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SUPPLEMENTARY ONLINE MATERIAL FOR

**New artiopodan euarthropods from the Chengjiang fauna
(Cambrian, Stage 3) at Malong, Yunnan, China**

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Supplementary Online Material

SOM text. Character list for phylogenetic analyses

SOM data. Data matrix for phylogenetic analyses in NEXUS format.

SOM fig. 1. Strict consensus trees of Artiopoda using parsimony analyses with different concavity values k

Character list

The current phylogenetic dataset was based on the dataset of Zhang et al. (2022) containing 65 taxa, which was updated with four taxa added, including *Sidneyia minor* Du et al. 2023 and the three new species described herein. All the 93 characters were from the dataset in Zhang et al. (2022).

1. Nature of first appendage: raptorial appendage (0); antennae (1).
2. Number of podomeres on raptorial limb: four (0); three (1); two (2).
3. Raptorial appendages with flagellum: absent (0); present (1).
4. Length of distal spines on podomeres: absent or shorter than podomere (0); subequal to length of podomeres (1); longer than entire podomere series (2).
5. Number of post-ocular head segments: none (0); one (1); two (2); three (3); four (4); five (5); six (6); seven (7).
6. Nature of second appendage pair: biramous walking leg or antennae (0); uniramous walking leg (1).
7. Nature of third appendage pair: biramous walking leg (0); uniramous walking leg (1).
8. Appendages under cephalo-thoracic articulation: absent (0); present (1).
9. Trunk endopods: absent or reduced (0); present (1).
10. Trunk exopod structure: simple oval flap (0); exopod differentiated into proximal and distal lobes, the proximal lobe bearing lamellar setae, the distal lobe bearing short setae (1); numerous podomeres, each bearing a single seta (2); undivided lobe with lamellae (3); book gills (4).
11. Proximal exopod lobe: flattened lobe (0); slender shaft (1).
12. Distal exopod lobe: small to moderate sized flap (0); large, teardrop shaped lobe with long attachment (1).
13. Exopod with articulations: absent (0); present (1).
14. Imbricate exopod lamellae: absent (0); present (1).
15. Lamellae structure: thick, flat lamellae (0); delicate, comb-like lamellae (1); paddle-shaped lamellae with marginal setae (2).
16. Non-overlapping marginal setae on distal lobe: absent (0); small setae (1); long spines or filaments (2).
17. Gnathobasic limbs: absent (0); present (1).
18. Lateral eyes: absent (0); present (1).
19. Nature of lateral eyes: stalked (0); sessile (1).
20. Ventral eyes in front of head: absent (0); present (1).
21. Calcified eyes: absent (0); present (1).
22. Dorsal exoskeletal bulge: absent (0); present (1).
23. Eye slits: absent (0); present (1).
24. Dorsal median eyes: absent (0); present (1).
25. Free head shield: absent (0); present (1).
26. Bivalved carapace: absent (0); present (1).
27. Cephalic doublure: absent (0); present (1).
28. Cephalon notched: absent (0); present (1).

29. Hypostome: median extension of the doublure, with no suture (0); natant, sclerite not in contact with doublure (1); with narrow overlap with pre-hypostomal sclerite (2); narrow attachment to doublure at hypostomal suture (3); absent (4).
30. Anterior sclerite: absent (0); present (1).
31. Ecdysial sutures: absent (0); present (1).
32. Position of ecdysial sutures: marginal (0); dorsal (1).
33. Elevated marginal rim: absent (0); present (1).
34. Marginal rim ornamented: absent (0); present (1).
35. Differentiated glabellar region: absent (0); present (1).
36. Head shield outline: genal spines (0); acute genal angles (1); rounded genal angles (2); lateral spine-like extensions of the carapace (3).
37. Posterior cephalic band: absent (0); present (1).
38. Pleural cephalic furrows: absent (0); present (1).
39. Cuticle sculpture: absent (0); present (1).
40. Mineralized cuticle: absent (0); present (1); state 2 (2).
41. Expanded lateral pleurae: absent (0); present (1).
42. Free thoracic tergites: absent (0); present (1).
43. Decoupling of tergites and limb pairs: absent (0); present (1).
44. Tergite articulations: tergites non-overlapping (0); extensive overlap of tergites (1); edge to edge pleural articulations (2).
45. Dorsal trunk effacement: trunk with defined (separate or fused) tergite boundaries (0); trunk tergite boundaries effaced laterally (1); trunk tergite boundaries completely effaced (2).
46. Cephalic articulation fused: absent (0); present (1).
47. Head shield extends over anterior tergites: overlap absent or identical to overlap between thoracic segments (0); head shield covers first thoracic tergite only (1); head shield covers multiple anterior trunk tergites (2).
48. Articulation with reduced tergite: absent (0); present (1).
49. Trunk narrowed anteriorly: absent (0); present (1).
50. Trunk tergites reflexed anteriorly: absent, boundaries transverse or reflexed posterolaterally (0); present (1).
51. Joints between posterior tergites functional: absent (0); present (1).
52. Posterior tergite with single axial spine: absent (0); present (1).
53. Radial pleurae: absent (0); present (1).
54. Raised axial region: absent or weakly defined (0); present and well defined (1).
55. Anterior tergal processes: absent (0); present (1).
56. Tuberculation of posterior tergite margin: absent (0); present (1).
57. Axial spines or nodes: absent (0); present (1).
58. Length of postabdomen: one segment (0); two segments (1); three segments (2); five segments (3).
59. Postabdomen without walking legs: absent (0); present (1).
60. Postabdomen as differentiated tergites: absent (0); present - tergite free (e.g., Some aglaspids, cheloniellids, *Emeraldella*, *Sidneyia*) (1); present - preterminal tergite fused with telson (most aglaspids) (2).

61. Posterior tergites strongly curved: absent (0); present (1).
62. Pygidium: absent (0); present (1).
63. Position of anus: terminal, within telson (0); at base of telson (1).
64. Pygidium with median keel: absent (0); present (1).
65. Pygidium with broad median spine: absent (0); present (1).
66. Pygidium with lateral spines: absent (0); present (1).
67. Tailspine: absent (0); present (1).
68. Tailspine shape: spinose (0); paddle shaped (1); cap-like (2).
69. Length of tailspine: shorter than half the length of the trunk (0); longer than half the length of the trunk (1).
70. Marginal spines on tailspine: absent (0); present (1).
71. Tailspine with medial cleft or keel: absent (0); present (1).
72. Paddle with projections: absent (0); present (1).
73. Ventral sclerite covering anal region: absent (0); present (e.g., aglaspidids, *Sidneyia*) (1).
74. Paired modified appendages: absent (0); present (1).
75. Nature of preterminal appendages: uropods (0); furca (1).
76. Reduced carapace: absent (0); present (1).
77. Width of doublure: narrow to moderately wide (0); wide (1); covers entire ventral side of cephalon (2).
78. Length of thorax relative to pygidium: longer than pygidium (0); shorter than pygidium (1).
79. Articulating half rings: absent (0); present (1).
80. Axial furrows on trunk: absent (0); present (1).
81. Postventral plate medial attachment: narrow attachment by central portion (0); wide longitudinal attachment (1).
82. Dorsal eyes confined to anterior half: absent (e.g., Trilobita) (0); present (e.g., Aglaspidida) (1).
83. Dorsal eye abutting glabella anteriorly: absent (e.g., Trilobita) (0); present (e.g., Aglaspidida) (1).
84. Dorsal eyes merge anteriorly into cephalon: absent (e.g., Trilobita) (0); present and eyes are separate (e.g., *Glypharthus*) (1); present and eyes are medially fused (e.g., *Cyclopites*) (2).
85. Nature of anal sclerite: anal plate (e.g., *Sidneyia*) (0); postventral plate (e.g., Aglaspidida) (1).
86. Nature of differentiated preterminal tergite: tergite with reduced pleurae (e.g., *Weinbergina*) (0); cylindrical tergite without pleurae (e.g., Cheloniellida, *Emeraldella*) (1).
87. Pleural tips on posterior end with elongate spines: absent (0); present (1).
88. Antennal scale: absent (0); present (1).
89. Head shield with lateral notches: absent (0); present (1).
90. Tailspine with multiple articulations (new): absent (0); present (1).
91. Shape of undivided expod lobe with lamella: broad lobe (e.g., *Retifacies*, *Pygmaclypeatus*) (0); slender shaft (e.g., *Naraoia compacta*) (1).

92. Head/trunk exopods heteronomous: absent, exopods with same morphology in head and trunk (0); present, exopods with different morphology in head and trunk (1).
93. The presence of exites: absent (0); present (1).

Supplementary References

- Du, K.S., Bruton, D., Yang, J., and Zhang, X.G. 2023. An early Cambrian *Sidneyia* (Arthropoda) resolves the century-long debate of its head organization. *Science China Earth Sciences* 66: 521–527.
- Zhang, M.Y., Liu, Y., Hou, X.G., Ortega-Hernández, J., Mai, H.J., Schmidt, M., Melzer, R.R., and Guo, J. 2022. Ventral morphology of the non-trilobite arthropod *Retifacies abnormalis* Hou, Chen & Lu, 1989, from the Early Cambrian Chengjiang Biota, China. *Biology* 11: 1235.

SOM Data. Data matrix for phylogenetic analyses in NEXUS format.

#NEXUS

BEGIN DATA;

DIMENSIONS NTAX=69 NCHAR=93;

FORMAT DATATYPE = STANDARD GAP = - MISSING = ? SYMBOLS = " 0 1 2 3 4 5 6 7";

MATRIX

```
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Haikoucaris_ercaiensis 0101400010---0-2010100000-00400-0-0100001101000000000000-00001---10010-00-00-00-----0000-00
Alalcomenaeus_cambricus 0112400010---0-2110100000-00400-0-0100001101000000000000-00001---11010000-0-00-----0000-00
Leancoilia_illecebrosa 0112400010---0-2110?00000-00?00-0-0100001101000000000000-00101---10010-00-0-00-----0000-01
Burgessia_bella 1--0400010---0-000-----00-10400-0-0200001000020000000000-00001---10100-00-0-00-----000-00
Marrella_splendens 1--021-012---0-00-----00-00?00-0-030000010000200000-0000-0000?---12000-00-0-00-----000-00
Mimetaster_hexagonalis 1--0311012---0-0-01000000-00100-0-030000010000200000-0000-0000?---12000-00-0-00-----000-00
Martinsonia_elongata 1--0500012---0-10-----00000400-0-01000001000020000000000310000---0-----00-0-00-----00-00
Nebalia_bipes 1--0500012---0--110100001100400-0-01000001000020000000000210000---0-----00-0-00-----00-00
Rehbachiaella_kinnekuensis 1--0500012---0--110100001100400-0-01000001000020000000000210000---0-----00-0-00-----00-00
Squamacula_clypeata 1--010-010---0-110-----00-10000-0-0100001101000000000000-0-1110000-----00-02000-----000---?
Acanthomeridion_anacanthus ??????????????????0---000-10?0110-01000011?10000000001000-0-10?---10000-?0-00-00-----0?00???
Acanthomeridion_serratum ??????????????????0---000-10?0110-01000011?10000000001000-0-10?---10000-?0-00-00-----1?00???
Australimicola_spriggi 1--0?????????????????0---000-10210-0-01000011?10000010001000-0-10?---10010-?0-00-00-----0000???
Zhiwenia_coronata 1--04????1?0??1????10100000-10000-0-02000011?10001010001000-0-10?---10010-?0-00-00-----0010???
Retifacies_abnormalis 1--0411013---12-00-----00-10000-0-0000001101000000000000-0-1110010100-00-0000-----00010-1
Pygmaeclypeatus_daziensis 1--0400013---12-10-----00-10000-0-0100001101000000000000-0-11?00010000-00-0000-----001010
Cindarella_eucalla 1--0500011001111010100000-10100-0-01000011110021000100000-001110000-----00-00000-----001--00
Luohuilinella_rarus ??????????????????1?00000-?0?00-0-01000011?10021000001000-?-1?????????????????0?000-----0?1????
Luohuilinella_deletres 1--0400011?0?111?10000000-10100-0-01000011?10021000001000-0-11?0100-----?0-00000-----001--0?
Xandarella_spectaculum 1--070001110111110001100-10100-0-01000011110021000000000-0-110110-----00-00000-0-0-000--00
Zhugeia_acuticaudata ??????????????????1?0?1000-?0?0-0-00000011?1002100000000-0-11?0110-----?0-0?000-0-0-0?0-??
Sinoburius_lunaris 1--050001110111110001000-10100-0-00000011110021000001000-0-01?0110-----00-00000-0-0-010--10
Phytophilaspis_pergamena ??????????????????10001100-00100-0-1100110??10?1000001000-0-01?0000-----?0-0-101-000?-?0-??
Misszhouia_longicaudata 1--050011110111110000000-10110-0-020000100-2000100000000-0-110000-----00-00?00-----10--00
Naraoia_compacta 1--0{4 5}00113101121110000000-10100-0-020000100-2000100000000-0-110000-----00-00?00-----00-100
Naraoia_spinosa 1--050011101011110000000-10100-0-000000100-2000100000000-0-110010-----00-00?00-----00--01
Tariccoia_arrusensis ??????????????????????000-10?00-0-02000011?10010100000000-0-0111000-----00-01100-----0?0-??
Soomaspis_splendida ??????????????????????000-10?00-0-02000011?10010100000000-0-0111000-----00-01110-----0?0-??
Liwia_convexa 1--0?00?11???1?????????00-?0?00-0-0100001101001010000000-?0-111010-----00-0?100-----0?0--0?
Buenaspis_forteyi ??????????????????????0000-10?00-0-02000011?10000100000000-0-011?000-----00-00010-----0?0-??
Tegopelte_gigas 1--0?00?1?????0100?000-11210-0-0-000010?211--00?000000-0-110000-----00-00?00-----?0-??
Skioldia_aldna 1--0?00?1????10??10001000-11210-0-0-000010?211--001000000-0-110000-----00-00?00-----?0-0?
Saperion_glumaceum 1--0?0??11011100010001000-11210-0-0-0000100211--001000000-0-110000-----00-00?00-----?0-0?
Kuamaia_lata 1--0?00?11011120110001000-11210-0-01000011020000011001000-0-01110110-----00-000?0-----0?0--00
Helmetia_expansa ??????????????????10001000-11210-0-01000011020000011000000-?0-110110-----00-000?0-----0?0-??
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SOM Fig. 1. Strict consensus trees of Artipoda using parsimony analyses with different concavity values k . Bootstrap, jackknife and group present/contradicted supports are placed at the top left, bottom left, and middle right of nodes and are in regular, italics and bold, respectively. Nodal supports are all in percentage, and those of 100 are not shown.

