A new stem-neopterygian fish from the Middle Triassic of China shows the earliest over-water gliding strategy of the vertebrates

ELECTRONIC SUPPLEMENTARY MATERIAL

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(a) characters and character states used in the phylogenetic analysis.

Characters are mainly adopted or modified from previous publications on the phylogenetic relationships of the Neopterygii (GS, Gardiner and Schaeffer [22]; GML, Gardiner, Maisey and Littlewood [23]; GSM, Gardiner, Schaeffer and Masserie [26]; P, Pinna [27]; GB, Grande and Bemis [28]; G, Grande [29]; C, Coates [24]; CA, Cloutier and Arraita [25]; XG, Xu and Gao [30]; XW, Xu and Wu [31]). Those characters of our own have no author and character number citations.

1. Skull: no more than one-fourth of total length (0); roughly one-third of total length (1).
2. Post-temporal fossa: rudimentary (0); well developed (1); lost (2). (GS-28)
3. Sub-temporal fossa: present (0); absent (1). (GS-29)
4. Dilatator fossa above hyomandibular facet: absent (0); present (1). (GS-31)
5. Lateral cranial canal: absent (0); present (1). (C-32)
6. Posterior myodome: present (0); absent (1). (Modified from GS-10)
7. Posterior myodome: paired (0); enlarged into a median cavity (1). (Modified from GS-10)

8. Anterior myodome: present (0); absent (1). (Modified from C-42)

9. Number of anterior myodome: paired (0); a median single (1). (Modified from C-42)

10. Parasphenoid/basioccipital contact: absent (0); present (1). (Modified from GSM-8)

11. Basipterygoid process: present (0); absent (1). (GSM-12)

12. Internal carotid foramen on parasphenoid: absent (0); present (1). (GML-14)

13. Efferent pseudobranchial foramen on parasphenoid: absent (0); present (1). (GML-15)

14. Pterotic: present (0); absent (1). (GML-2)

15. Intercalar: present (0); absent (1). (GML-4)

16. Extrascapular: present (0); absent (1).

17. Sphenotic with small dermal component: absent (0); present (1). (G-23)

18. Rostral as a discrete element: present (0); absent (1).

19. Shape of rostral: as a deep cap on snout apex (0); reduced to a narrow tube (1). Modified from GML-19)

20. Rostral/frontal contact: absent (0), present (1). (Modified from XG-19)

Potanichthys is similar to two species of “Thoracopterus” from Italian [10], Perleidiformes, Peltopleuriformes, and basal neopterygians (e.g. Australosomus) in having a broad rostral that contacts the nasal laterally and the frontals posteriorly. Griffith [7] described that the paired nasals meet medially and prevent the rostral from the frontal in Thoracopterus and Gigantopterus, but these observations were dubious (Tintori &
Sassi [10]). This character state is coded here as unknown in *Thoracopterus* and *Gigantopterus*.

21. Anteriormost lacrimal: as part of orbital ring (0); anterior to orbital ring (1). (G-20)

22. Tube-like canal bearing anterior arm of antorbital: absent (0); present (1). (G-12)

23. Foramen for olfactory nerves on premaxilla: absent (0); present (1). (G-8)

24. Peg-like anterior process of maxilla: absent (0); present (1). (G-45)

25. Nasal involvement of anterior border of orbit: present (0); absent (1). (XW-22)

26. Antorbital involvement of anterior border of orbit: present (0); absent (1).

27. Posttemporal as a discrete element: present (0); absent (1).

28. Parietal as a discrete element: present (0); absent (1).

29. Nasal process of premaxilla that tightly sutured to frontals: absent (0); present (1). (G-6)

30. Premaxillae: paired (0); fused (1).

31. Number of lacrimal bones: single (0); two or more (1). (Modified from G-21)

32. Vomers in adults: paired (0); fused (1). (Modified from G-37)

33. Frontal: elongated (0); laterally expanded (1).

34. Supraorbital sensory canal: ending at frontal (0); ending at parietal (1).

35. Infraorbitals posterior to antorbital and below dermosphenoid: three or less elements (0); four or more elements (1). (Modified from GS-21)

36. Supraorbitals: absent (0); present (1). (GS-14)

37. Number of supraorbitals: single (0); two or more (1).

38. Suborbitals: present (0); absent (1). (Modified from GS-9)

39. Number of suborbitals: single element (0); two or more (1).
40. Dermohyal: present (0); absent (1). (GSM-24)

41. Mobile premaxilla: absent (0); present (1). (XW-30)

42. Maxilla free from preopercle: absent (0); present (1). (C-15)

43. Mobile maxilla in cheek: absent (0); present (1). (C-16)

44. Supramaxilla: absent (0); present (1). (Modified from GS-22)

45. Supramaxilla: one (0); two (1). (Modified from GS-22)

46. Supra-angular: present (0); absent (1). (GSM-27)

47. Coronoid process: absent (0); present (1). (GS-17)

48. Suspensorium angle: acute (0); nearly vertical (1). (Modified from GSM-29)

49. Symplectic: absent (0); present (1). (Modified from GSM-13)

50. Symplectic involvement of jaw joint: absent (0); present (1). (GB-61)

51. Quadratojugal: present (0); absent (1). (C-20)

52. Quadratojugal: plate-like (0); splint-like (1). (Modified from GSM-26)

53. Uncinate processes on epibranchials: absent (0); present (1). (C-25)

54. Number of hypobranchials: three (0); four (1). (G-99)

55. Opercle: larger than subopercle (0); roughly equal to or smaller than subopercle (1).

   (XW-43)

56. Hinge position of jaws: far backwards from posterior margin of orbital (0); near or well
   anterior to post margin of orbital (1).

57. Suborbital/maxilla contact: absent (0); present (1). (CA-88)

58. Interopercle: absent (0); present (1). (GS-18)

59. Median gular: present (0); absent (1). (Modified from C-11)
60. Lateral gular: present (0); absent (1). (Modified from C-11)

   The anterior most “fifth branchiostegal ray” of the *Perleidus* species from Madagascar is
   reinterpreted by us as the lateral gular because it has pit-lines as in non-neopterygians.

61. Presupracleithrum: present (0); absent (1). (GSM-38)

62. Posterior margin of maxilla: straight or slightly convex (0); concave with a posterior
   maxillary notch (1). (GB-62)

63. Clavicle: present (0); absent (1). (Modified from C-53; XG-49)

64. Clavicle: large, cap anterior end of cleithrum (0); reduced into small plates on
   postbranchial lamina of cleithrum (1). (Modified from GML-37)

65. Fringing fulcra: absent (0); present (1). (Modified from GSM-34)

66. Pectoral fin enlarged as wing: absent (0); present (1).

67. Diural caudal skeleton: absent (0); present (1). (P-1; XW-51)

68. Division of hypurals into dorsal and ventral groups: absent (0); present (1). (P-3; XW-52)

69. Dorsal and anal fins: rays more numerous than radials (0); rays and radials equal (1).
   (GSM-31)

70. Pelvic fin enlarged as wing: absent (0); present (1).

71. Dense lepidotrichial segments of pectoral fin rays between innermost principle pectoral
   fin ray and body: absent (0); present (1).

72. Anal fin: larger than or equal to dorsal fin (0); smaller than dorsal fin (1).

73. Endoskeletal support of anal fin: present (0); absent (1).

74. Dorsal and anal fin rays: segmented throughout length (0); segmented distally (1).
   (XG-62)
75. Caudal fin: forked (0); unforked (1). (XG-64)

76. Caudal fin: lower lobe slightly shorter than or equal to upper lobe (0); lower lobe longer than upper lobe present (1).

77. Uroneural: absent (0); present (1). (P-2)

78. Median caudal neural spines: absent (0); present (1). (GML-32).

79. Body scales: body fully covered (0); reduced to a few (no more than four) rows of scales in caudal region (1); entirely lost (2).

80. Scale shape: rhomboid (0); circular to cycloid (1).

81. Dorsal ridge scales (with posteriorly directed spines): absent (0); present (1). (Modified from GML-36)

82. Horizontal row of scales along lateral line: slightly deeper than those scales above or below lateral line (0); much deeper than those scales above and below lateral line (1); lost (2).

83. Ossified vertebral centra: absent (0); present (1).
(b) Data matrix of taxa and characters

*T. magnificus* and *T. martinisi* respectively represent “Thoracopterus” *magnificus* and “Thoracopterus” *martinisi*. The states of three characters (no. 4, 7, 57) are constant throughout the selected taxa and are not included when performing this phylogenetic analysis.

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