representing the upper part of the Kilbride Formation are found to be poorly fossiliferous (Doyle 1994), with uncommon storm-generated shell-beds containing low-diversity faunas with the brachiopods *Eoplectodonta* and *Coolinia* forming thin, but persistent, shell concentrations (Harper and Doyle 2003). Farther west still, around Lough Muck on the Atlantic Coast, the succession continues from the Llandovery into the Wenlock, and is marked by regression and culminates in red beds with dispersed horizons packed with lingulid brachiopods.

The ophiuroids described herein are from the upper part of the Kilbride Formation (Telychian) exposed in the western outcrop, immediately west of the Maam Fault complex (Fig. 1), and specifically from the mountain locality of Munterowen (see Doyle 1989 for location information). The siltstones and mudstones exposed at this locality contain a shelly fauna commonly concentrated in thin shell beds (Harper and Doyle 2003) and they comprise Facies G of Doyle (1994). These represent the deepest water conditions, locally, in the Kilbride Formation and are probably equivalent to Benthic Assemblage Zone 5 (*Clorinda* Community) of various authors. The shells beds are interpreted as winnowed lags, in the distal storm belt. The Kilbride ophiuroids are essentially complete and undistorted, although accessory spinelets and granules are missing. The ophiurian skeleton consists of many relatively small skeletal ossicles imbedded in a dermal tissue; although specimens of many species are typically sturdy enough to resist initial disturbance, ossicles will be quickly dispersed with tissue decay. Thus, the ophiuroids of the Kilbride Formation would appear not to have been seriously disturbed by either physical events (such as sediment reworking) or scavengers after their initial burial.

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Systematic palaeontology

Interpretation of material

Incomplete specimens of five ophiuroids are available, all mouldic, and including no counterparts. Specimen orientation, whether it is the dorsal (aboral) or ventral (oral) surface that is exposed, can be determined based on expression of the ambulacral column together with mouth frame configuration; three of the new specimens show the dorsal surface and two the ventral (Fig. 2). The surfaces of asterozoans differ sufficiently to challenge inferences of same taxon correspondence among specimens lacking counterparts, and because none of the five exposes both surfaces, assignment to a single taxon is considered here.

All specimens were from a single restricted locality, Munterowen (see above and Fig. 1), and all are similar in size. On those specimens in which a portion of the disc remains, plating and expression of ambital framework ossicles are similar regardless of the surface exposed. Ambital framework ossicles, as recognised here, are equivalent to the ‘marginals’ of many earlier usages; specifically these are the ossicles of ophiuroids judged not homologous with the marginals of asteroids, and therefore a separate term is used (Blake and Guensburg, 2015). Arms of all specimens are more or less elliptical or ovate, and broadest at the disc edge. Although the morphology of ambulacrals and laterals, as exposed on the two surfaces, differ in detail, variation is judged within limits reasonable for a single taxon. Laterals on opposite sides of a few arms appear to differ, being broad and rectangular on one side, but small and seemingly recurved on the other (compare, for example, Fig. 2b and Fig. 2g); however, partially exposed arm margins reveal that the laterals are deflected enough to obscure their shapes. As noted under the taxonomic section, orientation and shape have been emphasized in evaluation of taxon affinities (Jell and Theron 1999). Laterals exposed in dorsal aspect bear a distinct elongate grooving not found on those in ventral aspect; comparable expressions are found in other encrinasterid ophiuroids (Fig. 3). Together, these criteria are deemed sufficient to justify the assignment of all available specimens to a single species.

***Insert Fig. 2 around here** – please allow one full page for the image, and place the figure caption on either the top or bottom of the adjacent (facing) page.*

***Insert Fig. 3 around here** – please allow one full-page width.*

Taxonomic assessment of the new fossils

Taxonomic arrangements and rankings of genera of Palaeozoic Ophiuroidea are still evolving, and views on character significance vary; comprehensive reviews of earlier research were provided by Spencer (1914, 1930), Spencer and Wright (1966) and Shackleton (2005). Potentially fundamental is the positioning of the ambulacral ossicles across the arm midline. Whereas among varied early asterozoans, positioning was more or less irregular, definite offset and definite pairing of ambulacral ossicles emerged early in ophiuran history, with the paired ossicles becoming fused during ophiuran phylogeny to form so-called 'vertebrae'. Interpretation of the significance of the two arrangements has verged on recognition of two class-level taxa (Sollas and Sollas 1912; Spencer 1914, p. 52; Hotchkiss 1976), whereas Shackleton (2005) recognised a single class, which included both expressions. The offsets of alternating ambulacrals occur in a plesiomorphic ‘aabab’ pattern that embeds information on homologies of individual rays between echinoderm classes (Hotchkiss 1978, 1995). Ossicles are offset in the Encrinasteridae, including the new Irish specimens described herein.

A class-level partitioning of traditional Ophiuroidea was proposed by Schöndorf (1910), which recognised the class Auluroidea and was built around the lysophiurinid family Encrinasteridae, as later recognised by Spencer and Wright (1966). In a detailed discussion, separation of Auluroidea as a taxonomic group was rejected by Spencer (1914), whose argument is accepted here, although Kesling (1964) subsequently revisited this notion.

Spencer (1930, p. 401) recognised and described three families originally considered new: the Euzonosomatidae, Cheiropterasteridae and Protasteridae; the first two were subsequently recognised as synonyms of the Encrinasteridae (Spencer and Wright 1966), and the Protasteridae was credited to Miller (1889). Later treatments of encrinasterids include Harper and Morris (1978), Haude (1995, 1999), Jell (1997), Jell and Theron (1999), Shackleton (2005) and Blake *et al*. (2015). Spencer and Wright (1966, p. U83-U87) separated the Encrinasteridae from the Protasteridae based in part on presence of subventral laterals in the Encrinasteridae (p. U84), which "commonly" have a broad, transversely elongate “oral” (or ventral) face with curved ossicular boundaries. The disc margin “commonly” is bound by enlarged ossicles. In protasterids (Spencer and Wright 1966, p. U87), the laterals wrap around the arms to form side shields and no "well-developed" edging (i.e., ambital framework) is present in this family. Based on the reconstructions of Spencer and Wright (1966, figs. 74, 75), neither form nor positioning of laterals or arm shape is consistently developed. Certain encrinastereids, as recognised, lack ambital framework ossicles, whereas these are present in the genus *Bohemura*, which was assigned to the Protasteridae.

A new encrinasterid genus and subfamily, *Armathyraster* Harper and Morris, 1978, and the Armathyrasterinae were recognised, and those authors were of the view that *Cheiropteraster* Stürtz, 1890, and *Loriolaster* Stürtz, 1886, might be separated based on the form of the disc and ambulacral ossicles. The homonym *Marginaster* Haude, 1995, was replaced by *Marginura* Haude, 1999, and both it and *Euzonasoma* were aligned in the subfamily Euzonosomatinae Spencer (1930) [Further note that *Marginura* was later replaced by *Marginix* Martinez and del Rio, 2015, because the former was a junior homonym of an arthropod]. Based on the presence of an unplated dorsal disc extended nearly to the arm tips, ambulacral shape and absence of lateral spines, Jell (1997) recognized the Cheiropterasteridae and assigned a new genus, *Vandelooaster*, to the family. *Schoenaster* Meek and Worthen, 1860, was considered to be a "virtually unrecognizable" possible synonym of *Euzonasoma* (Spencer and Wright 1966, p. U86), whereas, based on new material, the genus was redescribed and assigned to the Encrinasteridae by Jell (1997). Jell and Theron (1999) proposed *Hexuraster*, replacing the preoccupied name *Hexura* Spencer, 1950, and assigned the genus to the Cheiropterasteridae. Jell and Theron (1999) wished to synonymize *Euzonosoma* with *Encrinaster*, arguing that Spencer (1930) separated the two based on apparent relative width of the laterals, whereas Jell and Theron (1999, p. 165) noted that apparent ossicular width "may often be influenced by the attitude in which a specimen is buried". Authors are now beginning to exploit ambulacral outline in taxonomic interpretation (e.g., Hunter and McNamara 2017), but such comparison for encrinasterids is not attempted here because of the concerns raised by Jell and Theron (1999) together with the limited available data.

In a phylogenetic study focused on Ordovician asterozoans and based on single species, Shackleton (2005) assigned three genera, *Mastigactis*, *Encrinaster* and *Euzonasoma*, to the Encrinasteridae, generic separation based largely on ambulacral form and accessory development. Blake *et al*. (2015) recognised the new Devonian encrinasterid *Ophiocantabria*, its overall appearance superficially suggestive of the asteroid *Xenaster*.

Descriptively, but usefully, lysophiurinids may be divided into two groups of genera:

those that are relatively delicate and therefore quite unlike the new Irish fossils (e.g., *Cheiropteraster*, *Loriolaster*, *Armathyraster* Harper and Morris, 1978; *Hexuraster* Jell and Theron, 1999) and the more robust forms (which include *Encrinaster*, *Euzonasoma*, *Crepidosoma* and *Ophiocantabria* Blake *et al*., 2015). Although assigned to the Protasteridae by Spencer and Wright (1966, p. U87), the overall configuration of *Bohemura* Jaekel, 1903 (see also Petr 1989), including presence of an enlarged ambital framework, is similar to the new fossils, as are *Marginura* Haude, 1999 (now *Marginix*) and *Haughtonaster* Rilett, 1971.

Class Ophiuroidea Gray, 1840
Order Oegophiurida Matsumoto, 1915
Suborder Lysophiurina Gregory, 1897
Family Encrinasteridae Schuchert, 1914

Remarks

The family Aspidosomatidae was first proposed by Gregory (1899) for *Aspidosoma arnoldi* Goldfuss, 1848, the familial concept based on offset ambulacral ossicles, presence of enlarged 'marginal' (i.e., ambital framework) ossicles, and depressed interradial areas. Schuchert (1914) substituted the name Encrinasteridae, pointing out subsequently (Schuchert 1915, p. 241) that the name *Aspidosoma* was preoccupied; his 1915 diagnosis was based on ambulacral shape in ventral aspect and expression of the 'marginalia'. The diagnoses of both of these workers were brief and interpretation of the new specimens here is developed largely around the later assessments of Spencer (1930, 1934), Spencer and Wright (1966) and Harper and Morris (1978). The subfamilial partitioning of Harper and Morris (1978) is pertinent to the interpretation of the new Irish fossils, and therefore their diagnosis for Encrinasterinae is reproduced below.

Subfamily Encrinasterinae Schuchert, 1914 (sensu Harper and Morris, 1978).

Diagnosis (of Harper and Morris 1978, p. 156).

> “Small- to large-sized ophiuroids; ambulacral ossicles alternating, commonly with boot-shaped oral surfaces; adambulacral [=lateral] ossicles subventral, composed of heavy plates continuous in a radial direction, with broad oral surfaces, often bearing rows of pustules, and commonly with curved sutures producing rope-like twists; disc large, with well-developed interrays, commonly bounded by stout frame of marginal ossicles; podial basins supported by ambulacrals and adambulacrals [=laterals], tending toward size reduction laterally”.

Remarks

In evaluation with the diagnosis of Harper and Morris (1978), the ambulacrals in ventral aspect are more nearly triangular than boot-shaped in the Irish material (Fig. 2g), the outline reflecting whether the transverse bar separating sequential podia is placed approximately at the centre of the ossicle, as interpreted here, or at the proximal extremity. The traditional term 'lateral' rather than 'adambulacral' is used here because the latter term assumes homology with asteroids (Blake 2014; Blake and Guensburg 2015). The notion of a subventral positioning for these structures is found in the familial diagnosis of Spencer and Wright (1966, p. U84). Laterals of encrinasterids were robust, projected laterally, and seemingly subject to significant taphonomic displacement; literature evaluation and interpretation of the specimens described herein leads to an interpretation of a more typical ophiuran lateral rather than a subventral positioning for the lateral ossicles of encrinasterids. It is important, however, that the lateral positioning recognised in the new material is essentially consistent with that of many previously illustrated specimens, regardless of nuance of interpretation of life positioning. The remainder of the subfamilial diagnosis of Harper and Morris (1978) is consistent with the new fossils.

Genus *Crepidosoma* Spencer, 1930

Diagnosis

Encrinasterid with an ambital framework; ossicular number and form differs among species. The mouth frame is comparatively weak and proximal ambulacrals do not overlap.

Remarks

In his key to encrinasterids (then termed "Euzonosomatidae"), Spencer (1930, p. 404) separated *Euzonosoma*, *Encrinaster* and *Mastigactis* from *Crepidosoma* and *Urosoma* based on whether or not (respectively) the first pair of ambulacrals overrides the second pair. The non-overriding *Crepidosoma*-*Urosoma* expression is recognised in one of the available Irish specimens (Fig. 2d, E). *Crepidosoma* in turn was differentiated from *Urosoma* based on presence of 'marginalia' (here, ambital framework ossicles) in the former taxon; two species of *Crepidosoma* were originally recognized by Spencer (1930) with newly proposed *C. doylei* potentially adding a third to the group, but see *Remarks* under the species description.

Subsequently, Spencer and Wright (1966, p. U86) limited their diagnosis of *Crepidosoma* to "Like *Euzonosoma* but mouth frame weaker." This interpretation remains consistent with Spencer's (1930) earlier perspective, and also with the apparently redrafted illustrations of the later contribution (Spencer and Wright 1966, see their fig. 74). Jell and Theron (1999, p. 163), in favouring synonymising *Euzonasoma* with *Encrinaster*, appear to implicitly challenge the concept of *Crepidosoma* as well. After reviewing the complexities of earlier terminological usages, Jell and Theron (1999) argued that Spencer (1930, pp. 404-405) distinguished *Encrinaster* and *Euzonasoma* based on just a single feature, the relative lateral ossicular breadth, which for taphonomic reasons, they 'suggest' (p. 165) is equivocal. The expanded diagnoses of Spencer and Wright (1966, pp. U85-86) for these genera were not treated by Jell and Theron (1999). Nine species were assigned to an expanded *Encrinaster* by Jell and Thereon (1999, p. 163); however, neither generic nor familial diagnoses were provided, and comparisons were not made with other encrinasterids *sensu* Spencer and Wright (1966). Given limited documentation and the uncertainties of Jell and Theron (1999, for example their use of the term ‘suggest’), *Euzonasoma* and therefore *Crepidosoma* are retained here, while recognizing the need for comprehensive re-evaluation based on all available specimens.

Crepidosoma doylei sp. nov.

Figure 2

Etymology

In honour of our colleague, Dr. Eamon N. Doyle, who collected the specimens described herein when he was a research student.

Material

All specimens are deposited in the National Museum of Ireland (Natural History), prefix NMING. Three specimens exposed in dorsal aspect, the holotype (NMING:F34763; Fig. 2a, b), consisting of the disc, a much disrupted mouth frame and portions of four arms, one nearly complete; paratype (NMING:F34765; Fig. 2d, e), consisting of about half of the disc, a partially preserved mouth frame, one nearly complete arm and the stub of a second; paratype (NMING:F34767; Fig. 2c), consisting of the terminal with part of a single arm. Two specimens exposed in ventral aspect, paratype (NMING:F34764; Fig. 2f, g), consisting of the disc with a largely disrupted mouth frame (although portions of this structure remain, they are highly ambiguous) and portions of four arms, two nearly complete; and paratype (NMING:F34766; Fig. 2h, i), consisting of most of the disc largely obscured by dorsal disc ossicles, most of two arms, one obscured by dorsal ossicles, and the base of a third arm.

Diagnosis

Disk and arm laterals positioned immediately beyond ambital framework ossicles not angular in transverse section. Dorsal surface of each lateral grooved longitudinally, grooves of sequential ossicles aligned to form a well-defined channelway on the disc (Fig. 2b, blue arrow) and appearing to extend full arm length. Ambital framework ossicles relatively flat and somewhat irregular in form, the ossicles themselves are not strongly S- or Z-shaped.

Description

Ambulacral ossicles robust, offset across arm midline; ambulacrals slightly longer than wide (Fig. 2a, b). In ventral aspect, the medially-placed transverse ridge separates sequential podial positions forming a triangular ossicular outline (Fig. 2f, g). In dorsal aspect, proximal and distal extremities flared to form enlarged depressions for inter-ossicular articular tissues, the articular depressions bordered by ridges; medial portion of ossicles depressed (Fig. 2b). As viewed dorsally, laterals can be quite closely linked to ambulacrals (Fig. 2b, left of view) or, alternatively, ossicular positioning can be somewhat dilated, the curvature suggesting the confines of the dorsal perimeter of the podia (Fig. 2b, right of view). These two configurations probably approximate degrees of natural flexure. Ambulacral ventral longitudinal articular tissue depressions more subdued than those of dorsal surfaces; transverse ridge positioned medially, basin margins separating successive podia evenly curved.

In dorsal aspect, lateral ossicles of bowed, approximately rectangular outline, the convex curvature proximal (Fig. 2c); arm outline elliptical to ovate, the widest ambulacrals approximately at the disc margin (Fig. 2f, h). Medial portion of dorsal surfaces of successive laterals bearing a conspicuous longitudinal channelway; both adjacent (adradial and abradial) lateral surfaces raised, bearing uniform, rounded pustules, these more or less aligned in a double series; pustules better preserved adradial to the channelway in available specimens (Fig. 2c; see also Fig. 3). Dorsal abradial lateral margin convexly rounded, adradial margin concave, forming a portion of the podial edging, each basin margin shared between successive laterals, the articular ridge extending toward the ambulacral located distally on the ossicles and not bisecting the basin edge.

In ventral aspect (Fig. 2f-i), as in the dorsal view, laterals appear subrectangular, curved or arched distally; a prominent, triangular, articular ridge extends from about the midpoint of the adradial margin to the ambulacral, the ridge flared to form an apparent podial margin; the edge of the transverse ridge appears rimmed and bears small pustules. The surface of the exposed face is weakly and uniformly pustulate; the distal margin bears a row of discrete pustules, about six in number in the largest midarm laterals.

Ambulacral column preservation approaching the disc does not allow clear determination of differentiation of either ambulacrals or laterals in the proximal arms. In ventral aspect (Fig. 2h, i), mouth frame ossicles were clearly robust, but preservation is poor; in dorsal aspect (Fig. 2d, e), the more or less Y-shaped configuration of mouth angle ossicles [MAO] and immediately adjacent ossicles typical of ophuroids are clear; the first ambulacrals beyond the MAO do not appear to significantly override the next ambulacrals.

The ambital margin of each interbrachium (Fig. 2b, f, h, i) is bordered by three or four enlarged plate-like ossicles of differing sizes, which are irregular, subrectangular, polygonal and articulated. The ambital margin series appears to have been oriented approximately perpendicular to the lateral series and does not curve as the lateral series is joined. The remainder of the disc is plated with small, flat, irregularly polygonal, weakly imbricated ossicles, these extending over the arms and disc during life. All disc and edging ossicles appear weakly granulated. A hydropore is not recognised.

Remarks

The disk and arm laterals located immediately beyond the ambital framework of the type species of *Crepidosoma*, *C. wenlocki*, as described and illustrated by Spencer (1930, p. 430 fig. 276, pl. 27.5), are angular, an expression not developed in *C. doylei*. The dorsal surface of laterals of *C. doylei* are grooved longitudinally, the grooves of sequential ossicles aligned to form a well-defined channelway that occurs on the disc (Fig. 2b, blue arrow) and appears to have extended the full length of the arm. Laterals of the two species also appear to differ in specifics of shape. Spencer also stressed ambital framework configuration in *C. wenlocki*; the dorsal appearance of those particular ossicles abutting the laterals is S- or Z- shaped, the ossicular surfaces are ridged and this ridging appears accentuated in Spencer (1930)'s photograph (pl. 27.5). Although the preservation of the new Irish material is admittedly not good, the corresponding ossicles appear to have been relatively flat, plate-like and perhaps irregular in form, rather than S- or Z- shaped. Three ambital framework ossicles occur in each interradius of *C. wenlocki* Spencer, 1930, whereas three or four occur in the new specimens.

Spencer (1930, p. 430) listed *Crepidosoma*? *goslariensis* as one of two species of *Crepidosoma*, based on Halfar (1893), who recognized *C. goslariensis* as a "variety" of *Aspidosoma petaloides*, citing Simonowitsch, 1871. Spencer (1930) separated *C*.? *goslariensis* from *C. wenlocki* based on more numerous "disc-marginalia" that were described as "thin … placed very steeply to the plane (of) the arms". The ambital framework ossicles in the seemingly careful reconstructions of "*Aspidosoma petaloides* Simon. var. *goslariensis*" of Halfar (1893, pl. 10) are quite massive and closely abutted rather than thin and steeply inclined, but neither configuration appears similar to the corresponding ossicles of either *C. wenlocki* or *C. doylei*. *C.* ? *goslariensis* also appears to differ in ambulacral and lateral morphology, and therefore *Crepidosma* here is limited to the type, *C. wenlocki*, and *C. doylei*, n. sp.

A longitudinal channel structure similar to that developed on the dorsal surfaces of the laterals of *C. doylei* (Fig. 2b, c, blue arrows) also occurs in the encrinasterids *Ophiocantabria* Blake *et al*., 2015, and *Encrinaster goldfussi* (Fig. 3, blue arrows); the three occurrences differ in relative size of this linear feature. Function of the channelway is not known, although clarity of definition and widespread occurrence implies some significance.

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FIGURES

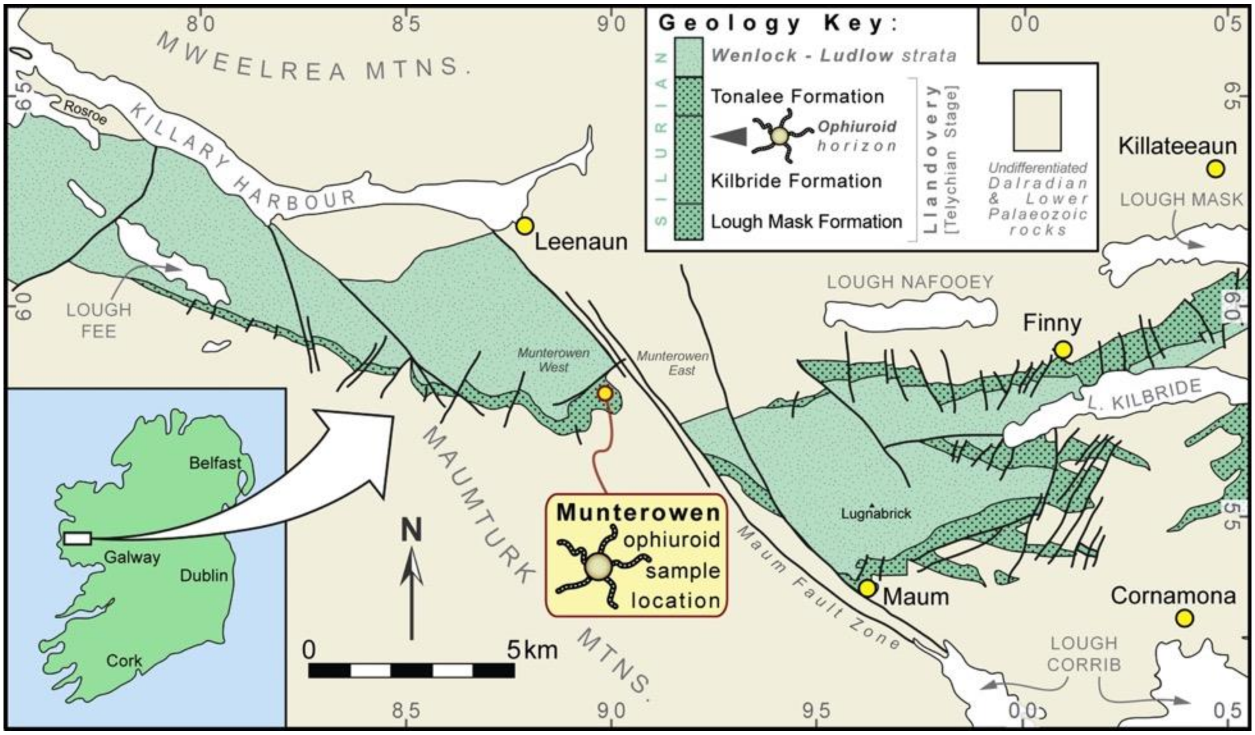
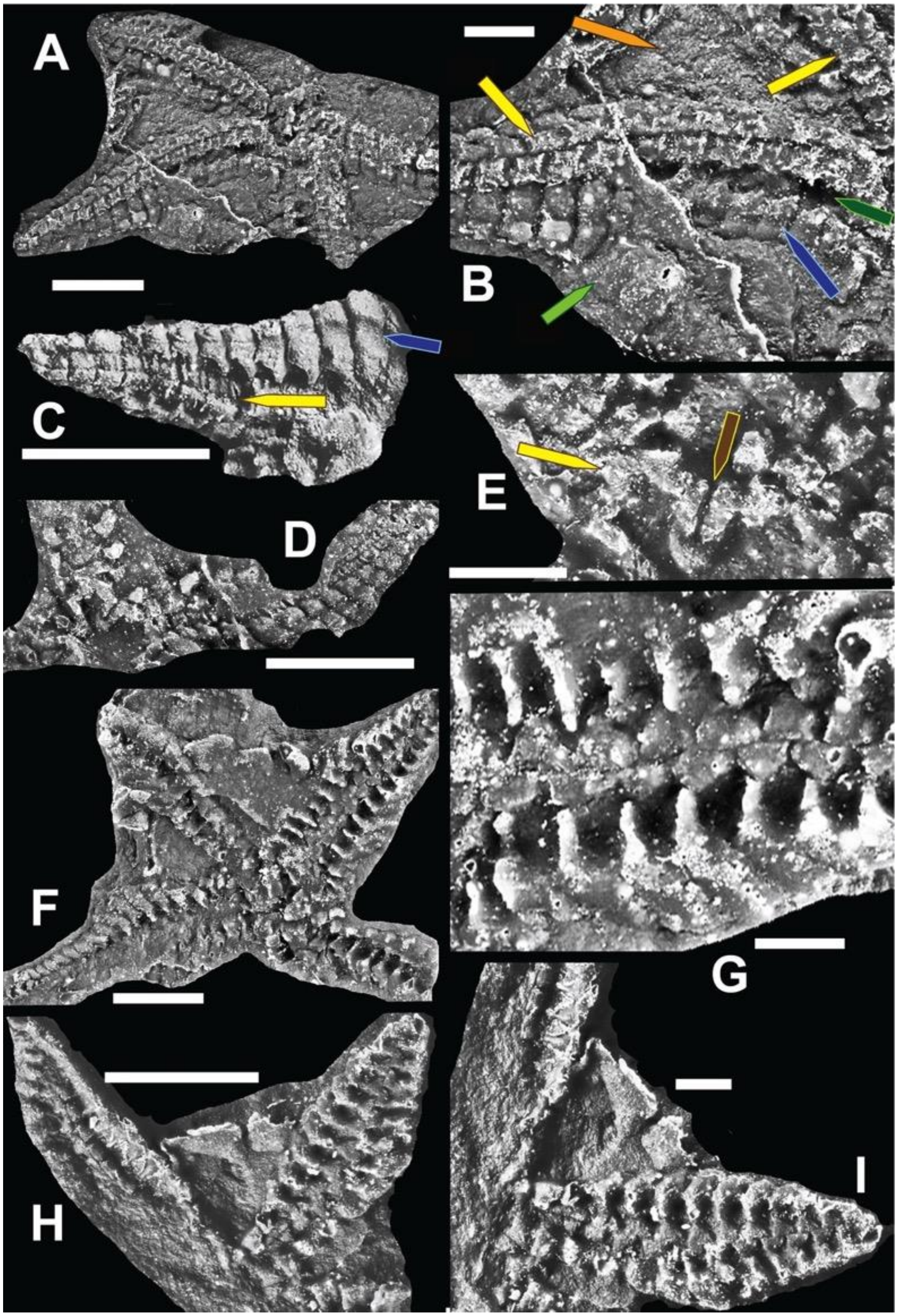


Fig. 1—Outline geological map showing the distribution of Silurian outcrop in the border area between counties Galway and Mayo. The new fossil ophiuroids were recovered from Munterowen, which is located approximately 4.5km south-southeast from the village of Leenaun (see Doyle 1989 for more site information). The approximate stratigraphic position of the ophiuroids is indicated on the inset column and the inset map (bottom left) shows the position of the main geological map in western Ireland. Modified from Harper and Doyle (2003, text fig. 2).

Fig. 2 (next page) —*Crepidosoma doylei* sp. nov. All specimens paratypes unless stated otherwise. **a, b,** NMING:F34763, holotype, dorsal configuration. **a,** overall view, **b,** left arm of (a), ambulacrals (yellow arrows); disk ossicles (orange arrow), ambital framework (light green arrow), longitudinal lateral channelway (blue arrow); dorsal aspect of podial positioning (dark green arrow); mouth frame poorly preserved. **c,** NMING:F34767, arm in dorsal aspect, form of laterals with longitudinal channelway (blue arrow) and ambulacral series (yellow arrow). **d, e,** NMING:F34765, disk region and proximal arms in dorsal aspect, mouth angle ossicles (brown arrow) and disrupted proximal first ambulacrals (yellow arrow). **f, g,** NMING:F34764, ventral configuration. **f,** overall view, ambital framework ossicles in the two upper quadrants, shapes obscured by incomplete exposure and taphonomic disruption, mouth frame largely disrupted; ovate arms broadest approximately at position of ambital framework; **g,** ambulacral and lateral ossicles, positioning of podial basins. **h, i,** NMING:F34766, ventral configuration. **h,** disk and two arms, the unillustrated arm intervals are fragmentary; **i,** upper right arm, ambulacral and lateral ossicles with large podial basins; enlarged ambital framework ossicles in interbrachium. Scale bars for (a, c, d, f, h) represent 3 mm; for (b, e, g, i) they represent 1 mm.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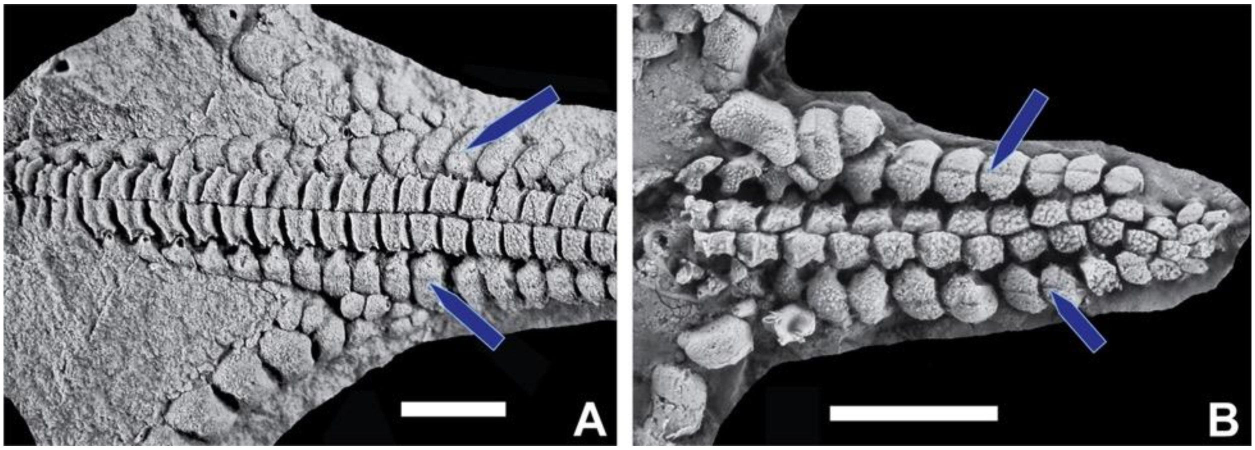

Fig. 3—Comparative morphology among Encrinasteridae, **a,** *Encrinaster goldfussi* (Schöndorf, 1910), Geologisch-paläontologische Sammlung der Universität Marburg, Germany, Mbg 3388, dorsal aspect, longitudinal channelway developed on lateral ossicles (blue arrows) is comparatively weakly developed. [Locality? Horizon? Age?] **b,** *Ophiocantabria elegans* Blake et al., 2015, Museo del Departamento de Geología-Paleontología de Oviedo (Asturias, Spain), DPO 33484, dorsal aspect, longitudinal channelway of lateral ossicles (blue arrows) is comparatively well developed. [Locality? Horizon? Age?] Scale bars represent 3 mm.