



## Comment on supposed holothurian body fossils from the middle Ordovician of Wales (Botting and Muir, *Palaeontologia Electronica*: 15.1.9A)

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### ABSTRACT

Light and SEM study of body fossils from the Middle Ordovician of Wales recently described as the oldest articulated holothurians by Botting and Muir (*Palaeontologia Electronica* Article number: 15.1.9A) finds no traits that allow them to be assigned to the Echinodermata.

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### COMMENT

In a recent paper describing a middle Ordovician (Darriwilian) fauna from Wales, Botting and Muir (2012) assigned some vase-shaped fossils to the echinoderm class Holothuroidea, establishing a new genus and species, *Oesolcucumaria eostre*. While isolated skeletal elements of holothurians first appear at about this time (Reich, 1999, 2001) the fossil record of articulated holothurians is extremely sparse (Smith and Gallemí, 1991; Gilliland, 1993; Reich, 2010a, in press). So this discovery, if correct, has some importance: as the oldest articulated holothurians ever recorded, they could potentially provide critical evidence about the morphology of the earliest members of this class.

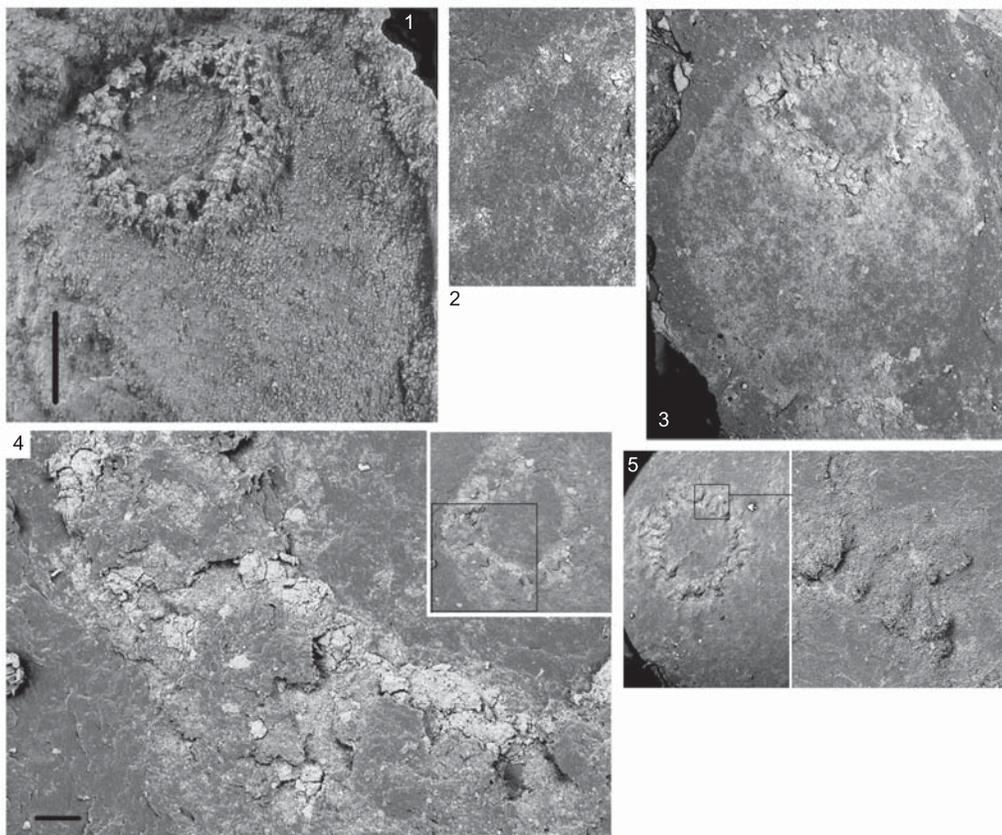
*Oesolcucumaria* was described as having a multi-plated calcareous ring, skeletalized ambulacra, and cruciform dermal sclerites, though these last elements were illustrated only sketchily in the paper. The descriptions were based on light microscopic study of the original fossils preserved as moulds.

We studied the type material (NHM EE.8734, 8736-8739; Figure 1) using low-angle light microscopy but could find no traits that indicate this material has echinoderm affinities. We therefore cast two of the specimens and examined them under light and scanning electron microscopy in order to clarify aspects of its morphology. It is standard practice when studying echinoderms preserved as

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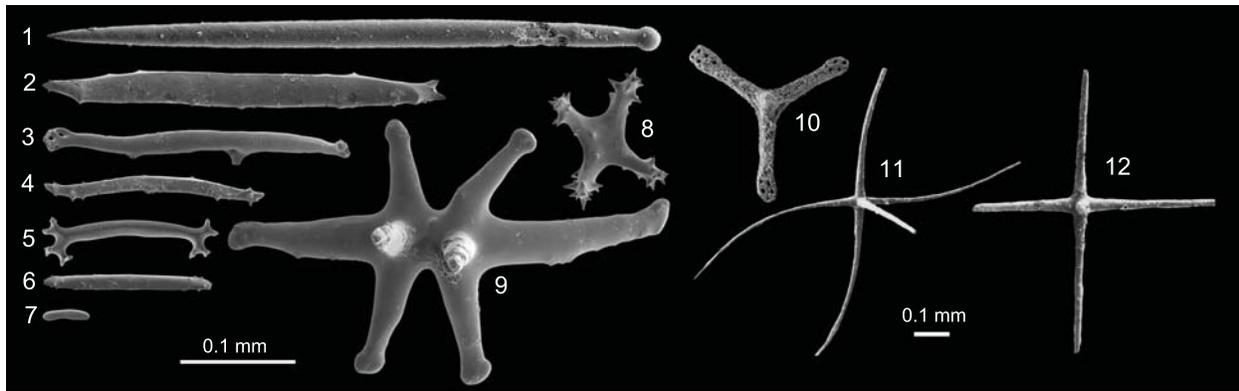
**FIGURE 1.** *Oesolcucumaria eostre* Botting and Muir, 2012, Darriwilian, middle Ordovician of Bach-y-Graig, Llandrindod, Wales. 1-4, NHM EE8734, latex cast of showing the structure of the oral ring. 2, SEM micrograph of the body wall showing fine acicular cruciform spicules. 3, SEM micrograph of body fossil. 4, SEM micrograph of part of the perioral ring (inset shows the complete ring); note the lack of regular structure. 5, NHM EE8739, SEM micrograph of the perioral ring; general view and detail showing granular microstructure. All specimens housed in the Natural History Museum, London. Scale bars: 1 = 1 mm; 4 = 200 µm.

moulds to cast them in latex, as this is by far the best way to reveal details of plating. This is how other early Palaeozoic holothurian mouldic body fossils have been studied by previous authors (i.e., Haude, 1995b; Jell, 2011) and it is latex casts that are illustrated and described in those papers. While it is usual to remove iron oxides from specimens prior to latexing, as the iron oxide fill can obscure details, in this case the specimen was left untreated because of its delicate state of preservation. The latexes were examined under SEM because only at this level of resolution do the details of ossicle microstructure become evident.

A basic synapomorphy of all echinoderms is the presence of a calcitic skeleton with stereom microstructure. In holothurians the body wall skeleton is 'reduced' to small (and mostly) diagnostic platelets and ossicles (Seilacher, 1981; Gilliland, 1993) and only outer test scales, anal plates and calcareous ring elements retain the characteristic

perforate microstructure. The Silurian holothurian *Porosothyone* (Jell, 2011), for example, has a body covered in flat ovoid platelets whose stereom microstructure is clearly apparent under the light microscope. No such elements were found in *Oesolcucumaria*. Elements in the body wall in *Oesolcucumaria* are sparse and difficult to make out under SEM but appear to be very fine, simple, solid, acicular rods or crosses (Figure 1.2), like those found in many Palaeozoic sponges (e.g., Rigby and Gutschick, 1976; Rigby and Toomey, 1978; Schallreuter, 1991; Kozur et al., 1996; Maletz and Reich, 1997; Mehl and Lehnert, 1997; Botting, 2003, 2004; Botting and Muir, 2011). Rod-like and/or cruciform elements do occur in holothurians (Figure 2.2-10) but these are never simple acicular and show branched or perforated flattened or even spinose tips (Figure 2.1, 2.11-12).

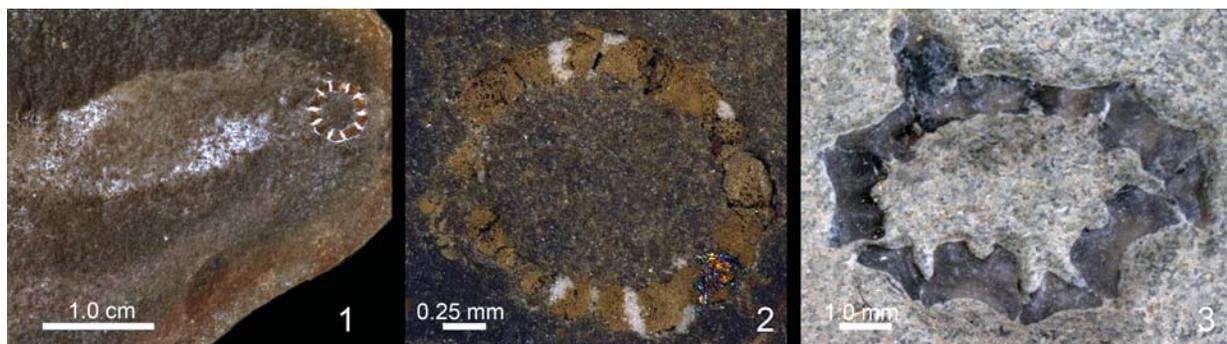
A synapomorphy uniting all holothurians is the presence of a ring of large skeletal elements sur-



**FIGURE 2.** Comparison of rod- and cruciform-like sclerites of sponges (1, 11-12) and holothurians (2-10); 1, fossil isolated tylostyl (Demospongea), Eocene: Ypresian, Wobbanz, Isle of Rügen, Germany, GZG.001251/19 [from Ansorge and Reich, 2004]; 2, 4, 6, 8, Recent *Laetmogone violacea* Théel (Elasipodida: Laetmogonidae), North Atlantic Ocean, water depth 1,015 m, SMNH.110035/110036; 3, Recent *Echinocucumis hispida* (Barrett) (Dactylochirotida: Ypsilothuriidae), Norwegian Sea, water depth 100-300 m, SMNH.110122/110124; 5, Recent *Trochodota purpurea* (Lesson) (Apodida: Chiridotidae), southern Atlantic Ocean, water depth 11-13 m, SMNH.110131/110132; 7, Recent *Chiridota pisanii* Ludwig (Apodida: Chiridotidae), South Atlantic Ocean, water depth 10 m, SMNH.110126/110128; 9, Recent *Elpidia heckeri* Baranova (Elasipodida: Elpidiidae), Arctic Ocean, water depth 2,700 m, SMNH.110012/10013; 10, fossil cross-shaped table of *Tribrachiodemus ordovicicus* Reich (Aspidochirotida: Synallactidae), Late Ordovician (Katian/Hirnantian), Sweden, GZG.INV.20072 [from Reich, 2010b]; 11-12, fossil isolated pentactines (Hexactinellida), early Silurian (Telychian), Sweden, GZG.INV.24436, 24706 [from Maletz and Reich, 1997]. Abbreviations: GZG, Geoscience Centre, Georg-August University of Göttingen, Germany; MHI, Muschelkalk-Museum Ingelfingen, Germany; ROM, Royal Ontario Museum, Toronto, Canada; SMNH, Swedish Museum of Natural History, Stockholm, Sweden.

rounding the pharynx (Figure 3). This calcareous ring acts as an anchor for the anterior section of the water vascular system including the buccal tentacles and also for the longitudinal and (if present) retractor muscles. The ring is composed of 10 cylindrical elements that abut and are arranged with pentaradial symmetry – five radial elements (R) alternating with five interradial elements (IR).

This structure is clearly and unambiguously seen in Palaeozoic holothurian body fossils, such as the Silurian *Porosothyone* (Jell, 2011), the Devonian *Andenothyone* (Haude, 1995b), *Nudicorona* (Haude, 1995a, 1997), and gen. et sp. nov. (Hunsrück Slate, Bartels et al., 1998). In the Carboniferous Mazon Creek Lagerstätte, an undescribed apodid holothurian preserves in addition the diges-



**FIGURE 3.** Holothurian body fossils, showing the preserved calcareous ring of 'standard architecture' with 5 radial and 5 interradial plates, and stereom structure of single elements. 1-2, Undescribed apodid holothurian body fossil with calcareous ring and body wall ossicles *in situ*, late Pennsylvanian Mazon Creek fossil Lagerstätte, Illinois, USA; 1, GZG.INV.50000 showing the calcareous ring and the body outline, 2, ROM.58481 showing the calcareous ring with stereom structure; 3, Undescribed aspidochirotid calcareous ring (Holothuriidae) with well-preserved radial and interradial elements, from a Triassic obrution deposit Lagerstätte in southern Germany, Upper Muschelkalk (Ladinian) MHI.1230 [from Reich, 2004, detail]. Abbreviations as in Figure 2.

tive tract, which is encircled by the circumoral ring at its oral end (Reich and Stegemann, 2010; Figure 3.1). Elements of this ring structure have a distinctive, highly structured morphology and, when viewed under SEM, show always the characteristic stereom microstructure (Figure 4), and this is the case even for isolated ring elements from Ordovician and Silurian deposits (e.g., Reich, 1999; Figure 4.5-8). *Oesolcucumaria*, by contrast, has a large opening with a thickened lip (Figure 1.1, 1.3-5), similar to small hexactinellid sponges figured by Botting et al. (2011, fig. 2G-J). This structure consists of a random, irregular pattern of ridges and sediment-filled pits showing no pentaradial symmetry (Figure 1.4). High-resolution images of this region show a fine granular texture (Figure 1.5) and no trace of stereom could be found anywhere. The style of preservation in *Oesolcucumaria* contrasts with that seen in definitive echinoderms from this horizon where plates preserve traces of a stereom meshwork (see the illustration of the mitrate carpoid *Anatifopsis?* in Botting and Muir, 2012, fig. 5.1).

Botting and Muir (2012, p. 21) suggested *Oesolcucumaria* was related to modern Apodida, based on the presence of 'multiple internodals' (a term which is applicable in crinoids, but not in holothurians) in its multi-plated ring. Palaeozoic holothurians, however, accommodated additional tentacles by adding anterior processes to their 10 ring elements, not by adding additional plates. Modern holothurians in which the total number of calcareous ring elements has been increased to accommodate extra tentacles do occur, but only in advanced Synaptidae in Cenozoic times and always retain clearly differentiated radial and inter-radial elements.

Two additional points are worth noting. Despite preservation of the soft tissue body outline, there is no trace of a digestive tract preserved, and the presence of differentiation of 'ambulacral zones' reported in the original description simply cannot be confirmed. The latter assumption of the authors (Botting and Muir, 2012, p. 21-22) is mainly based on a misinterpretation of the stone canal of *Palaeocucumaria* (Devonian Hunsrück Slate, Germany) in X-radiographs by Haude (1994, 1995a, 2002) and others (Reich and Smith, pers. obs.).

Bold claims need strong evidence. Without evidence for stereom, pentaradial symmetry, diagnostic body wall spiculation or an organized calcareous ring there is no case for assigning

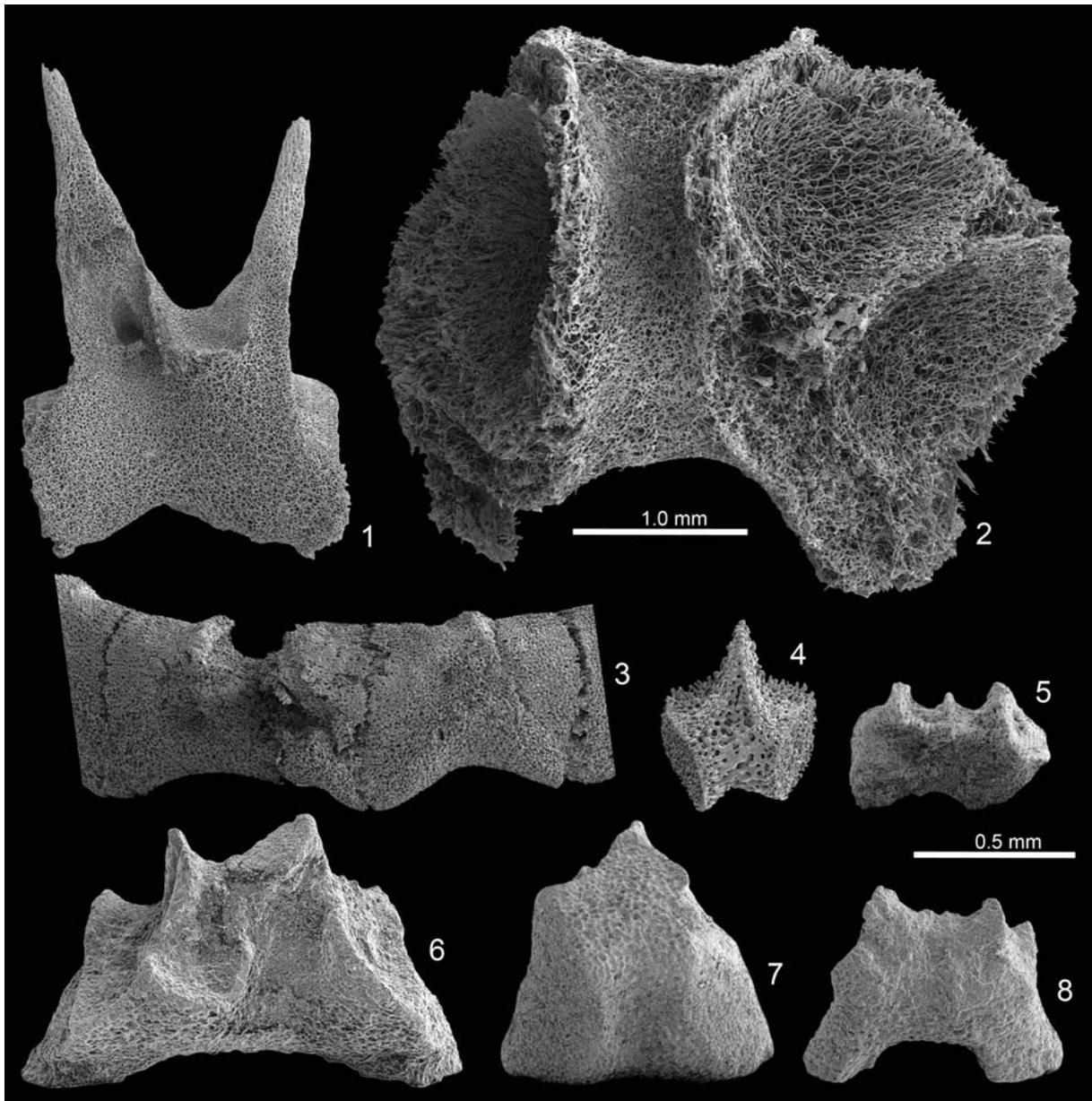
*Oesolcucumaria* to the class Holothuroidea or indeed to the phylum Echinodermata. The fine and delicate cruciform and bipolar acicular needles in the body and a single large circular opening with a strengthened rim seem more indicative of poriferan affinities, though stronger evidence is clearly needed to resolve its true taxonomic affinities.

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**FIGURE 4.** Morphology of modern and fossil holothurian calcareous ring elements showing the typical stereo architecture; 1, outer view of right dorsolateral radial element, Recent *Myriotrochus rinkii* Steenstrup (Apodida: Myriotrochidae), Arctic Ocean, water depth 22 m, SMNH.110016/110019; 2, inner oblique view of a radial element, Recent *Laetmogone violacea* Théel (Elasipodida: Laetmogonidae), North Atlantic Ocean, water depth 1,015 m, SMNH.110035/110037; 3, outer view of an radial (left) and interradial element (right), Recent *Chiridota pisanii* Ludwig (Apodida: Chiridotidae), South Atlantic Ocean, water depth 10 m, SMNH.110126/110128; 4, inner view of an interradial element *Eupyrgus scaber* Lütken (Molpadiida: Eupyrgidae), North Atlantic Ocean, water depth 30-80 m, SMNH.110029/110031; 5, undescribed fossil radial element (stem group Apodida), inner view, middle Ordovician (early Darriwilian), Germany/Sweden, GZG.INV.20001; 6, undescribed fossil radial element (Apodida), outer view, late Silurian (Ludfordian), Gotland, Sweden, GZG.INV.13251; 7, undescribed fossil interradial element (stem group Apodida), inner view, late Silurian (Ludfordian), Gotland, Sweden, GZG.INV.40710; 8, undescribed fossil radial element (Aspidochirotida), inner view, late Silurian (Ludfordian), Gotland, Sweden, GZG.INV.13255. Scale: 1.0 mm (1-2); 0.5 mm (3-8). Abbreviations as in Figure 2.

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