**Supplementary Information**

Rahman IA, Thompson JR, Briggs DEG, Siveter DJ, Siveter DJ, Sutton MD. 2019 A new ophiocistioid with soft-tissue preservation from the Silurian Herefordshire Lagerstätte, and the evolution of the holothurian body plan. *Proc. R. Soc. B.*

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**Description of characters used in phylogenetic analyses**

The following characters are modified from those used in the phylogenetic analysis of [1], which were based in part on [2].

1. Body form: axial area much greater than extraxial area (0); axial area much smaller than extraxial area (1).
2. Growth meridional (0); radial (1).
3. Body vermiform (> 4x longer than diameter); no (0); yes (1).
4. Body with differentiated ventral sole: no (0); yes (1).
5. Position of mouth: terminal (0); subterminal, displaced downwards in dorsoventral differentiation (1); subterminal, displaced to upper surface body, often U-shaped (2).
6. Position of anus (where present): terminal in extraxial component (0); placed laterally in axial region between ambulacra (1); absent (2).
7. Posterior region greatly narrowed and elongated as a tail: no (0); yes (1).
8. Body wall: with large multilayered embedded plates (0); membranous, skeleton reduced primarily to small spicules (1).
9. Presence of wheel-shaped ossicles: no (0); yes (1). May be homologous to spine rudiments as developing spines are initiated as a wheel-like deposit.
10. Presence of spired plates or tables (elements with distinct outgrowth perpendicular to plate surface): no (0); yes (1).
11. Presence of bilaterally symmetrical columns of ambulacral ossicles associated with water vascular system: no (0); yes (1).
12. Location of radial water vessel relative to ambulacral plates: external to ambulacral ossicles (0); enclosed within ambulacral plates (1); on the interior of the test relative to ambulacral plates but not enclosed within them (2). Scored as NA where character #11 is 0.
13. Interambulacral plating present: yes (0); no (1). Scored as NA where character #8 is 1.
14. Number of columns of plates in interambulacral areas: multiple (0); one or two (1). Scored as NA where character #13 is 1.
15. Perradial series of ambulacral plates present: yes (0); no (1). Scored as NA where character #11 is 0, except for *Rotasaccus*.
16. Differentiated, calcified genital plates present above growth zones: no (0); yes (1). Scored as NA where character #8 is 1 (or 0 for *Chirodota* and *Myriotrochus*).
17. Imbrication of test plates: plates imbricating flexibly over one another (0); plates tessellate and abutting (1). Scored as NA where character #8 is 1 (or 0 for *Chirodota* and *Myriotrochus*).
18. Tube feet associated with: single pore (0); double pore (1); multiple small perforations (2). Scored as NA where character #11 or #12 is 0.
19. Ambulacral pores located: between plates (0); spanning across plates (1); within a single plate (2). Scored as NA where character #11 or #12 is 0.
20. Number of columns of plates in ambulacral areas: two (0); more than two (1). Scored as NA where character #11 is 0.
21. Ambulacra arranged into petals: no (0); yes (1). Scored as NA where character #11 is 0.
22. Body wall thickness: standard mesoderm with ossicles (0); thin without calcification (1); thick and gelatinous (2).
23. Presence of articulated spines: no (0); yes (1).
24. Enlarged bottom feeding tentacles: no (0); yes (1).
25. Radial water vessels: absent, tentacles arise directly from aquapharyngeal ring (0); present, but very short (1); present and extensive (2).
26. Radial vessels and tube-feet: uniform along length (0); differentiated into a large-bore proximal part with tentacles and narrow-bore extraxial part (the auxillary vessel) with tube-feet (1).
27. Tentacles (primary tube-feet): simple, unbranched (0); branched, peltate or digitate (1).
28. Tentacle branching style: digitate (0); shield shaped with distal papillae (1); long and branching (dendritic) (2). Scored as NA where character #27 is 0.
29. Calcified tube feet present: no (0); yes (1).
30. Tentacle ampullae: absent or minimal (0); long and hanging into the body coelom (1). Scored as NA where character #27 is 0.
31. Pharyngeal introvert: absent (0); present (1).
32. Calcareous ring present encircling the pharynx: no (0); yes (1).
33. Ambulacral jaw apparatus present: no (0); yes (1).
34. Teeth arranged into battery: no (0); yes (1). Scored as NA where character #33 is 0.
35. Radial calcareous ring elements with posterior projection: no (0); yes (1). Scored as NA where character #32 is 0.
36. Radial calcareous ring elements with notch or perforation: no (0); yes (1). Scored as NA where character #32 is 0.
37. Internal lantern with hemipyramids: no (0); yes (1).
38. Teeth composed of stacked biseries present: no (0); yes (1). Scored as NA where character #33 is 0.
39. Teeth composed of single stack of elements: no (0); yes (1). Scored as NA where character #33 is 0.
40. Radial elements in calcareous ring much longer than wide: no (0); yes (1). Scored as NA where character #32 is 0.
41. Perignathic girdle present: absent (0); present (1). Scored as NA where character #33 is 0, except for *Echinocardium*.
42. Calcified madreporite: absent (0); present, loosely coalesced spicules (1); present as a solid, well-formed button-like plate (2).
43. Madreporite opening: external (0); internal (1).
44. Madreporite consisting of: furrowed opening (0); series of small, circular perforations (1). Scored as NA where character #42 is 0 or 1.
45. Stone canal calcified: no or with spicules only (0); yes, encased by a uniserial or biserial column of plates (1).
46. Position of madreporic plate: adoral, opening close to the mouth in axial region (0); directed away from the mouth and connected by long stone canal (1).
47. Rete mirabile: absent (0); present (1).
48. Respiratory trees outpouching from cloaca: absent (0); present (1).
49. Longitudinal muscles in the body wall: undivided (0); divided (1).
50. Ciliated funnels: absent (0); present (1).
51. Statocysts: absent (0); present (1).

**Supplementary references**

1. Smith AB, Reich M. 2013 Tracing the evolution of the holothurian body plan through stem-group fossils. *Biol. J. Linn. Soc*. **109**, 670–681. (doi:10.1111/bij.12073)
2. Kerr AM, Kim J. 2001 Phylogeny of Holothuroidea (Echinodermata) inferred from morphology. *Zool. J. Linn. Soc*. **133**, 63–81. (doi:10.1006/zjls.2000.0280)