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SUPPLEMENTARY ONLINE MATERIAL FOR

An unusual new palaeoscolecoidomorph worm from the Cambrian Stage 3 Sirius Passet Lagerstätte in North Greenland

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Supplementary Online Material

SOM 1: fig. S1. *Avannaascolex apalos* gen. et sp. nov. holotype, NHMD002051391 (counterpart) from Sirius Passet, North Greenland, Cambrian.

SOM 1: fig. S2. *Avannaascolex apalos* gen. et sp. nov. NHMD002051395 from Sirius Passet, North Greenland, Cambrian.

SOM 1. fig. S3–8. Complete phylogenetic consensus trees.

SOM 2. The phylogenetic character list.

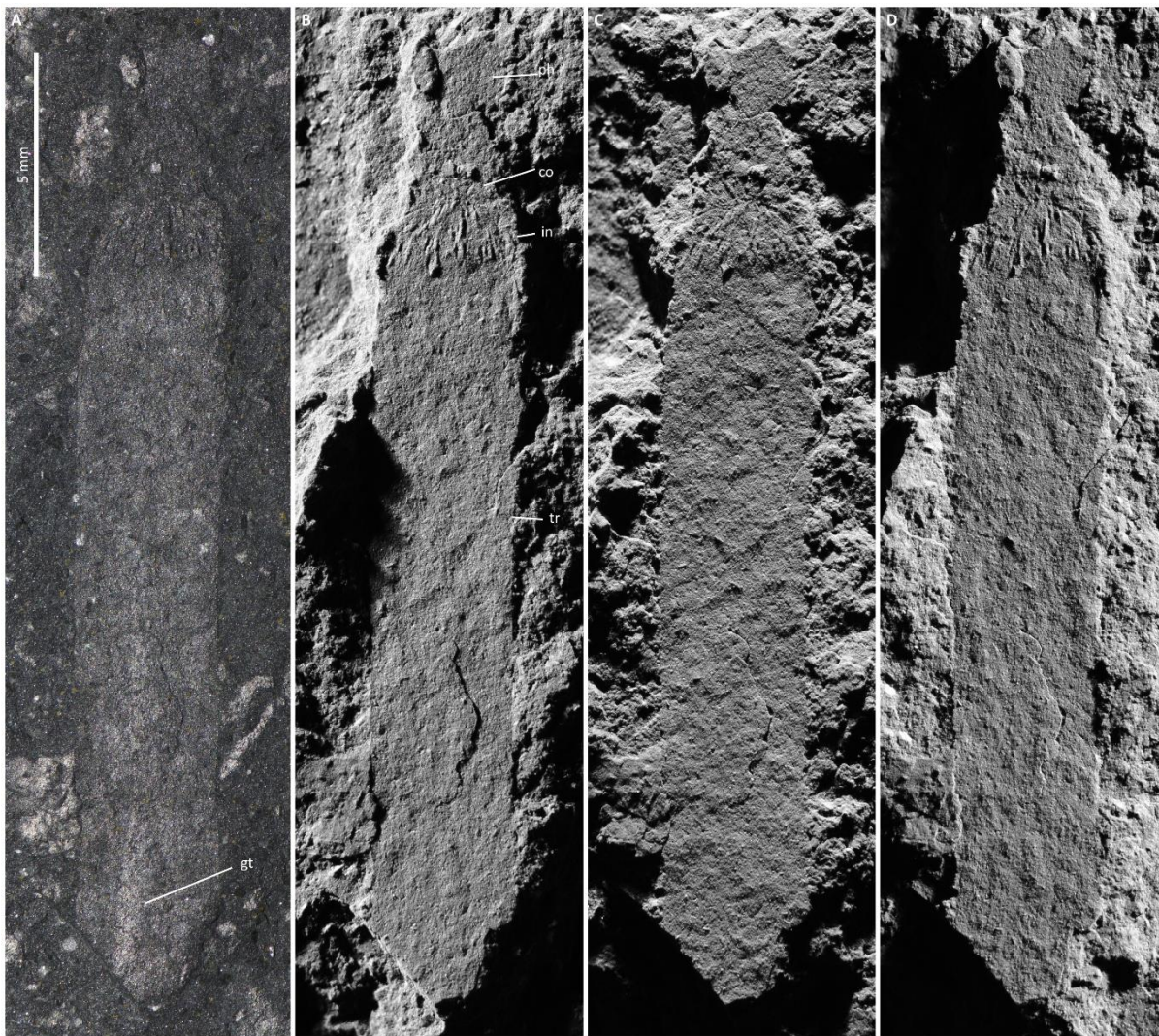
SOM 3. The phylogenetic character matrix
available at http://app.pan.pl/SOM/app71-Farrell_etal_SOM/SOM_3.nex

SOM 4. The RTI datasets used to produce the images (can be viewed in RTIViewer) available at
NHMD002051391 anterior: http://app.pan.pl/SOM/app71-Farrell_etal_SOM/SOM_4_91_ant.ptm
NHMD002051391 posterior: <https://figshare.com/s/dc6409c9ee047f98882d>
NHMD002051393 anterior: http://app.pan.pl/SOM/app71-Farrell_etal_SOM/SOM_4_93_ant.ptm

SOM 5. All element maps produced for the the three specimens studied using WDS and EDS (list of all available images).



SOM 1: fig. S1. *Avannaascolex apalos* gen. et sp. nov. holotype, NHMD002051391 counterpart. The counterpart is missing the anterior and posterior regions of the body. **A**, under high-angle illumination, submerged in water. **B**, under low-angle illumination from northwest, specimen coated with MgO. Arrowheads indicate ventral nerve cord. Abbreviations: ant, anterior; gt, gut; post, posterior.



SOM 1: fig. S2. NHMD002051395. **A**, under high-angle illumination, submerged in water. **B–D**, under low-angle illumination, specimen coated with MgO: **B**, from northwest; **C**, from north; **D**, from northeast. Abbreviations: co, collar; gt, gut; in, introvert; ph, pharynx.

SOM 2. Phylogenetic character list

This character list is copied from Shi et al. (2021), detailed character descriptions and discussion are available in that manuscript.

Head, anterior trunk, proboscis etc.

1. Cephalization:

(0) Proboscis

(1) Distinct head region clearly discriminated

2. Proboscis invaginable (introvert):

(0) Absent

(1) Present

(-) Inapplicable if proboscis absent (character 1).

3. Degree to which the introvert can be invaginated:

(0) Partially invaginable (i.e., part of Zone I)

(1) Completely invaginable into the trunk (i.e., to the base of Zone I)

(-) Inapplicable if proboscis not invaginable (character 2)

4. Introvert represents 30-50% of body length:

(0) Absent

(1) Present

(-) Inapplicable if proboscis not invaginable (character 2)

5. Bulbous head:

(0) Absent

(1) Present

(-) Inapplicable if distinct head region not clearly discriminated (character 1)

6. Anterior sclerite “cap”:

(0) Absent

(1) Present

(-) Inapplicable if distinct head not clearly discriminated (character 1)

7. Head covered by sclerites

Absent (0)

Present (1)

(-) Inapplicable if distinct head not clearly discriminated (character 1)

8. Head shield formed by fused cephalic segments:

(0) Absent

(1) Present

(-) Inapplicable if head not covered by sclerites (character 7)

9. Isolated, articulating dorsal sclerite associated with eye-stalks and innervated by the protocerebrum:

(0) Absent

(1) Present

(-) Inapplicable if distinct head region not clearly discriminated (character 1), or head shield formed by fused cephalic segments present (character 8)

10. Shape of isolated dorsal sclerite associated with eyestalks and protocerebrum:

(0) Semi-circular/rounded

(1) Well-developed and elongate

(-) Inapplicable if dorsal sclerite associated with eye-stalks and innervated by the protocerebrum is absent (character 9).

11. Extent of coverage of dorsal isolated dorsal sclerite associated with eyestalks and protocerebrum on head:

(0) Broad attachment to the cephalic region

(1) Narrow attachment with anterior edge of cephalic region

(-) Inapplicable if dorsal sclerite associated with eye-stalks and innervated by the protocerebrum is absent (character 9).

12. Isolated lateral sclerites, forming tri-partite carapace:

(0) Absent

(1) Present

(-) Inapplicable if cephalic shield formed from fused segments is present (character 8), or head not covered by sclerites (character 7).

Sensory structures

13. Eyes:

(0) Absent

(1) Present

14. Eye attachment

(0) Sessile

(1) Stalked

(-) Inapplicable if eyes absent (character 13).

15. Five stalked eyes:

(0) Absent

(1) Present

(-) Inapplicable if eye stalks absent (character 14).

16. Type of eyes:

(0) Single lens eye or pigment spots

(1) Multiple visual units (including compound eyes)

(-) Inapplicable if eyes absent (character 13)

17. Lateral amphids:

(0) Absent

(1) Present

18. Trunk tumuli:

(0) Absent

(1) Present

19. Trunk tubuli:

(0) Absent

(1) Present

20. Flosculi, N-flosculi or sensory spots:

(0) Absent

(1) Present

Oral, circumoral and pharyngeal morphology

21. Mouth opening orientation:

(0) Terminal

- (1) Ventral
- (2) Posterior

22. One or more pairs of appendages located anteriorly relative to the mouth opening:

- (0) Absent
- (1) Present
- (-) Inapplicable if limbs absent (character 77)

23. Mouth cone:

- (0) Absent
- (1) Present

24. Mouth tube:

- (0) Absent
- (1) Present

25. Subdivided pharyngostome:

- (0) Absent
- (1) Present

26. Metastegosomal teeth:

- (0) Absent
- (1) Present
- (-) Inapplicable if subdivided pharyngostome is absent (character 25)

27. Odontostyle:

- (0) Absent
- (1) Present
- (-) Inapplicable if metastegomal teeth absent (character 26)

28. Radially symmetrical circumoral structures (i.e. Conway Morris Zone I armed):

- (0) Absent
- (1) Present

29. General form of radial circumoral structures (i.e. Conway Morris Zone I):

- (0) Scalids – hollow spines with apical pore and sensory cells surrounded by a thin layer of cuticle (scalidophorans)
- (1) Hooks composed exclusively of cuticle (nematomorphs, some nematodes)
- (2) Oral papillae or lamellae (some tardigrades, some lobopodians)
- (3) Radial plates organised as a mouth apparatus (some lobopodians, radiodonts)
- (4) “Lips” (some nematodes, possibly *Shergoldana*)
- (5) Cephalic setae (some nematodes)
- (-) Inapplicable if radially symmetrical circumoral structures absent (character 28)

30. Zone I armature comprises:

- (0) Fewer than 3 rings
- (1) Many rings (i.e. more than 3)
- (-) Inapplicable if radially symmetrical circumoral structures absent (character 28).

31. Arrangement of Zone I armature into discrete parallel longitudinal rows:

- (0) Absent
- (1) Present
- (-) Inapplicable if radially symmetrical circumoral structures absent (character 28).

32. Unarmed distal introvert:

- (0) Absent
- (1) Present
- (-) Inapplicable if scalids absent (character 29).

33. Symmetry of circumoral structures:

- (0) Hexaradial
- (1) Pentaradial
- (2) Tetraradial
- (3) Triradial
- (4) Octaradial
- (-) Inapplicable if circumoral structures absent (character 28).

34. Anterior ring of anteriorly directed jointed, broad appendages:

- (0) Absent
- (1) Present
- (-) Inapplicable if radially symmetrical circumoral structures absent (character 28).

35. Sexual dimorphism of clavoscalids:

- (0) Clavoscalids all the same
- (1) Branched clavoscalids in males
- (-) Inapplicable if clavoscalids absent (character 34).

36. Rings of segmented, elongated spinose appendages:

- (0) Absent
- (1) Present
- (-) Inapplicable if radially symmetrical circumoral structures absent (character 28).

37. Double organ:

- (0) Absent
- (1) Present
- (-) Inapplicable if spinoscalids absent (character 35).

38. Trichoscalids:

- (0) Absent
- (1) Present

39. Number of trichoscalids on proximal part of Zone I

- (0) 0
- (1) 6
- (2) 14
- (-) Inapplicable if trichoscalids are absent (character 38).

40. Number of elements comprising the first three rings and, hence, defining the number of longitudinal rows of elements in Zone I (assuming there are more than three):

- (0) ≤ 20
- (1) 25
- (2) >25
- (-) Inapplicable if circumoral structures not arranged in many rings (character 30).

41. Zone II:

- (0) Unarmed
- (1) Armed
- (-) Inapplicable if zone II absent (see discussion in character 28)

42. Number of elements in the proximal circlet of Zone II:

- (0) Numerous (>8)
- (1) Eight
- (2) <8
- (-) Inapplicable if collar/zone II absent or unarmed (character 41).

43. Coronal spines at boundary of Zones I and II:

- (0) Absent
- (1) Present, undifferentiated
- (2) Present, elongate spines
- (-) Inapplicable if collar absent or unarmed (character 41).

44. Structure of mouth apparatus:

- (0) Variable number of undifferentiated plates
- (1) Plates with differentiation of enlarged plates
- (-) Inapplicable if radial plates organised as a mouth apparatus absent (character 29).

45. Zone III:

- (0) Unarmed
- (1) Armed

46. Zone III comprises sclerotized pharyngeal teeth circlets:

- (0) Absent
- (1) Present
- (-) Inapplicable if Zone III unarmed (character 45).

47. Number of circlets of Zone III armature:

- (0) 1-4
- (1) 6-8
- (2) 16 or more
- (-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 46).

48. General morphology of proximal circlets of Zone III armature (teeth):

- (0) Absent
- (1) Spines or papillae
- (2) Multispinose
- (3) Multispinose but massively reduced
- (4) Hooks
- (5) Conical with a fringe of spines
- (6) Sclerotized trabeculae
- (7) Pectinate
- (8) Conical papillae terminating in a long spine (prickle)
- (-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 46).

49. Morphology of middle circlets of Zone III armature (teeth):

- (0) Absent
- (1) Spines or papillae
- (2) Multispinose
- (3) Pectinate
- (-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 46).

50. Morphology of distal circlets of Zone III armature:

- (0) Absent
- (1) Spines
- (2) Multispinose

(3) Pectinate

(-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 46).

51. Number of elements in the first circlet of pharyngeal armature (base on Zone III):

(0) >10

(1) 10

(2) 5

(-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 456).

52. Pentaradial symmetry of Zone III armature:

(0) Absent

(1) Present

(-) Inapplicable if Zone III unarmed, i.e. pharyngeal armature absent (character 45).

53. Number of proximal pentagonal circlets in Zone III:

(0) None

(1) Five

(2) Six

(3) Seven

(-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 46).

54. Teeth of second circle of the larvae with very small median denticle:

(0) Absent

(1) Present

(-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 46).

55. Distal portion of Zone III expanded into a bulb:

(0) Absent

(1) Present

(-) Inapplicable if Zone III not eversible (character 56).

56. Zone III eversibility:

(0) No degree of eversibility

(1) Eversible (to any degree)

57. Eversibility of Zone III:

(0) Completely eversible

(1) Incompletely eversible, eversible beyond the proximal teeth

(2) Eversible only as far as the proximal teeth

(-) Inapplicable if Zone III not eversible (character 56).

58. Cone-like eversible pharynx:

(0) Absent

(1) Present

(-) Inapplicable if pharynx not eversible (character 56)

59. All Zone III elements:

(0) Of approximately equal size

(1) Decreasing regularly in size from the posterior to the anterior

(-) Inapplicable if Zone III armature does not comprise circlets of teeth (character 46).

60. Radial oral stylets in mouth cone:

(0) Absent

(1) Present

(-) Inapplicable if mouth cone absent (character 23).

61. Number of radial oral stylets:

- (0) 4
- (1) 6
- (2) 8
- (3) 9
- (-) Inapplicable if radial oral stylets absent (character 60).

62. Placids:

- (0) Absent
- (1) Present

63. Number of placids

- (0) 8
- (1) 16
- (-) Inapplicable if placids absent (character 62).

64. Triradial cuticular thickenings ornamenting pharynx:

- (0) Absent
- (1) Present

65. Pharyngeal lumina:

- (0) Round
- (1) Triradiate

Trunk region

66. Locomotion by peristaltic contraction:

- (0) Absent
- (1) Present

67. Body musculature:

- (0) Circular and longitudinal peripheral musculature
- (1) Longitudinal peripheral only
- (2) Metameric skeletal musculature

68. Circular musculature inside longitudinal musculature:

- (0) Circular muscles inside longitudinal
- (1) Longitudinal muscles inside circular
- (-) Inapplicable if circular peripheral musculature absent, or metameric skeletal musculature is present (character 67).

69. Dorsal integument sclerotized and connected by arthrodial membranes:

- (0) Absent
- (1) Present

70. Sternites connected by arthrodial membranes:

- (0) Absent
- (1) Present
- (-) Inapplicable if dorsal sclerotized integument absent (character 69).

71. Trunk integument subdivided into 11 subunits covered by dorsal and ventral plates:

- (0) Absent
- (1) Present

72. Neck-like constriction on lobopodous trunk:

- (0) Absent
- (1) Present

(-) Inapplicable if paired appendages absent (character 78), or sclerotized dorsal integument with arthrodial membranes present (character 69).

73. Annulations:

(0) Absent

(1) Present

74. Papillae on annulations:

(0) Absent

(1) Present

(-) Inapplicable if annulations absent (character 73).

75. Branching of annular rings:

(0) Unbranched

(1) Branched

(-) Inapplicable if annulations absent (character 73).

76. Serially repeated mid-gut glands:

(0) Absent

(1) Present

Serially repeated trunk nodes/sclerites

77. Trunk with serially repeated paired ventral/ventrolateral structures:

(0) Absent

(1) Present

78. Form of serially repeated paired ventral/ventrolateral trunk structures:

(0) Spines/protuberances

(1) Moveable limbs producing an overall gait – i.e. paired appendages

(-) Inapplicable if paired ventral structures are absent (character 77).

79. Serially repeated epidermal specializations:

(0) Absent

(1) Present

80. Position of serially repeated epidermal specializations:

(0) Dorsal/lateral/dorsolateral longitudinal rows

(1) Incomplete transverse rings

(2) Complete transverse rings

(-) Inapplicable: serially repeated epidermal specializations absent (character 79).

81. Nature of serially repeated epidermal dorsolateral specializations:

(0) Epidermal depressions

(1) Epidermal evaginations

(-) Inapplicable: serially repeated epidermal specializations absent (character 79).

82. Proportions of serially repeated epidermal trunk evaginations:

(0) Wider than tall (e.g. nodes or plates)

(1) Taller than wide (e.g. spines)

(-) Inapplicable if serially repeated epidermal evaginations are absent (character 81).

83. Serially repeated epidermal evaginations with acute distal termination:

(0) Absent

(1) Present

(-) Inapplicable if serially repeated epidermal evaginations are absent (character 81).

84. Acute distal termination in serially repeated epidermal evaginations is curved:

- (0) Absent
- (1) Present
- (-) Inapplicable if serially repeated epidermal evaginations with acute distal termination are absent (character 83).

85. Sclerotization of serially repeated epidermal evaginations:

- (0) Absent
- (1) Present
- (-) Inapplicable if serially repeated epidermal evaginations are absent (character 81).

86. Serially repeated sclerite ornamentation:

- (0) Net-like
- (1) Scaly
- (-) Inapplicable if serially repeated epidermal specializations not sclerotized (character 85).

87. Composition of serially repeated sclerites:

- (0) Phosphatic
- (1) Carbonaceous.
- (-) Inapplicable if serially repeated epidermal specializations not sclerotized (character 85).

88. Sclerites (including serially repeated sclerites) consist of a stack of constituent elements:

- (0) Absent
- (1) Present
- (-) Inapplicable if sclerites absent

89. Maximum number of primary serially repeated epidermal specializations above each pair of paired ventral structures:

- (0) One
- (1) Two
- (2) Three
- (3) Four
- (4) Five
- (5) Seven
- (-) Inapplicable if serially repeated epidermal specializations are absent (character 79).

90. 'Secondary' sclerotized dorsolateral spines:

- (0) Absent
- (1) Present
- (-) Inapplicable if epidermal evaginations absent (character 81).

91. Serially repeated sclerotized spine-like evaginations of variable length along the body:

- (0) Similar length along body
- (1) Variable length along body
- (-) Inapplicable if serially repeated epidermal evaginations not spinose (character 82).

92. Spacing between serially repeated epidermal specializations along longitudinal body axis:

- (0) Regularly spaced
- (1) Irregularly spaced
- (-) Inapplicable if serially repeated epidermal specializations absent (character 79).

93. Correspondence of serially repeated dorsolateral epidermal specializations to ventral paired structures:

- (0) 1:1 relationship
- (1) 2:1 relationship

- (2) 3:1 relationship
- (3) 4:1 relationship
- (-) Inapplicable if serially repeated epidermal specializations (character 79) or paired ventral structures absent (character 77).

94. Variation in morphology of serially repeated epidermal specializations between groups:

- (0) Absent
- (1) Two alternating morphologies along length of trunk
- (2) Two alternate morphologies in anterior and posterior regions of trunk
- (-) Inapplicable if serially repeated epidermal specializations are absent (character 79).

Anterior and head appendages

95. Differentiated anterior appendages:

- (0) Absent
- (1) Present
- (-) Inapplicable if paired appendages absent (character 78).

96. Nature of post-ocular (post-protocerebral) body appendages:

- (0) Lobopodous
- (1) Arthropodized (sclerotized, arthrodial membranes present)
- (-) Inapplicable if paired appendages absent (character 78).

97. Sclerotization of pre-ocular (protocerebral) limb pair:

- (0) Not sclerotized
- (1) Sclerotized
- (-) Inapplicable if paired appendages absent (character 78).

98. Pre-ocular (protocerabral) limb pair with arthrodial membranes:

- (0) Absent
- (1) Present
- (-) Inapplicable if protocerebral limbs not sclerotized (character 97).

99. Nature of post-ocular lobopodous inner branch:

- (0) Cylindrical/subconical appendage
- (1) Laterally expanded swimming flap
- (-) Inapplicable if post-ocular limbs are arthropodized (character 96).

100. Nature of first post-ocular (deutocerebral) appendage:

- (0) Lobopodous ambulatory limb
- (1) Lobopodous sensorial limb
- (2) Lobodous limb with sclerotized jaw
- (3) Arthropodized antenniform with distinct podomeres
- (4) Arthropodized short great-appendage
- (5) Arthropodized undifferentiated biramous appendage
- (-) Inapplicable if paired appendages absent (character 78).

101. Inner blade of deutocerebral jaw with diastema:

- (0) Absent
- (1) Present
- (-) Inapplicable if deutocerebral jaw absent (character 100).

102. Deutocerebral limb pair structurally differentiated from rest of trunk appendages:

- (0) Absent
- (1) Present
- (-) Inapplicable if paired appendages absent (character 78).

103. Nature of second post-ocular (tritocerebral) appendage:

- (0) Undifferentiated lobopodous limb
- (1) Specialized papillae
- (2) Arthropodized ambulatory limb with distinct podomeres
- (3) Arthropodized specialized post-antennal appendage
- (-) Inapplicable if paired appendages absent (character 78).

104. Position of pre-ocular (protocerebral) appendage pair:

- (0) Lateral
- (1) Ventral
- (2) Terminal
- (-) Inapplicable if paired appendages are absent (character 78).

105. Pre-ocular (protocerebral) appendage pair fused:

- (0) Not fused
- (1) Fused
- (-) Inapplicable if paired appendages absent (character 78).

106. Nature of pre-ocular (protocerebral) appendage fusion:

- (0) Basal only, with separate distal elements
- (1) Fused into a labrum or equivalent structure
- (2) Reduced labrum
- (-) Inapplicable if protocerebral appendages not fused (character 105).

107. Spines/spinules on pre-ocular (protocerebral) appendage:

- (0) Absent
- (1) Present
- (-) Inapplicable if paired appendages absent (character 78), or protocerebral appendages fused into a labrum (character 106).

108. Number of spine/spinule series on pre-ocular (protocerebral) frontal appendage:

- (0) One series
- (1) Two series
- (-) Inapplicable if protocerebral appendages fused into labrum (character 106), or spines/spinules on protocerebral appendages absent (character 107).

109. Coplanar spine/spinule series in pre-ocular (protocerebral) frontal appendages:

- (0) Absent
- (1) Present
- (-) Inapplicable if protocerebral appendages fused into labrum (character 106), or spines/spinules on protocerebral appendages absent (character 107).

110. Multifurcate distal termination of protocerebral appendage

- (0) Absent
- (1) Present
- (-) Inapplicable if protocerebral appendages fused into labrum (character 106) or spines/spinules on protocerebral appendages absent (character 107).

Trunk appendages:

111. Trunk exites:

- (0) Absent
- (1) Present
- (-) Inapplicable if paired appendages absent (character 78).

112. Exite organisation:

- (0) Lanceolate dorsal blades
- (1) Simple oval paddle with marginal spines
- (2) Bipartite shaft with lamellar setae
- (3) Book gill/lung or equivalent
- (-) Inapplicable if trunk exites absent (character 111)

113. Exites/lanceolate dorsal blades associated with dorsolateral flaps:

- (0) Absent
- (1) Present
- (-) Inapplicable if post-ocular limbs biramous (character 115).

114. Exite/setal blade distribution:

- (0) Confined laterally
- (1) Present dorsally
- (-) Inapplicable if exites absent (character 111), or if dorsal integument is sclerotized (character 69).

115. Dorsal flaps/exites fused with endopod into biramous appendage:

- (0) Not fused
- (1) Fused
- (-) Inapplicable if trunk exites absent (character 111).

116. Antero-posteriorly compressed protopodite with gnathobasic endites in post-deutocerebral appendage pair:

- (0) Absent
- (1) Present
- (-) Inapplicable if post-ocular limbs not arthropodized (character 96).

117. Setae on lobopodous limbs:

- (0) Absent
- (1) Present
- (-) Inapplicable if post-ocular limbs not lobopodous (character 96).

118. Appendicules on lobopodous limbs:

- (0) Absent
- (1) Present
- (-) Inapplicable if limbs not lobopodous (character 96).

119. Papillae on lobopodous limbs:

- (0) Absent
- (1) Present
- (-) Inapplicable if limbs not lobopodous (character 96).

120. Papillae with terminal spine:

- (0) Spine absent
- (1) Spine present
- (-) Inapplicable if papillae on lobopods absent (character 119).

121. Finger-like elements in distal tip of limbs:

- (0) Absent
- (1) Present
- (-) Inapplicable if paired appendages absent (character 78).

122. Terminal claws on trunk limbs:

- (0) Absent

- (1) Present
- (-) Inapplicable if paired appendages absent (character 78).

123. Terminal claws with multiple branches:

- (0) Absent
- (1) Present
- (-) Inapplicable if terminal claws absent (character 122).

124. Number of claws on trunk limbs:

- (0) One
- (1) Two
- (2) Three
- (3) Four
- (4) Seven
- (-) Inapplicable if terminal claws absent (character 122).

125. Differentiated distal foot in lobopodous trunk limbs:

- (0) Absent
- (1) Present
- (-) Inapplicable if paired appendages absent (character 78), post-ocular appendages arthropodized (character 96), or inner branch modified as lateral flaps (character 113).

126. Hypertrophied set of anterior body flaps

- (0) Absent
- (1) Present
- (-) Inapplicable if inner branch is not a lateral flap (characters 111-115) and dorsolateral flaps absent

127. Strengthening ray in lateral flaps:

- (0) Absent
- (1) Present
- (-) Inapplicable if inner branch is not a lateral flap and dorsolateral flaps absent (characters 111-115).

128. Posterior tapering of lateral flaps:

- (0) Absent
- (1) Present
- (-) Inapplicable if inner branch is not a lateral flap and dorsolateral flaps absent (characters 111-115).

129. Anterior sets of reduced lateral flaps

- (0) Absent
- (1) Present
- (-) Inapplicable if inner branch is not a lateral flap and dorsolateral flaps absent (characters 111-115).

130. Lobopodous limbs differentiated into two batches of multiple anterior/long and posterior/short limbs:

- (0) Absent
- (1) Present
- (-) Inapplicable if post-ocular limbs not lobopodous (character 96)

131. Number of anterior morphologically differentiated elongated limbs:

- (0) Five
- (1) Six
- (-) Inapplicable if lobopodous morphologically distinct batches absent (character 130).

132. Appendages comprise 15 or more podomeres:

- (0) Absent

(1) Present

(-) Inapplicable if postocular limbs not arthropodized (character 96).

Posterior region

133. Limbless posterior extension of the lobopodous trunk beyond the last appendage pair:

(0) Absent

(1) Present

(-) Inapplicable if trunk limbs arthropodized (character 96) or dorsal trunk covered by sclerotized plates (character 69).

134. Posterior tagma composed of three paired lateral flaps:

(0) Absent

(1) Present

(-) Inapplicable if inner branch is not a lateral flap and dorsolateral flaps absent (characters 111-115).

135. Posteriormost trunk appendage pair structurally differentiated:

(0) Absent

(1) Present

(-) Inapplicable if paired appendages absent (character 78)

136. Nature of differentiated posterior appendages:

(0) Appendicular tail

(1) Partially fused/reduced walking legs

(-) Inapplicable if posterior appendages undifferentiated (character 135).

137. Nature of appendicular tail:

(0) Tail rami

(1) Tail flaps

(2) Setiferous tail

(-) Inapplicable if appendicular tail absent (character 136).

138. Claws on posterior appendages directed anteriad:

(0) Normal orientation (claws pointing posteriad)

(1) Rotated anteriad

(-) Inapplicable if appendages lack terminal claws (character 122) or appendicular tail is present (character 136).

139. Swollen hook-bearing posterior:

(0) Absent

(1) Present

140. Posterior ring papillae:

(0) Absent

(1) Present

141. Eversible bursa:

(0) Absent

(1) Present

142. Caudal appendage(s):

(0) Absent

(1) Present

143. Division of caudal appendage(s):

(0) Unpaired

- (1) Paired
- (-) Inapplicable if caudal appendage absent (character 142).

144. Caudal appendage vesiculate:

- (0) Absent
- (1) Present
- (-) Inapplicable if caudal appendage absent (character 142).

145. Caudal appendage thin and tail-like:

- (0) Absent
- (1) Present
- (-) Inapplicable if caudal appendage absent (character 142).

146. Terminally posterior spines, hooks, or cones of basal diameter >20% of trunk diameter:

- (0) Absent
- (1) Present

147. Number of terminally posterior spines, hooks:

- (0) One
- (1) One pair
- (2) Three
- (3) Two pairs
- (4) Three pairs
- (-) Inapplicable if terminally posterior spines, hooks, cones etc. absent (character 146).

148. Arc or ring of posterior spines or hooks:

- (0) Absent
- (1) Present

Cuticle:

149. Cuticle surface with ornament of tessellating polygons:

- (0) Absent
- (1) Present

Soft tissue organisation

150. Polythyridium:

- (0) Absent
- (1) Present

151. Ventral nerve cord unpaired throughout its length:

- (0) Paired
- (1) Unpaired

152. Ventral nerve cord with paired ganglia:

- (0) Absent
- (1) Present

153. Brain type:

- (0) Condensed dorsal ganglionic
- (1) Circumpharyngeal

154. Apical part of the brain composed of perikarya:

- (0) Absent
- (1) Present

155. Two rings of retractor muscles attached through the collar-shaped brain:

(0) Absent

(1) Present

(-) Inapplicable if collar-shaped (circumpharyngeal) brain absent (character 153).

156. Pharyngeal nervous system comprised of numerous tooth ganglia connected by a diagonal nerve net:

(0) Absent

(1) Present

157. Number of neuromeres integrated into the dorsal condensed brain:

(0) One

(1) Two

(2) Three

(-) Inapplicable if dorsal condensed brain absent (character 153).

158. Mouth innervation relative to brain neuromeres:

(0) Protocerebral innervation

(1) Deutocerebral innervation

(2) Innervation from multiple neuromeres

(-) Inapplicable if dorsal condensed brain absent (character 153).

159. Nerve cord lateralised:

(0) Absent

(1) Present

(-) Inapplicable if dorsal condensed brain absent (character 153).

160. Dorsal heart:

(0) Absent

(1) Present

161. Protonephridia:

(0) Absent

(1) Present

162. Protonephridia flow into the gonoduct and/or are integrated into the gonad (= urogenital system):

(0) Absent

(1) Present

(-) Inapplicable if protonephridia absent (character 161).

163. Urogenital system attached to the body wall by a ligament:

(0) Absent

(1) Present

(-) Inapplicable if protonephridia/urogenital system absent (character 162).

Development and reproduction:

164. Developmental mode:

(0) Direct

(1) Distinct larval stages

165. Loricata stage in life cycle:

(0) Absent

(1) Present

166. Lorica present in larva:

- (0) Absent
- (1) Present

167. Lorica present in adult:

- (0) Absent
- (1) Present
- (-) Inapplicable if loricate stage absent (character 165).

168. Loricite macrofaunal form:

- (0) Absent
- (1) Present
- (-) Inapplicable if loricate stage absent (character 165).

169. Lorica subdivided into two transverse bands of seven plates:

- (0) Absent
- (1) Present
- (-) Inapplicable if loricate stage absent (character 165).

170. Lorica opens posteriorly and proceeded by a vermiform trunk:

- (0) Absent
- (1) Present
- (-) Inapplicable if loricate stage absent (character 165).

171. Lorica with circular cross-section:

- (0) Absent
- (1) Present
- (-) Inapplicable if loricate stage absent (character 165).

172. Lorica of the larvae dorso-ventrally flattened (at least in older stages), with 6 lateral plates in-folded accordion-like:

- (0) Absent
- (1) Present
- (-) Inapplicable if lorica is absent (character 165).

173. Cuticle of the lorica thickened in dorsal and ventral plates (at least) with sculpture of four to six longitudinal rows of narrow, rectangular fields:

- (0) Absent
- (1) Present
- (-) Inapplicable if lorica is absent (character 165).

174. Lorica with plicae:

- (0) Absent
- (1) Present
- (-) Inapplicable if lorica is absent (character 165).

New character description

175. Lorica separated from introvert by a neck:

- (0) Absent
- (1) Present
- (-) Inapplicable if lorica is absent (character 165).

176. Larvae with six long pharynx retractor muscles:

- (0) Absent
- (1) Present

(-) Inapplicable if direct developing (character 164).

177. Division of the body into a distinct proboscis and abdomen in the juvenile/larva:

(0) Absent

(1) Present

178. Cloaca in both sexes:

(0) Absent

(1) Present

179. Spermatozoa without a flagellum:

(0) Absent

(1) Present

Supplementary references

Shi, X., Howard, R.J., Edgecombe, G.D., Hou, X., and Ma, X. 2021. *Tabelliscolex* (Cricocosmiidae: Palaeoscolecoidomorpha) from the early Cambrian Chengjiang Biota, and the evolution of seriation in Ecdysozoa. *Journal of the Geological Society*.

SOM 5. All element maps produced for the the three specimens studied using WDS and EDS (see Methods for details).

Note that in NHMD002051391 and NHMD002051392 there is extensive carbon overprint on some parts of these specimens, obscuring detail of the fossils. These are areas where latex peels have been taken in the past and have left an invisible carbonaceous residue on the specimen. Unfortunately, we were unable to remove this residue before analysis

Maps available at

NHMD002051391 anterior:

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NHMD002051391 posterior:

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