

Supplementary Information for

A large aberrant stem ichthyosauriform indicating early rise and demise of ichthyosauromorphs in the wake of the end-Permian extinction

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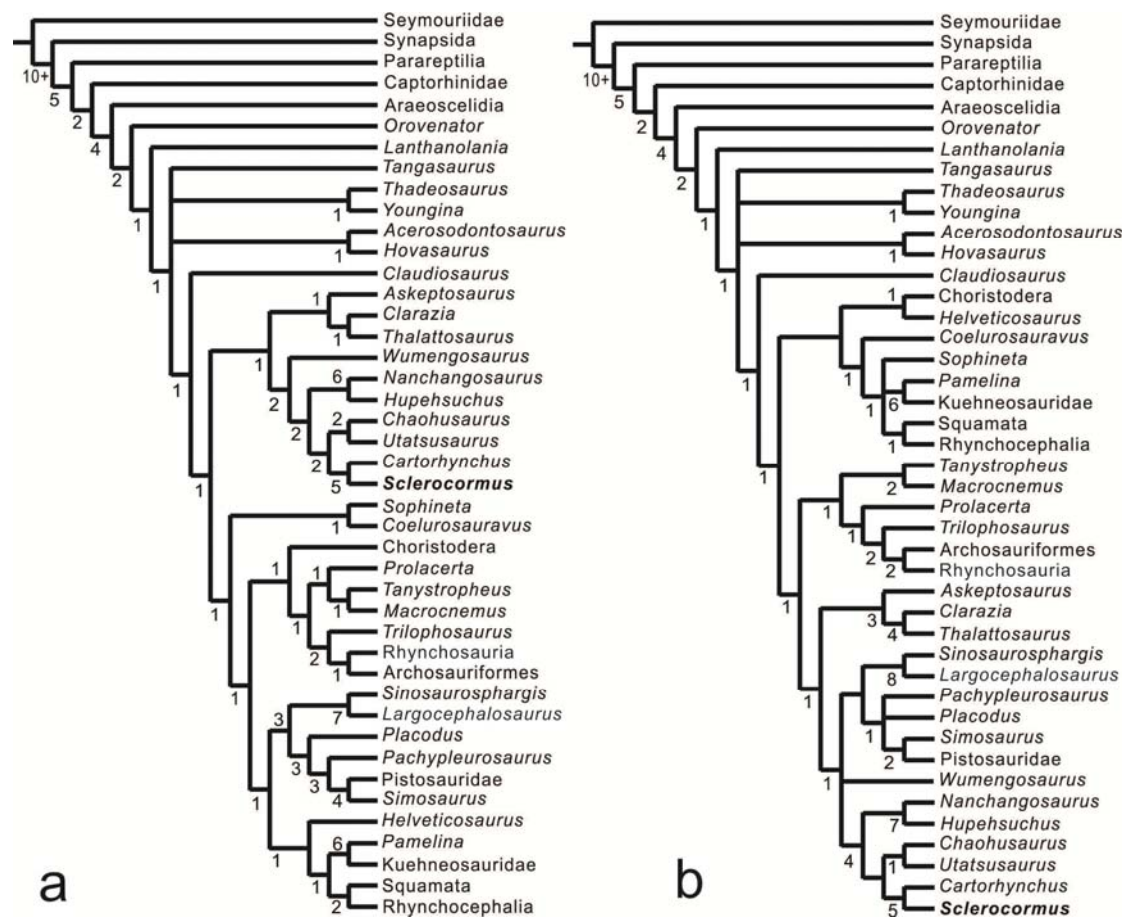
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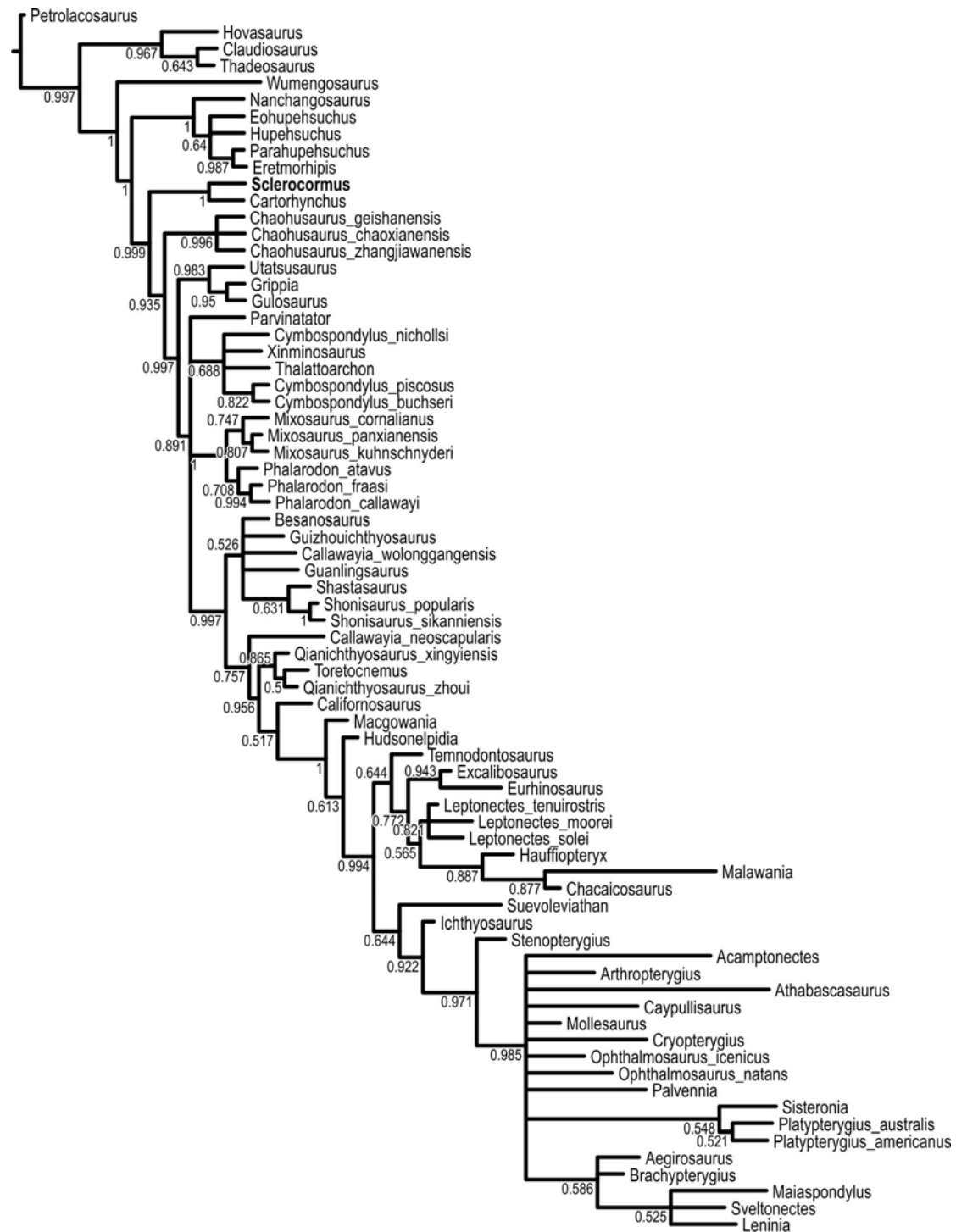
Supplementary Extended Data Figures



Extended Data Figure 1. Phylogenetic hypothesis of Ichthyosauromorpha based on parsimony analyses in PAUP* 4b10. **a**, When poorly known taxa are removed according to a previous work¹. Strict consensus of 800 most parsimonious trees (TL=640, CI=0.369, RI=0.781) obtained by a heuristic search in PAUP* 4b10 (hold=10, nreps=100, addseq=random, swap=tbr). Taxa removed are: *Parvinatator*, *Acamptonectes*, *Maiaspondylus*, *Arthropterygius*, *Malawania*, *Chacaicosaurus*, *Mollesaurus*, *Leninia*, *Thalattoarchon*, *Palvennia*, and *Sisteronia*. **b**, When all taxa in the data are included. Strict consensus of 100000 equally most parsimonious trees (TL=674, CI=0.350, RI=0.778). Original tree of Fig. 4. For both a and b, numbers associated with clades are Bremer support values calculated in TNT 1.1. Based on the data described in Supplementary Information.



Extended Data Figure 2. Phylogenetic hypotheses of *Sclerocormus* among Diapsida. Based on parsimony analyses in PAUP* 4b10. **a**, When aquatic adaptations are recoded as ambiguous. Strict consensus of 2 most parsimonious trees (TL=822, CI=0.310, RI=0.589) obtained by a heuristic search in PAUP* 4b10 (hold=10, nreps=100, addseq=random, swap=tbr). **b**, When aquatic adaptations are coded normally. Strict consensus of 12 most parsimonious trees (TL=857, CI=0.307, RI=0.614) obtained by a heuristic search in PAUP* 4b10 (hold=10, nreps=100, addseq=random, swap=tbr). For both a and b, numbers associated with clades are Bremer support values calculated in TNT 1.1. Based on the data described in Supplementary Information.



Extended Data Figure 3. Phylogenetic hypotheses of *Sclerocormus* among Ichthyosauromorpha based on Bayesian phylogenetic inference in MrBayes 3.2.6. The values associated with nodes are the mean posterior probabilities. See Supplementary Method for the settings used.

Supplementary Data S1. Character list and matrix for the internal phylogeny of Ichthyosauriformes

Coding by Ji et al. (2016) ¹ was adopted for all taxa except *Hupehsuchus*, *Chaohusaurus*, and *Cartorhynchus*, which were coded according to Motani et al. (2015) ². Note that *Chaohusaurus* was divided into three species by Motani et al. (2015). *Wumengosaurus* was added in case it may be closely related to Ichthyosauromorpha, as suggested by Chen et al. (2014) ³. Character coding schemes differ between Motani et al. (2015) and Ji et al. (in press) for characters 2, 18, 48, 61, 86, 94, 107, 126, 138, 147, and 152. Appropriate adjustments were made to those taxa for which coding from Motani et al. (2015) was employed to adjust for the scheme employed by Ji et al. (in press). New characters 184-195 were added. Character 94 of Motani et al. (2015) was removed following Ji et al. (2016).

Following Ji et al. (2016), the taxa below were considered poorly-known given that only a third of the characters or less were coded: *Parvinatator*, *Acamptonectes*, *Maiaspondylus*, *Arthropterygius*, *Malawania*, *Chacaicosaurus*, *Mollesaurus*, *Leninia*, *Thalattoarchon*, *Palvennia*, and *Sisteronia*. We therefore presented phylogenetic hypotheses with and without these taxa in Extended Data Figure 1b and a, respectively.

1. Ji C., Jiang D.-y., Motani R., Rieppel O., Hao W.-c., Sun Z.-y. 2016 Phylogeny of Ichthyopterygia incorporating the recent discoveries from South China. *J Vertbr Paleontol* **36**(1), e1025956, doi: 10.1080/02724634.2015.1025956.
2. Motani R., Jiang D.-y., Chen G.-b., Tintori A., Rieppel O., Ji C., Huang J.-d. 2015 A basal ichthyosauriform with a short snout from the Lower Triassic of China. *Nature* **517**, 485-488.
3. Chen X., Motani R., Cheng L., Jiang D., Rieppel O. 2014 The enigmatic marine reptile *Nanchangosaurus* from the Lower Triassic of Hubei, China and the phylogenetic affinity of Hupehsuchia. *PLoS One* **9**(7), e102361. (doi:10.1371/journal.pone.0102361).

Character Coding Revision

The following character coding revisions were applied to the matrix of Ji et al. (2016) by JC. The character numbering follows Ji et al. (2016). See the table below for the correspondence of character numbers between this study and Ji et al. (2016).

Utatusaurus 25 {0 -> 1}; 39 {0 -> ?}; 119 {? -> 0}

Grippia 43 {1 -> ?}; 50 {0 -> ?}; 116 {? -> 0}; 140 {? -> 0}; 141 {? -> 0}; 142 {? -> 0}

Gulosaurus 56 {0 -> 1}; 76 {2 -> 1}; 82 {? -> 1}; 139 {0 -> ?}; 151 {? -> 0}

Parvinatator 3 {0 -> ?}; 7 {? -> 0}; 60 {1 -> 0}; 110 {1 -> 0}; 112 {0 -> ?}

Mixosaurus cornalianus 48 {? -> 1}; 55 {1 -> 0}; 78 {? -> 1}; 79 {? -> 1}; 80 {? -> 1}; 81 {? -> 0}; 138 {? -> 0}; 147 {? -> 0}; 163 {? -> 0}

Mixosaurus kuhnschnyderi 18 {? -> 1}; 19 {? -> 0}; 22 {? -> 0}; 27 {? -> 1}; 33 {? -> 1}; 34 {? -> 0}; 35 {? -> 1}; 48 {? -> 1}; 50 {? -> 0}; 55 {? -> 2}; 57 {? -> 0}; 59 {? -> 0}; 60 {? -> 0}; 66

{1 -> ?}; 69 {? -> 1}; 70 {? -> 0}; 71 {? -> 0}; 72 {? -> 0}; 73 {? -> 0}; 74 {? -> 0}; 75 {? -> 0};
 76 {? -> 1}; 77 {? -> 0}; 78 {? -> 1}; 79 {? -> 1}; 81 {? -> 0}; 82 {? -> 1}; 83 {? -> 0}; 86 {? ->
 0}; 87 {? -> 1}; 90 {? -> 1}; 91 {? -> 0}; 92 {? -> 1}; 93 {? -> 0}; 94 {? -> 0}; 95 {? -> 0}; 96 {?
 -> 0}; 145 {0 -> ?}; 147 {? -> 0}; 148 {? -> 0}; 151 {? -> 1}
Phalarodon callawayi 56 {0 -> ?}; 84 {0 -> ?}; 116 {? -> 0}; 117 {? -> 0}; 119 {? -> 0}; 120 {?
 -> 1}; 121 {? -> 1}; 124 {? -> 0}; 126 {? -> 1}; 127 {? -> 0}; 128 {? -> 0}; 129 {? -> 0}; 130 {?
 -> 0}; 131 {? -> 0}; 132 {? -> 0}; 133 {? -> 1}; 134 {? -> 0}; 135 {? -> 0}; 136 {? -> 0}; 137 {?
 -> 0}; 138 {? -> 0}; 139 {? -> 0}; 140 {? -> 0}; 141 {? -> 0}
Cymbospondylus piscosus 20 {0 -> 1}; 68 {1 -> ?}; 141 {0 -> ?}
Cymbospondylus buchseri 9 {0 -> ?}; 116 {0 -> ?}; 118 {0 -> ?}; 120 {1 -> ?}; 154 {0 -> ?}
Cymbospondylus nichollsi 6 {? -> 0}; 32 {? -> 1}; 43 {? -> 1}; 49 {? -> 0}
Xinminosaurus 26 {1 -> ?}; 75 {? -> 0}; 114 {? -> 1}; 115 {? -> 0}
Besanosaurus 68 {1 -> ?}; 89 {? -> 0}; 97 {? -> 0}; 107 {1 -> 2}; 162 {0 -> ?}
Guizhouichthyosaurus 91 {0 -> 1}; 107 {1 -> 2}
Callawayia wolonggangensis 77 {? -> 0}; 101 {? -> 1}; 110 {? -> 1}; 139 {0 -> ?}
Guanlingsaurus 25 {0 -> 1}; 72 {? -> 0}; 91 {0 -> 1}; 106 {1 -> 0}; 107 {1 -> 2}; 113 {1 -> 0}
Shastasaurus 30 {0 -> ?}; 32 {? -> 1}; 55 {? -> 0}; 91 {0 -> 1}
Shonisaurus popularis 25 {0 -> ?}; 27 {1 -> ?}
Shonisaurus sikanniensis 71 {? -> 2}; 72 {? -> 0}
Californosaurus 71 {? -> 2}; 74 {? -> 0}; 75 {? -> 0}; 76 {? -> 3}; 78 {? -> 1}; 79 {? -> 1}; 80 {?
 -> 0}; 82 {2 -> 1}; 83 {? -> 0}; 89 {? -> 0}
Toretocnemus 10 {1 -> ?}; 26 {2 -> ?}; 28 {? -> 0}; 112 {? -> 1}; 138 {2 -> 1}
Qianichthyosaurus zhoui 3 {? -> 0}; 26 {2 -> 1}; 38 {? -> 0}; 52 {? -> 0}; 73 {? -> 0}; 74 {? ->
 0}; 79 {0 -> 1}; 139 {1 -> 0}; 154 {? -> 0}; 163 {? -> 1}
Qianichthyosaurus xingyiensis 56 {0 -> ?}; 71 {0 -> 2}; 74 {1 -> 0}; 75 {? -> 0}
Callawayia neoscapularis 38 {? -> 0}; 66 {1 -> ?}; 68 {1 -> ?}; 86 {2 -> 1}; 104 {0 -> ?}; 126 {0
 -> 1}; 132 {? -> 1}; 138 {2 -> 1}
Hudsonelpidia 100 {? -> 1}; 130 {? -> 1}; 131 {? -> 0}; 132 {? -> 1}; 135 {0 -> ?}; 136 {0 -> ?};
 137 {0 -> ?}
Macgowania 16 {? -> 1}; 30 {0 -> ?}; 48 {? -> 0}; 77 {0 -> ?}
Suevoleviathan 11 {? -> 0}; 47 {0 -> 1}; 97 {1 -> 0}; 115 {0 1 -> 1}; 139 {0 -> 1}; 149 {0 -> 1};
 160 {? -> 2}
Aegirosaurus 20 {1 -> 0}; 38 {1 -> ?}; 101 {0 1 -> 1}; 113 {? -> 1}; 121 {0 -> ?}
Acamptonectes 48 {1 -> ?}; 109 {1 -> ?}
Maiaspondylus 2 {0 -> 1}; 104 {? -> 0}; 105 {1 -> ?}; 128 {1 -> ?}; 129 {0 -> ?}; 145 {0 -> ?};
 146 {0 -> ?}; 147 {? -> 1}
Arthropterygius 37 {1 -> ?}; 40 {1 -> 0}; 46 {1 -> ?}; 71 {1 -> ?}; 100 {0 -> 1}; 108 {? -> 1}; 126
 {? -> 0}
Athabascasaurus 18 {? -> 0}; 20 {1 -> 0}; 22 {0 -> 1}; 28 {? -> 1}; 30 {1 -> ?}; 39 {0 -> 1}; 74
 {1 -> ?}; 118 {1 -> 2}; 125 {1 -> ?}
Sveltonectes 2 {1 -> ?}; 23 {? -> 1}; 92 {1 -> ?}; 93 {1 -> ?}; 95 {0 -> ?}; 129 {1 -> 0}; 157 {? ->
 2}
Brachypterygius 6 {? -> 1}; 36 {0 -> 1}
Caypullisaurus 1 {? -> 0}; 2 {? -> 0}; 5 {? -> 0}; 6 {? -> 0 1}; 13 {0 -> 1}; 20 {0 -> 1}; 26 {? ->

2}; 31 {? -> 1}; 129 {? -> 0}; 145 {0 -> ?}; 149 {1 -> ?}
Malawania 3 {0 -> ?}
Mollesaurus 6 {1 -> 0}; 43 {? -> 0}; 143 {1 -> ?}; 146 {1 -> ?}
Leninia 12 {0 -> 1}; 13 {? -> 1}; 14 {? -> 1}; 20 {? -> 0}; 40 {? -> 0}; 86 {1 -> ?}; 88 {0 -> ?}; 89 {0 -> ?}; 94 {1 -> ?}; 96 {1 -> ?}; 107 {1 -> ?}; 108 {0 -> ?}
Hauffiopteryx 13 {1 -> 0}; 20 {1 -> 0}; 37 {? -> 0}; 56 {? -> 0}; 82 {2 -> 1}; 84 {? -> 1}; 104 {1 -> 0}; 110 {1 -> 0}; 112 {? -> 1}; 136 {0 -> 1}; 152 {? -> 0}; 160 {? -> 2}
Platypterygius australis 48 {? -> 0}; 79 {0 -> 1}; 82 {0 -> 2}; 121 {? -> 0}; 141 {0 -> 1}; 148 {? -> 1}; 159 {? -> 1}
Platypterygius americanus 46 {? -> 1}; 67 {1 -> ?}; 82 {0 -> 2}; 116 {? -> 1}; 117 {? -> 2}; 118 {? -> 2}; 119 {? -> 1}; 120 {? -> 3}; 121 {? -> 0}; 134 {1 -> ?}; 135 {0 -> ?}; 139 {1 -> ?}
Cryptopterygius 4 {0 -> 1}; 6 {1 -> 0}; 20 {1 -> ?}; 26 {1 -> ?}; 82 {0 -> 2}; 109 {0 -> 1}; 120 {3 -> 2}; 157 {1 -> 2}
Ophthalmosaurus icenicus 43 {? -> 0}; 48 {1 -> 0}; 66 {? -> 1}; 68 {? -> 1}; 118 {1 -> 2}
Ophthalmosaurus natans 14 {1 -> ?}; 37 {? -> 1}; 38 {? -> 1}; 41 {? -> 2}; 42 {? -> 1}; 43 {1 -> 0}; 44 {? -> 1}; 48 {? -> 0}; 56 {? -> 0}; 76 {? -> 3}; 88 {0 -> 1}; 107 {2 -> ?}; 128 {? -> 1}; 136 {1 -> 0}; 139 {1 -> 0}; 152 {? -> 1}
Sisteronia 146 {? -> 1}

Character Number Correspondence

The characters were renumbered in the present study relative to Ji et al. (2016) based on anatomical consistency rather than derivation, following editorial requirement. To facilitate comparison, below is a table for the correspondence between character numbers of the present study and Ji et al. (2016).

This study	Ji et al.	18	16	37	32	56	51	75	64
		19	167	38	33	57	164	76	65
1	1	20	17	39	34	58	189	77	66
2	2	21	18	40	35	59	171	78	67
3	3	22	19	41	168	60	185	79	68
4	4	23	20	42	36	61	47	80	69
5	5	24	170	43	37	62	48	81	70
6	6	25	21	44	38	63	52	82	71
7	166	26	22	45	39	64	53	83	72
8	7	27	23	46	40	65	54	84	73
9	8	28	24	47	41	66	55	85	74
10	9	29	25	48	42	67	56	86	75
11	10	30	169	49	43	68	57	87	76
12	11	31	26	50	44	69	58	88	77
13	12	32	27	51	45	70	59	89	78
14	13	33	28	52	46	71	60	90	79
15	184	34	29	53	49	72	61	91	80
16	14	35	30	54	50	73	62	92	81
17	15	36	31	55	165	74	63	93	82

94	83	115	177	136	114	157	134	178	152
95	84	116	102	137	115	158	135	179	153
96	85	117	103	138	181	159	136	180	182
97	86	118	104	139	116	160	137	181	194
98	87	119	105	140	117	161	138	182	195
99	88	120	106	141	119	162	139	183	155
100	89	121	107	142	120	163	140	184	156
101	90	122	108	143	121	164	141	185	157
102	91	123	109	144	118	165	142	186	159
103	92	124	110	145	122	166	143	187	161
104	93	125	111	146	123	167	160	188	162
105	94	126	112	147	124	168	144	189	163
106	95	127	113	148	125	169	145	190	183
107	96	128	172	149	126	170	146	191	154
108	97	129	173	150	127	171	147	192	187
109	98	130	174	151	128	172	148	193	188
110	99	131	179	152	129	173	149	194	192
111	100	132	180	153	130	174	158	195	193
112	178	133	186	154	131	175	191		
113	175	134	190	155	132	176	150		
114	176	135	101	156	133	177	151		

Character Description

1. Premaxilla dorsal process: (0) long; (1) short (modified from Maisch and Matzke, 2000:10)
2. Premaxilla ventral process: (0) long; (1) short (modified from Maisch and Matzke, 2000:9)
3. Maxilla anterior process: (0) reduced; (1) extending anteriorly as far as nasal or further anteriorly (Fischer et al., 2011:7)
4. Maxilla dorsal lamina: (0) absent; (1) present (Motani, 1999:2)
5. Maxilla prefrontal contact: (0) absent; (1) present (Maisch and Matzke, 2000:12)
6. Maxilla external naris contact: (0) present; (1) absent (Motani, 1999:3)
7. Maxilla longer than premaxilla: (0) true; (1) false
8. External naris orientation: (0) lateral; (1) dorsal (Motani, 1999:4)
9. Shallow groove anterior to the external naris: (0) absent; (1) present
10. Narial shelf: (0) absent; (1) present (Jiang et al., 2006:4)
11. Nasal anteriorly extending beyond external naris: (0) false; (1) true
12. Nasal parietal contact lateral to frontal: (0) absent; (1) present (Motani, 1999:7)
13. Nasal postfrontal contact: (0) no contact; (1) contact extensive, posterior extension of nasal separates frontal from prefrontal in dorsal view; (2) eliminated by prefrontal medially extension (Modified from Motani, 1999:6)
14. Descending process of the nasal on the dorsal border of the nares: (0) absent; (1) present (Fernández, 2007:2)

15. Nasals rostrally reaching snout tip: (0) false; (1) true
16. Processus narialis of prefrontal: (0) absent; (1) present (Fischer et al., 2011:11)
17. Supraorbital crest on prefrontal and postfrontal: (0) absent; (1) present (Maisch and Matzke, 2000:22)
18. Prefrontal–postfrontal contact: (0) absent; (1) present (Motani, 1999:8)
19. Prefrontal exposure in upper temporal fenestra: (0) absent; (1) present
20. Anterior orbital margin: (0) of regular rounded shape; (1) irregular (Maisch and Matzke, 2000:23)
21. Postfrontal medially extension: (0) over the anteriormost margin of upper temporal fenestra; (1) not over the anteriormost margin of upper temporal fenestra
22. Supratemporal antero-medial extension: (0) short; (1) long
23. Supratemporal-postorbital contact: (0) absent; (1) present (Fischer et al., 2013:15)
24. Supertemporal / squamosal relative size: (0) equal or st smaller; (1) st clearly larger
25. Sagittal eminence: (0) absent; (1) present but small, involving only the parietal; (2) present and large, involving the parietal, frontal and nasal (Motani, 1999:16)
26. Frontal dorsal exposure: (0) clearly present; (1) nearly absent
27. Frontal participation in upper temporal fenestra: (0) absent; (1) present
28. Squamosal triangular shape: (0) false; (1) true; (2) squamosal absent (Fischer et al., 2013:16)
29. Squamosal participation in upper temporal fenestra: (0) present; (1) absent; (2) squamosal absent (Motani, 1999:13)
30. Squamosal-quadrato articulation: (0) present; (1) absent
31. Postorbital postero-dorsal corner: (0) narrow, giving triradiate shape; (1) broad and triangular; (2) absent or round
32. Postorbital participation in upper temporal fenestra: (0) present; (1) absent (Motani, 1999:12)
33. Jugal anterior margin: (0) tapering, between lacrimal and maxilla; (1) broad and fan-like, covering ma
34. Jugal/quadratojugal lateral contact: (0) present; (1) absent (Motani, 1999:23)
35. Lower temporal arch between jugal and quadratojugal: (0) present; (1) lost (Fisher et al., 2013a:18)
36. Quadratojugal: (0) longer than tall; (1) taller than long.
37. Quadratojugal exposure: (0) quadratojugal small; (1) extensive; (2) small, largely covered by squamosal and postorbital (Fischer et al., 2013:17)
38. Parietal ridge: (0) absent; (1) present (Motani, 1999:17)
39. Parietal supratemporal process: (0) short; (1) long (Motani, 1999:18)
40. Parietals' anterior processes: (0) contacting each other anteriorly, eliminating frontal from pineal foramen; (1) narrowly separated anteriorly, forming parietal fork, and frontal dorsally visible along the pineal foramen; (2) widely open, resulting in absence of clear fork (Motani, 1999:19)
41. Parietal-frontal suture inter-digitation: (0) absent; (1) present
42. Anterior terrace of upper temporal fenestra: (0) absent; (1) present but small; (2) present and large (Motani, 1999:14)
43. Basioccipital peg: (0) clearly present; (1) absent or extremely reduced (Motani, 1999:29)
44. Basioccipital extracondylar area: (0) wide; (1) reduced to a narrow band of concavity (Motani, 1999:30)

45. Basioccipital/atlas articulation convexity: (0) flat or anterior; (1) posterior
46. Ventral notch in the extracondylar area of the basioccipital: (0) present; (1) absent (Fischer et al., 2012:19)
47. Pterygoid, transverse flange: (0) antero-lateral; (1) not well defined; (2) postero-lateral (Motani, 1999:26)
48. Basispterygoid processes: (0) short, giving basisphenoid a square outline in dorsal view; (1) markedly expanded laterally, being wing-like, giving basisphenoid a marked pentagonal shape in dorsal view (Fischer et al., 2011:18)
49. Interpterygoid vacuity: (0) present; (1) absent or extremely reduced (Maisch and Matzke, 1997:22)
50. Ectopterygoid: (0) present; (1) absent (Callaway, 1989:9)
51. Shape of the paroccipital process of the opisthotic: (0) short and robust; (1) elongated and slender (Fischer et al., 2012:20)
52. Stapes proximal head: (0) slender, much smaller than opisthotic proximal head; (1) massive, as large or larger than opisthotic (Fischer et al., 2013:24)
53. Cheek orientation: (0) lateral; (1) posterior (Motani, 1999:25)
54. Overbite: (0) absent or very slightly; (1) present (Motani, 1999:33)
55. Prenarial snout longer than the postorbital skull: (0) false; (1) true
56. Snout extremely slender: (0) no; (1) yes (Motani, 1999:34)
57. Snout, constriction: (0) absent; (1) present
58. Snout flattened: (0) false; (1) true
59. Scleral ring extensively ossified, filling or almost filling the orbit: (0) false; (1) true
60. Pineal foramen posterior to or between orbits: (0) posterior; (1) between
61. Angular lateral exposure at its maximum depth: (0) semi-equal to surangular; (1) clearly shallower than surangular; (2) much deeper than surangular (Motani, 1999:32)
62. Coronoid region: (0) slightly elevated or high; (1) flat (Jiang et al., 2006:13)
63. Root striations: (0) present; (1) absent (Fischer et al., 2013:4)
64. Plicidentine: (0) absent; (1) at least partly present (Motani, 1999:36)
65. Bony fixation of teeth: (0) present; (1) absent (Motani, 1999:43)
66. Tooth horizontal section: (0) circular; (1) disto-medially compressed; (2) lateral compressed (Motani, 1999:37)
67. Tooth size relative to the skull width: (0) over 0.1; (1) below 0.05 (Motani, 1999:39)
68. Dentigerous region in adult: (0) complete; (1) largely reduced; (2) edentulous
69. Dental groove: (0) present throughout jaw margin; (1) only present anteriorly; (2) absent (Motani, 1999:41, 42)
70. Anterior sockets: (0) present; (1) absent
71. Maxilla multiple tooth row: (0) absent; (1) present (Motani, 1999:40)
72. Dentary labial shelf: (0) present; (1) absent (Jiang et al., 2006: char14)
73. Posterior tooth crown: (0) conical; (1) rounded; (2) flat (Motani, 1999:38)
74. Tooth crown surface of at least one maxillary tooth with mesiodistal ridge: (0) false; (1) true (Jiang et al., 2006:18)
75. Ossified sternum: (0) absent; (1) present (Motani, 1999:50)
76. Ossified cleithrum: (0) present; (1) absent (Motani, 1999:51)
77. Clavicle orientation at proximal end: (0) oblique to sagittal plane; (1) transverse

78. Clavicle scapular process length distal to clavicular main body: (0) short; (1) long
79. Interclavicle anterior process separating clavicles: (0) present; (1) absent
80. Interclavicle posterior process: (0) rod-like; (1) triangular; (2) absent
81. Scapular blade shaft: (0) absent; (1) present at least proximally (Motani, 1999:47)
82. Scapula anterior flange: (0) complete; (1) emarginated; (2) absent (modified from Maisch and Matzke, 2000:70)
83. Scapula antero-proximal extension toward clavicle: (0) absent; (1) present
84. prominent acromion process of scapula: (0) absent; (1) present (Fischer et al., 2011:28)
85. Scapula posterior extension: (0) present; (1) absent (modified from Maisch and Matzke, 2000:71)
86. Scapular axis and glenoid facet orientations: (0) nearly parallel; (1) at 60 degrees or more (Motani, 1999:48)
87. Coracoid facet on scapula: (0) fused scapulocoracoid; (1) absent; (2) equal or smaller than glenoid facet of scapula; (3) twice as large as glenoid facet (Motani, 1999:49)
88. Coracoid parasagittal length vs. transverse width: (0) semi-equal or longer than wide; (1) clearly wider than long
89. Coracoid foramen: (0) present; (1) absent
90. Coracoid anterior notch or concavity: (0) absent; (1) present
91. Coracoid posterior notch or concavity: (0) absent; (1) present
92. Interacoid facet: (0) short, medial margin round shaped; (1) long, medial margin relatively straight (modified from Maisch and Matzke, 2000:73)
93. Humerus anterior flange: (0) absent; (1) present and complete; (2) present but reduced proximally, leaving leading edge tuberosity (Callaway, 1989:29)
94. Plate-like dorsal ridge on humerus: (0) absent; (1) present (Motani, 1999:56)
95. Protruding triangular deltopectoral crest on humerus: (0) present but small; (1) present and very large, bordered by concave areas (Fischer et al., 2013:39)
96. Humerus distal proximal width ratio: (0) nearly equal; (1) distal wider (Motani, 1999:55)
97. Humerus with posterodistally deflected ulnar facet and distally facing radial facet: (0) ulnar facet contains convexity in lateral view; (1) absent; (2) present (modified from Fischer et al., 2013:42).
98. Humerus distal articular facets: (0) not terminal; (1) radial facet larger than ulna facet; (2) two facet nearly equal; (3) three facets (Motani, 1999:52)
99. Humerus anterodistal facet for accessory zeugopodial element anterior to radius: (0) absent; (1) present (Fischer et al., 2013:41)
100. Humerus/intermedium contact: (0) absent; (1) present (Fernández, 2007:15)
101. Radius peripheral shaft: (0) complete or nearly complete; (1) notch or absent (modified from Motani, 1999:59) please see the text for detailed discussion.
102. Radius contiguous shaft: (0) about half or more of radial length; (1) notch or absent (modified from Motani, 1999:60) please see the text for detailed discussion.
103. Ulna peripheral shaft: (0) complete or nearly complete; (1) notch or absent (modified from Motani, 1999:62) please see the text for detailed discussion
104. Ulna contiguous shaft: (0) complete or nearly complete; (1) notch or absent (modified from Motani, 1999:63) please see the text for detailed discussion
105. Shape of the posterior surface of the ulna: (0) radius not discoidal; (1) rounded or straight and

- nearly as thick as the rest of the element; (2) concave with a thin, blade-like margin (Fischer et al., 2012:36)
106. Radius/ulna relative size: (0) nearly equal; (1) radius much larger than ulna; (2) ulna larger than radius (Motani, 1999:64)
 107. Radio-ulnar foramen: (0) present; (1) absent (Fischer et al., 2013:46)
 108. Radiale, anterior notch: (0) absent; (1) present (Motani, 1999:65)
 109. Manual pisiform: (0) present; (1) absent (Motani, 1999:67)
 110. Manual pisiform 2 (neomorph): (0) absent; (1) present (Jiang et al., 2006:20)
 111. Intermedium: (0) longer than wide; (1) as wide as long or wider than long (Jiang et al., 2006)
 112. Proximal carpals: (0) packed; (1) small, round and separated
 113. Distal carpal 1: (0) ossified; (1) unossified; (2) absent
 114. Distal carpal 2: (0) ossified; (1) unossified; (2) absent
 115. Manual centralia: (0) present; (1) absent
 116. Metacarpal I peripheral shaft: (0) complete; (1) notch or largely reduced; (2) absent; (3) mc 1 not ossified (Motani, 1999:68)
 117. Metacarpal III shaft: (0) present; (1) absent (Motani, 1999:69)
 118. Metacarpal V: (0) present; (1) not ossified (Motani, 1999:70)
 119. Manual digit 2 distal elements peripheral shaft: (0) complete; (1) notch or absent; (Motani, 1999:71)
 120. Forelimb hyperphalangy with more than five phalanges ossified in longest digit: (0) absent; (1) present (Motani, 1999:77)
 121. Notching of anterior facet of leading edge elements of forefin in adults: (0) elements not discoidal; (1) present; (2) absent (Fischer et al., 2013:48)
 122. First preaxial accessory digits on forelimb: (0) absent; (1) present (Maisch and Matzke, 2000:91)
 123. Postaxial accessory digit on forelimb: (0) absent; (1) only one; (2) more than one (Motani, 1999:72)
 124. Proximal manual phalanges proximo-distal packing: (0) well-packed; (1) not packed
 125. Manual digit between 4th and 5th digits: (0) absent; (1) present (Motani, 1999:73)
 126. Propodial + epipodial versus manus length: (0) propodial + epipodial longer; (1) manus longer (Motani, 1999:58)
 127. Forelimb/hindlimb ratio: (0) nearly equal or hind longer; (1) forelimb longer but less than twice as hindlimb; (2) forelimb longer twice as much as hindlimb (Motani, 1999:79)
 128. Zeugopodium flattened: (0) false; (1) true
 129. Manual anterior sesamoid: (0) absent; (1) present
 130. Second preaxial accessory digit of forelimb: (0) absent; (1) present
 131. Delayed mesopodial ossification: (0) present; (1) absent
 132. Forelimb hypophalangy with less than five digits ossified in longest digit: (0) absent; (1) present
 133. Carpus elongated, as long as the more distal forelimb part or longer: (0) false; (1) true
 134. Extra proximal carpal preaxially: (0) absent; (1) present
 135. Interdigital separation: (0) present; (1) absent (Motani, 1999:78)
 136. Iliac blade shape: (0) with thick shaft; (1) plate-like; (2) narrow and styloid (Motani, 1999:80)

137. Iliac antero-medial prominence: (0) absent; (1) present (Motani, 1999:81)
138. Ilium-pubis relative proximo-distal length: (0) semi-equal; (1) ilium clearly shorter
139. Pubis, styloidal or plate-like: (0) plate-like; (1) styloidal (Motani, 1999:85)
140. Pubis obturator foramen: (0) completely enclosed in pubis; (1) mostly in pubis but open on one side; (2) part of obturator fossa (Motani, 1999:84)
141. Pubis and ischium median symphysis: (0) present; (1) not well defined (modified from Maisch and Matzke, 2000:108)
142. Pubis and ischium fused in adult: (0) complete; (1) absent; (2) present only medially; (3) present medially and distally (Motani, 1999:83)
143. Pubis ischium relative size: (0) nearly equal or ischium slightly larger; (1) pubis twice as large as ischium (Motani, 1999:86)
144. Ischium, styloidal or plate-like: (0) plate-like, longer sagittally than wide transversely; (1) plate-like, wider transversely than long sagittally; (2) styloidal (modified from Motani, 1999:87)
145. Thyroid fenestra: (0) absent; (1) one median opening; (2) two openings, being medially separated (Motani, 1999:82)
146. Femur strongly constricted medially, forming a slender shaft region, proximal width remarkably larger than medial width: (0) present; (1) absent
147. Femur antero-distal expansion, forming a distinctive structure at the distal end: (0) absent; (1) present.
148. Prominent, ridge-like dorsal and ventral processes demarcated from the head of the femur and extending up to mid-shaft: (0) absent; (1) present (Fischer et al., 2011:46)
149. Wide distal femur blade: (0) absent, the proximal and distal extremity of the femur being sub-equal in dorsal view; (1) present (Fischer et al., 2013:61)
150. Femur distal facets: (0) two; (1) three (Maxwell, 2010:32)
151. Astragalus/femoral contact: (0) absent; (1) present (Maxwell, 2010:33)
152. Femur anterodistal facet for accessory zeugopodial element anterior to tibia: (0) absent; (1) present (Fischer et al., 2011:48)
153. Tibia contiguous shaft: (0) complete or nearly complete; (1) notch or absent (Motani, 1999:91)
154. Tibia peripheral shaft: (0) complete or nearly complete; (1) notch or absent (modified from Motani, 1999:92)
155. Tibia antero-proximal end nearly rectangular, forming a deep notch on the anterior margin: (0) absent; (1) present
156. Fibula posterior extent: (0) not fixed, fibula being mobile relative to femur; (1) much posterior to femur; (2) about the same level as femur (Motani, 1999:93)
157. Fibula contiguous margin: (0) concave; (1) nearly straight or convex
158. Fibula posterior flange: (0) absent; (1) present
159. Tibia and fibula: (0) in contact or closely placed with each other; (1) widely separated from each other (Motani, 1999:88)
160. Spatium interosseum between tibia and fibula: (0) present; (1) absent (Fischer et al., 2013:64)
161. Hind fin leading edge element in adults: (0) elements not discoidal; (1) notched; (2) straight (Fischer et al., 2013:65)
162. Postaxial accessory digit in hind limb: (0) absent; (1) present (Fischer et al., 2011:50)

163. Pes digit 1: (0) present; (1) absent (Motani, 1999:89)
164. Distal tarsal 2 in line with distal tarsals 3 and 4: (0) true; (1) false, distal tarsal 2 in line with calcaneum
165. Atlas/axis fusion: (0) absent; (1) present (Motani, 1999:94)
166. Presacral count: (0) less than 30; (1) between 40-52; (2) 55 or more (Motani, 1999:95)
167. Vertebra count between sacral and apical about: (0) tail stem not well defined; (1) 1/2 of the prepelvic count; (2) 2/3 of the prepelvic count or more
168. Posterior dorsal centra shape: (0) cylindrical; (1) discoidal (Motani, 1999:97)
169. Posterior dorsal/anterior caudal centra degree of shortening: (0) 3.5 times or less as high as long; (1) four times or more as high as long (Fischer et al., 2013:26)
170. Cervical bicipital rib facet: (0) absent; (1) present (Motani, 1999:99)
171. Rib articulation in thoracic region: (0) predominantly unicapitate; (1) exclusively bicapitate (Maisch and Matzke, 2000:53)
172. Antero-dorsal rib facets: (0) confluent with anterior facet in at least near pelvic girdle; (1) not confluent in any of the centra (Motani, 1999:101)
173. Posterior-dorsal bicipital rib facet: (0) absent; (1) present, might be resulted from the split of diapophysis (Motani, 1999:100)
174. Last caudal rib facet reaching the caudal peak area: (0) false; (1) true
175. Rib mid-shaft broadening rostro-caudally: (0) absent; (1) present
176. Sacral ribs: (0) at least two, distinguishable; (1) absent (Motani, 1999:104)
177. Anterior dorsal neural spine: (0) normal; (1) narrow (Motani, 1999:102)
178. Neural spines of atlas-axis: (0) functionally separate, never fused; (1) completely overlapping, may be fused (Druckenmiller and Maxwell, 2010:26)
179. Neural spine anticlination in tail: (0) absent; (1) present (Motani, 1999: 103)
180. Dorsal neural arch, transverse process: (0) present; (1) absent
181. Second dorsal segment on dorsal neural spines: (0) absent; (1) present
182. Anterior dorsal neural spines with thickened central axis and rostral and caudal median ridges or flanges: (0) absent; (1) present
183. Caudal peak with curved vertebral column, near anticlination of neural spine: (0) absent; (1) present (Motani, 1999:96)
184. Anterior caudal vertebral size about 1/2 of the largest dorsal vertebrae or less: (0) false; (1) true
185. Mid-caudal vertebrae height change: (0) gradually decrease; (1) increase; (2) sudden decrease (Motani, 1999:98)
186. Pre-flexural wedge-shaped centra: (0) absent; (1) present
187. Tail: (0) as long or longer than the rest of the body; (1) distinctly shorter (modified from Maisch and Matzke, 2000:65)
188. Lunate tailfin: (0) absent; (1) well developed lunate tailfin (modified from Maisch and Matzke, 2000:66)
189. Chevrons in apical region: (0) present; (1) absent (Sander et al., 2000:72)
190. Fluke vertebrae, laterally flattened and packed: (0) absent; (1) present
191. Posterior gastralia immediately craniad of pelvic girdle: (0) present; (1) absent (Motani, 1999:105)
192. Flat gastral elements with caudad one outlying the craniad one: (0) absent; (1) present

195. Dermal armor above dorsal neural spines, first layer: (0) absent; (1) present

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Parahupehsuchus

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Eretmorhipis

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Sclerocormus

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Cartorhynchus

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Chaohusaurus geishanensis

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Chaohusaurus chaoxianensis

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Chaohusaurus zhangjiawanensis

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Mixosaurus panxianensis

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Mixosaurus cornalianus

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Mixosaurus kuhnschnyderi

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Phalarodon atavus

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Phalarodon fraasi

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Phalarodon callawayi

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Cymbospondylus piscosus

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Cymbospondylus buchseri

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Cymbospondylus nichollsi

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Xinminosaurus

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Besanosaurus

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Guizhouichthyosaurus

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Callawayia wolonggangensis

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Guanlingsaurus

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Shastasaurus

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Shonisaurus popularis

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Shonisaurus sikanniensis

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Californosaurus

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Toretocnemus

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Qianichthyosaurus zhoui

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Qianichthyosaurus xingyiensis

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Callawayia neoscapularis

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Macgowania

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Temnodontosaurus

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Leptonectes tenuirostris

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Leptonectes moorei

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Leptonectes solei

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Excalibosaurus

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Eurhinosaurus

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Stenopterygius

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Aegirosaurus

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Acamptonectes

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Maiaspondylus

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Arthropterygius

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Sveltonectes

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Brachypterygius

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Malawania

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Mollesaurus

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Palvennia

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Sisteronia

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Squamata

(012)0(01)000(01)0(01)00(012)010(12)0000(01)11000000(01)0(01)1(01)(012)(02)1011
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Prolacerta

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Trilophosaurus

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Rhynchosauria

0111101000000?01111101101000001111231111112100111000001111110011?001110
011001000010101010111101111121102001102000010110100?00100101110012100?0?011
0001110010100010110001100011010111101011101100300000112?0000110010100?00

Archosauriformes

(01)1(01)(01)101(01)(01)1000(01)0101110000(01)(01)00001010(02)(02)1?(01)1011(12
)0010(01)0010(01)1(01)111?011111?11?1(01)0110100001(01)1(01)1(012)1011(01)111001?
1110000(01)10(12)00001(012)10(01)(01)0(01)01010(01)1(02)112001(12)?00?0(12)0110001
1011001000(01)0110001(012)01011010111101(01)11100(01)(01)02000001(01)2(01)00001(
01)0(01)1(01)(12)00?00

Claudiosaurus

100000?110000?11010?0?0001?001101100101102201001100?001000?10????10???000
10010100000120100001?10010010000001010000?0110000?0100010101000010000001100
0100?00010001102000100100001011000000000001010000010000010111011100000

Coelurosauravus

00?0001111000??000??100000010011?011110221?0010?0????1?1110?11????1?????
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Kuehneosauridae

0100001010000011110?00000100010010201011022200011301010001111??001??100
0110?0010?00?0?0110100011?010000000010?0010101100?111?1?0002000??0000001110
00000100100?02120?00??00?10211001??100?01?10000??0000011100?1000?00

Acerosodontosaurus

1???0?10????00????0?00?0?0?0?1?????002001?????????0?0?0?????????????
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Tangasaurus

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1001211?0200(01)1101(01)01(12)001201000110110000110000011(01)10??? (01)????0????
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Simosaurus

2000001010100??2010?0?00000011011111011022010111?010011001101??1???10?10
00111?011000211011010?11??110001101121100111011101010?111102000?00?00110012
100020011101112001201?0011?110000110000211?10?????????0?2?????000?0

Placodus

0010011101010??2010?11?00101010111101111002010?01?010010011101??1?1?1101
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111000000111010112001201000110111000110000(02)11220?????????0??2??0??100000

Pistosauridae

10?0001010100??2011?0??01100011011131011012011??1?0?0111001101??1???11?10
01011?0110?0?1?0???10?11??1000011011210001110??1010100?1?102(01)0??? (01)0?0(01)
11101?1?0200?1101112011001010(01)?01?000????001??0(012)1?????????2?????000
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Askeptosaurus

100001110010000100100?001010101010001111012101??0101?11101111?11?01?1?00
01?0?010000112110001100111?01000000112100010101101101000101010?000000?001000
01000000000010121011001000?101110000111000102?1??0?0?00000?????100000

Clarazia

0011001100100??001?0???11011100?00?1110122?1??010??111?1111???????1?0001
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0000000?0????2001?00?00??11110?01110000110?0??????000?0?0???100000

Thalattosaurus

1011001100100??011?01?0?110?1100?00?111012201??010??111?1111???????1???01
?0?01???0?1?111101100011121100001?12011?1010?00?10??00?01?????????????????
100?00???????1?????????01?????????01???1?????0?00???????1000??

Helveticosaurus

00?1001?1?????0?000?0?1?0????1??11??0?????????????????????????????????
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10001?111001?010000100110??111000?11320?0???0???0???0?0000

Largocephalosaurus

00?0001?00000??201110?100110001011310111020210?1?10?0???0010???????1?0?1
?21?100?0???100000?000?01?0(01)0?0??2??01101?1110?101000(01)?2(23)2?00100011
1101210002001?101(02)1210110010(01)00?0011??0(01)100??(02)10100?????????????
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Sinosauropsphargis

00?0001000000??01110?1001110?00??300111020210?1??0??0???010?????1?00??
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???1?10????10110000?????????????2??100?????????????100???

Wumengosaurus

10?0011100001?0100110?00010?(01)010?1???0110221?0111?????1?01?0???????????

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0002000?00130220010010100?0110??0?0000?11311???????0???????00000

Nanchangosaurus

10?0?01?0?000?0100110?00011110011110101102210011001?00?00?0?0?????????
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000?00113122?11?1?00??001?????????01020?????????????????01000

Hupehsuchus

10?0?01101000?0100111?00011110011110001102210011001?0?00?0?0?????????
??11?0??1???0?0100??0?0??02?????12100?101?110?00100000002010111012121100?1??
0000?00113122111110001?001001001000001020?????????????????010{01}0

Chaohusaurus

10?0011101001?0100111?00112000010100101102210011001?0?00?010?????????0??
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0210?0000000113122111(01)011000?101000011100001(01)001?????????????????00100

Utatusaurus

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00000000113122?11(01)011000?1010010011000010001??????0???1?????00100

Cartorhynchus

00?0011101001?0100010?00002(01)00100100111102210011001?0?1?01?0?0?????????
?????????????0?00001?0000???12???????0?100?110?0210?0?10100001100302110001
000000000113122111?0?10?0?001?????????01?010?????????????????10101

Sclerocormus

00??011??1001?0100?11?100001001001000111{01}200??0?00???????1?????????????
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0???0?1?????????0?100?001?????????01?000?????????1?????11111

Character matrix for the relationships of diapsids including aquatic adaptations (Extended Data Fig. 2b)

Character Matrix

Seymouriidae

000000000000000000000000100??00000010?0000000?00000000000000000000000000000
0000000000000000000000000?00000001010(01)1100000000000100000000(01)1000?0??0
000000000000100?

Synapsida

(01)0000000(01)(01)0000000000000?000011(01)0?100(01)0000101000(0)0000000000
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00000010?0000?0?00000000000(01)01000000000001000(01)00000000000000000000(02)
00000(01)00000000000000000000

Parareptilia

(01)00000(01)10000000(01)0000(01)1(01)??(01)0(01)010(01)0?(01)000000?(01)(01)10

10010100000120100001?10010010000001010000?0110000?0100010101000010000001100
0100?00010001102000100100001011000000000001010000010000010111011100000

Coelurosauravus

00?0001111000??000??100000010011?011110221?0010?0?0??1?1110?11??0?1????
?????????????1?01?????31?0?00?????0?010110?00?0?0001000?01??1?00?????????0?
??0?00020?002?0?00??101000000000010100100100?0000110010?000??

Kuehneosauridae

0100001010000011110?00000100010010201011022200011301010001111??001??100
0110?0010?00??0?0110100011?010000000010?0010101100?111?1?0002000??0000001110
00000100100?02120?00??00?10211001??100?01?10000??0000011100?1000?00

Acerosodontosaurus

1???0??10????00????0??00??0??0?1?????002001?????????0??0?????????????
????0???????11?????1?1????0????0?00?00?0??0??0?0?01?????0??0????????????00
100?20?10?1????????????????????0?????????0??3????0??0??

Tangasaurus

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??????00??????????01??????0??0?1?????0??0?0??0??0??00

Youngina

10000000000000001000?00?001?001101100??000110?000000100??0?10?1?????????
10?00?00100?01?????00??1000000101000000?0?0000?10??0?01001?????00??0?0?10
10?01?00100?0?0?0?0001??1?????000?10?0000000(01)???1??03????0?0?000

Thadeosaurus

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20?2001000000?011100?0?0?1?1000??00?000000?10?100?0?00

Lanthanolania

10???0?00?000?01????0?0???001?1???????012???????0?????????????????????0??
????0?????????1????????0????0?2??
????????????????????????????????0?????????3?????0???

Orovenator

10?0000?100000000010000?010001???0{02}101???1{12}?????0?0?????0?10?00?0??
??000100000?000000?10??0?00001?01?000000000?0?00????????????????????
????????????????????????????????????0???000?????????3?????0???

Sophineta

000000101000?101000?11102000?01?11001?11022000010???????1111?????????01
?0?10???0000010?0?0?????310?0000??0?0?00?1??1?0010?0??01????????????
????????????????0????????????000????00???????010??????0??

Pamelina

010000101000??11110000000101?10?1020101102220?0113???????1111?????????1?01
?0?0?0??00?0?010?0?0????010?00?0?010?0?10?0?0?0101?11??02????????????
????????????????????????????????0??1?00?0??????11?????????

Tanystropheus

11000011?1000?01011?0010001001011101111012201??0001001101110111?1111?10

0100100000000201010010100110100000011210001012110(012)?01100101020000?00?000
11000110000000001012100120101111011100011110020000010010200001310010100000

Choristodera

211000010101010111(01)00?1100000010?(01)2111110110?(01)001001011101110111?
0011?0??110010001000011010010?0??10110000010100001110100010(01)1001100100011
00?00111000101?00010001(02)1120010010(01)0?101110?101110101010010010001000100
110100000

Macrocnemus

11000011?1000?01?11?0?1?01?000001021111101210?????0??0?1?1011?11?01?1110?
1?0??0??00??0101001?1001101?0000010110001012110??00100101?10011?000000110001
10000000001?122001?00011110111000011101000000100102000?131?010100000

Hovasaurus

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00120?2?010?10000?01?10000?0??101020??00000000?300?100?0010

Pachypleurosaurus

1000001000(01)00??2010?0??00100111111001(01)11022010111?0?10?1011101??1???
11?1001111?0111??0?010010?111?11000000102100010101110101000110020002?00?001
1001211?0200(01)1101(01)01(12)001201000110110000110000011(01)10111(01)10111013
0112(01)1000?0

Simosaurus

2000001010100??2010?0??00000011011111011022010111?010011001101??1???10?10
00111?011000211011010?11??110001101121100111011101010?111102000??00?00110012
100020011101112001201?0011?110000110000211?10111?10111012011212000?0

Placodus

0010011101010??2010?11?00101010111101111002010?01?010010011101??1?1?1101
10200110110?01001101111000111101101102101000101101011001101020001?00?111110
111000000111010112001201000110111000110000(02)11220111010110112010?1100000

Pistosauridae

10?0001010100??2011?0??01100011011131011012011??1?0?0111001101??1???11?10
01011?0110?0?1?0???10?11??1000011011210001110??1010100?1?102(01)0???01)0?0(01)
11101?1??0200?1101112011001010(01)?01?000????001??0(012)1111??01111?2?1?21?0
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Askeptosaurus

100001110010000100100?001010101010001111012101??0101?11101111?11?01?1?00
01?0?010000112110001100111?010000001121000101011011000101010?000000?001000
01000000000010121011001000?101110000111000102?111000000000301121100000

Clarazia

0011001100100??001?0????11011100?00?1110122?1??010??111?1111???????1?0001
10?010??0?1?0111011?000??311000011101110?0?0110?0010?0?01010?01?000??110?010
0000000?0???2001?00?00??11110?01110000110?011?0?0?000?00?1??100000

Thalattosaurus

1011001100100??011?01?0?110?1100?00?111012201??010??111?1111???????1???01

Supplementary Table S1. Measurements (in mm) of the holotype of *Sclerocormus parviceps* gen. et sp. nov. (AGB6265).

Length of skeleton	1599.3
Length of skull along the mid-line	76.3
Length of skull from the tip to the posterior margin of the supratemporal	100.0
Length of dorsal trunk	602.5
Length of tail	920.5
Length of the prenarial snout	19.0
Length of the constricted narrow premaxillary snout	22.1
Length of the preorbital snout	35.1
External naris opening	ab3.8
Anterior-posterior length of the orbit	36.3
Anterior-posterior length of the upper temporal fenestra	ab36.7
Anterior-posterior length of the pineal fossa	9.1
Width of the parietal skull table at the level of pineal fossa	19.7
Depth of the post occipital embayment	24.5
Number of cervical vertebrae	5
Number of dorsal trunk vertebrae	ca. 29 (14+15?)
Number of sacral vertebrae	2
Number of caudal vertebrae	ca. 67
Height of neural spine of 1 st trunk vertebra	47.0
Width of neural spine of 1 st trunk vertebra (at mid height)	13.2
Height of neural spine of 5 th trunk vertebra	43.4
Width of neural spine of 5 th trunk vertebra	13.9
Length of 5 th rib	ca. 182.6
Width of proximal end of 5 th trunk rib	22.4
Width of distal end of 5 th trunk rib	10.4
Length of the 1 st sacral vertebra, preserved part	14.8
Height of the 1 st sacral vertebra	17.2
Length of the 2 nd sacral vertebra	15.5
Height of the 2 nd sacral vertebra	16.8
Length of the 1 st caudal vertebra	15.4
Height of the 1 st caudal vertebra	17.5
Length of the 5 th caudal vertebra	14.0
Height of the 5 th caudal vertebra	18.8
Length of the top of neural spine of the 5 th caudal vertebra	15.9
Height of the neural spine of the 5 th caudal vertebra	18.7
Length of the 1 st sacral rib	19.3

Width of the proximal end of the 1 st sacral rib	7.6
Width of the distal end of the 1 st sacral rib	11.6
Length of the 2 nd sacral rib	17.5
Width of the proximal end of the 2 nd sacral rib	9.3
Width of the distal end of the 2 nd sacral rib	6.9
Length of the 1 st caudal rib	15.5
Width of the proximal end of the 1 st caudal rib	7.5
Width of the distal end of the 1 st caudal rib	3.2
Length of the dorsal process of the right clavicle	68.6
Width of the lateral corner of the right clavicle	10.6
Length of the dorsal-ventral diameter of the scapula	47.8
Antero-posterior length of the scapula	34.9
Length of preserved carpal and hand	170.8
Length of the preserved carpal space	103.0
Length of the preserved metacarpal-phalanges	67.8
Width of the preserved distal end of the ulna	33.4
Largest diameter of the ulnare	16.1
Largest diameter of the preserved intermedium	15.7
Largest diameter of the radiale	5.8
Largest diameter of the centralia	11.6
Largest diameter of the distal carpal 5	13.3
Largest preserved diameter of the distal carpal 4	12.5
Length of 1 st metacarpal	10.6
Length of 2 nd metacarpal	10.5
Length of 3 rd metacarpal	12.4
Length of 4 th metacarpal	12.5
Length of 5 th metacarpal	9.1
Length of the right ilium	33.3
Width of the dorsal end of the right ilium	17.2
Width at the medial part of the right ilium	12.4
Width of the ventral end of the right ilium	21.6
Antero-posterior length of the right pubis	24.0
Latero-medial length of the right pubis	22.7
Antero-posterior length of the right ischium	29.1
Latero-medial length of the left ischium	>19.7
Length of tarsal and foot	113.9
Length of the preserved tarsal space	53.5
Length of the preserved metatarsal-phalanges	60.4

Length of the right femur	40.2
Width of the proximal end of the right femur	22.1
Width at the medial part of the right femur	22.3
Width of the distal end of the right femur	22.9
Length of the right tibia	27.0
Width of the proximal end of the right tibia	16.7
Width at the medial part of the right tibia	12.3
Width of the distal end of the right tibia	14.8
Length of the right fibula	32.4
Width of the proximal end of the right fibula	16.5
Width at the medial part of the right fibula	12.5
Width of the distal end of the right fibula	19.9
Largest diameter of the astragalus	13.4
Largest diameter of the calcaneus	11.6
Length of 1 st metatarsal	5.1
Length of 2 nd metatarsal	8.5
Length of 3 rd metatarsal	10.9
Length of 4 th metatarsal	11.2
Length of 5 th metatarsal	9.3

Supplementary Table S2. Data source for Fig. 4. Values for non-shastasaurids were measured from published reconstructions with scales. *Cartorhynchus* and Shastasaurid values are from the text of references. The body length of *Cartorhynchus* assumes a tail/body proportion of *Chaohusaurus* but it may be as large as 472 mm based on the proportion in *Sclerocormus* (i.e., the point would shift right in Fig. 4a).

	Body Length (mm)	Skull Length (mm)	Source
<i>Chaohusaurus</i> sp.	990	119	AGM L-4
<i>Chaohusaurus</i> sp.	763	101	Fig. 3 in ref ⁴
<i>Chaohusaurus</i> newborn	183	35	Fig. 4 in ref ⁴
<i>Cartorhynchus lenticarpus</i>	~400	58	Ref ²
<i>Hupehsuchus</i> sp.	885	134	Fig. 1 in ref ⁵
<i>Utatsusaurus hataii</i>	2562	347	Fig. 68 in ref ⁶
<i>Guizhouichthysaurus tangae</i>	5400	855	ref ⁷
<i>Guanlingsaurus liangae</i>	8300	689	ref ⁸
<i>Mixosaurus cornalianus</i>	751	188	Fig. 68 in ref ⁶
<i>Temnodontosaurus platyodon</i>	6879	1467	Fig. 68 in ref ⁶
<i>Ophthalmosaurus icenicus</i>	4409	1063	Fig. 68 in ref ⁶
<i>Stenopterygius quadriscissus</i>	2332	439	Fig. 4 in ref ⁴
<i>Stenopterygius</i> newborn	641	201	Fig. 4 in ref ⁴
<i>Sclerocormus parviceps</i>	1601	100	Present study

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Supplementary Table S3. Data for Fig. 5.

We did not include *Quasianosteosaurus* because it is based on two very fragmentary pieces of rock, one preserving only impression of a part of the cheek, and the other a small part of the snout. Its published diagnosis did not contain any unique apomorphy. Its addition would favor our argument for the taxonomic turnover at the Early/Middle Triassic boundary but only result in unnoticeable changes in Fig. 5.

Genus	Species	CLADE	FirstSubstage	LastSubstage
<i>Cartorhynchus</i>	<i>lenticarpus</i>	Ichthyosauriformes	Spathian	Spathian
<i>Chaohusaurus</i>	<i>chaoxianensis</i>	Ichthyopterygia	Spathian	Spathian
<i>Chaohusaurus</i>	<i>geishanensis</i>	Ichthyopterygia	Spathian	Spathian
<i>Chaohusaurus</i>	sp.	Ichthyopterygia	Spathian	Spathian
<i>Chaohusaurus</i>	<i>zhangjiawanensis</i>	Ichthyopterygia	Spathian	Spathian
<i>Corosaurus</i>	<i>alcovens</i>	Sauropterygia	Spathian	Spathian
<i>Eohupehsuchus</i>	<i>brevicollis</i>	Hupehsuchia	Spathian	Spathian
<i>Eretmorhipis</i>	<i>carrolldongi</i>	Hupehsuchia	Spathian	Spathian
<i>Grippia</i>	<i>longirostris</i>	Ichthyopterygia	Spathian	Spathian
<i>Hanosaurus</i>	<i>hupehensis</i>	Sauropterygia	Spathian	Spathian
<i>Hupehsuchus</i>	<i>nanchangensis</i>	Hupehsuchia	Spathian	Spathian
<i>Isfjordosaurus</i>	<i>minor</i>	Ichthyopterygia	Spathian	Spathian
<i>Keichousaurus</i>	<i>yuananensis</i>	Sauropterygia	Spathian	Spathian
<i>Kwangsaisaurus</i>	<i>orientalis</i>	Sauropterygia	Spathian	Spathian
<i>Majiashanosaurus</i>	<i>discoracoidis</i>	Sauropterygia	Spathian	Spathian
<i>Nanchangosaurus</i>	<i>sun</i>	Hupehsuchia	Spathian	Spathian
<i>Omphalosaurus</i>	<i>nettarhynchus</i>	Omphalosauria	Spathian	Spathian
<i>Omphalosaurus</i>	<i>nisseri</i>	Omphalosauria	Spathian	Spathian

<i>Parahupehsuchus</i>	<i>longus</i>	Hupehsuchia	Spathian	Spathian
<i>Sclerocormus</i>	<i>parviceps</i>	Ichthyosauriformes	Spathian	Spathian
<i>Thaisaurus</i>	<i>chonglakmanii</i>	Ichthyopterygia	Spathian	Spathian
<i>Utatusaurus</i>	<i>hataii</i>	Ichthyopterygia	Spathian	Spathian
<i>Agkistrognathus</i>	<i>campbelli</i>	Thalattosauriformes	Spathian_question	Longobardian_question
<i>Paralonectes</i>	<i>merriami</i>	Thalattosauriformes	Spathian_question	Longobardian_question
<i>Parvinatator</i>	<i>wapitiensis</i>	Ichthyopterygia	Spathian_question	Longobardian_question
<i>Gulosaurus</i>	<i>helmi</i>	Ichthyopterygia	Spathian_question	Longobardian_question
<i>Cymatosaurus</i>	<i>fridericianus</i>	Sauropterygia	Aegean	Aegean
<i>Cymatosaurus</i>	<i>latifrons</i>	Sauropterygia	Aegean	Aegean
<i>Cymatosaurus</i>	<i>minor</i>	Sauropterygia	Aegean	Aegean
<i>Cymatosaurus</i>	<i>multidentatus</i>	Sauropterygia	Aegean	Aegean
<i>Germanosaurus</i>	<i>schafferi</i>	Sauropterygia	Aegean	Aegean
<i>Chinchenia</i>	<i>sungi</i>	Sauropterygia	Aegean_question	Aegean_question
<i>Sanchiaosaurus</i>	<i>dengi</i>	Sauropterygia	Aegean_question	Aegean_question
<i>Thalattosaurus</i>	<i>borealis</i>	Thalattosauriformes	Aegean_question	Longobardian_question
<i>Shingyisaurus</i>	<i>unexpectus</i>	Sauropterygia	Anisian_question	Anisian_question
<i>Tanystropheus</i>	<i>conspicuus</i>	Protorosauria	Anisian_question	Anisian_question
<i>Nothosaurus</i>	<i>winkelhorsti</i>	Sauropterygia	Bithynian	Bithynian
<i>Nothosaurus</i>	<i>winterswijkensis</i>	Sauropterygia	Bithynian	Bithynian
<i>Palatodonta</i>	<i>bleekeri</i>	Sauropterygia	Bithynian	Bithynian
<i>Pararcus</i>	<i>diepenbroeki</i>	Sauropterygia	Bithynian	Bithynian
<i>Psephosaurus</i>	<i>mosis</i>	Sauropterygia	Bithynian	Bithynian
<i>Phalarodon</i>	<i>atavus</i>	Ichthyopterygia	Bithynian	Illyrian
<i>Placodus</i>	<i>gigas</i>	Sauropterygia	Bithynian	Fassanian
<i>Atopodentatus</i>	<i>unicus</i>	Sauropterygia	Pelsonian	Pelsonian

<i>Diandongosaurus</i>	<i>acutidentatus</i>	Sauropterygia	Pelsonian	Pelsonian
<i>Dianopachysaurus</i>	<i>dingi</i>	Sauropterygia	Pelsonian	Pelsonian
<i>Dinocephalosaurus</i>	<i>orientalis</i>	Protorosauria	Pelsonian	Pelsonian
<i>Largocephalosaurus</i>	<i>polycarpon</i>	Saurosphargidae	Pelsonian	Pelsonian
<i>Largocephalosaurus</i>	<i>qianensis</i>	Saurosphargidae	Pelsonian	Pelsonian
<i>Lariosaurus</i>	<i>hongguoensis</i>	Sauropterygia	Pelsonian	Pelsonian
<i>Mixosaurus</i>	<i>panxianensis</i>	Ichthyopterygia	Pelsonian	Pelsonian
<i>Nothosaurus</i>	<i>yangjuanensis</i>	Sauropterygia	Pelsonian	Pelsonian
<i>Nothosaurus</i>	<i>zhang</i>	Sauropterygia	Pelsonian	Pelsonian
<i>Phalarodon</i>	<i>fraasi</i>	Ichthyopterygia	Pelsonian	Longobardian
<i>Placodus</i>	<i>inexpectatus</i>	Sauropterygia	Pelsonian	Pelsonian
<i>Qianosuchus</i>	<i>mixtus</i>	Archosauria	Pelsonian	Pelsonian
<i>Sinosauropsphargis</i>	<i>yunguiensis</i>	Saurosphargidae	Pelsonian	Pelsonian
<i>Tanystropheus</i>	<i>haasi</i>	Protorosauria	Pelsonian	Pelsonian
<i>Tholodus</i>	<i>schmidi</i>	Ichthyopterygia	Pelsonian	Pelsonian
<i>Wumengosaurus</i>	<i>delicatomandibularis</i>	Sauropterygia	Pelsonian	Pelsonian
<i>Xinminosaurus</i>	<i>catactes</i>	Ichthyopterygia	Pelsonian	Pelsonian
<i>Anarosaurus</i>	<i>heterodontus</i>	Sauropterygia	Illyrian	Illyrian
<i>Anarosaurus</i>	<i>pumilio</i>	Sauropterygia	Illyrian	Illyrian
<i>Augustasaurus</i>	<i>hagdorni</i>	Sauropterygia	Illyrian	Illyrian
<i>Besanosaurus</i>	<i>leptorhynchus</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Cyamodus</i>	<i>kuhnschnyderi</i>	Sauropterygia	Illyrian	Fassanian
<i>Cyamodus</i>	<i>muensteri</i>	Sauropterygia	Illyrian	Illyrian
<i>Cyamodus</i>	<i>rostratus</i>	Sauropterygia	Illyrian	Illyrian
<i>Cymbospondylus</i>	<i>buchseri</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Cymbospondylus</i>	<i>nichollsi</i>	Ichthyopterygia	Illyrian	Illyrian

<i>Cymbospondylus</i>	<i>piscosus</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Thalattoarchon</i>	<i>saurophagis</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Dactylosaurus</i>	<i>gracilis</i>	Sauropterygia	Illyrian	Illyrian
<i>Mixosaurus</i>	<i>cornalianus</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Mixosaurus</i>	<i>kuhnschnyderi</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Nothosaurus</i>	<i>giganteus</i>	Sauropterygia	Illyrian	Julian
<i>Nothosaurus</i>	<i>juvenilis</i>	Sauropterygia	Illyrian	Illyrian
<i>Nothosaurus</i>	<i>marchicus</i>	Sauropterygia	Illyrian	Illyrian
<i>Nothosaurus</i>	<i>mirabilis</i>	Sauropterygia	Illyrian	Fassanian
<i>Omphalosaurus</i>	<i>nevadanus</i>	Omphalosauria	Illyrian	Illyrian
<i>Phalarodon</i>	<i>callawayi</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Phantomasaurus</i>	<i>neubigi</i>	Ichthyopterygia	Illyrian	Illyrian
<i>Pistosaurus</i>	<i>longaeus</i>	Sauropterygia	Illyrian	Illyrian
<i>Blezingeria</i>	<i>ichthyospondylus</i>	Thalattosauriformes	Fassanian	Fassanian
<i>Cyamodus</i>	<i>hildegardensis</i>	Sauropterygia	Fassanian	Fassanian
<i>Lariosaurus</i>	<i>buzzii</i>	Sauropterygia	Fassanian	Fassanian
<i>Neusticosaurus</i>	<i>edwardsi</i>	Sauropterygia	Fassanian	Fassanian
<i>Neusticosaurus</i>	<i>peyeri</i>	Sauropterygia	Fassanian	Fassanian
<i>Neusticosaurus</i>	<i>pusillus</i>	Sauropterygia	Fassanian	Fassanian
<i>Nothosaurus</i>	<i>jagisteus</i>	Sauropterygia	Fassanian	Fassanian
<i>Odoiporosaurus</i>	<i>Teruzzii</i>	Sauropterygia	Fassanian	Fassanian
<i>Omphalosaurus</i>	<i>wolffi</i>	Omphalosauria	Fassanian	Fassanian
<i>Parapladodus</i>	<i>broilii</i>	Sauropterygia	Fassanian	Fassanian
<i>Serpianosaurus</i>	<i>mirigiolensis</i>	Sauropterygia	Fassanian	Fassanian
<i>Simosaurus</i>	<i>gaillardoti</i>	Sauropterygia	Fassanian	Julian
<i>_Psephosaurus_</i>	<i>picardi</i>	Sauropterygia	Illyrian/Fassanian	Illyrian/Fassanian

<i>_Psephosaurus_</i>	<i>sinaiticus</i>	Sauropterygia	Illyrian/Fassanian	Illyrian/Fassanian
<i>Clarazia</i>	<i>schinzi</i>	Thalattosauriformes	Illyrian/Fassanian	Illyrian/Fassanian
<i>Eusaurosphargis</i>	<i>dalsassoi</i>	Helveticosauridae	Illyrian/Fassanian	Illyrian/Fassanian
<i>Helveticosaurus</i>	<i>zollingeri</i>	Helveticosauridae	Illyrian/Fassanian	Illyrian/Fassanian
<i>Hescheleria</i>	<i>ruebeli</i>	Thalattosauriformes	Illyrian/Fassanian	Illyrian/Fassanian
<i>Lariosaurus</i>	<i>stensioei</i>	Sauropterygia	Illyrian/Fassanian	Illyrian/Fassanian
<i>Macrocnemus</i>	<i>bassanii</i>	Protorosauria	Illyrian/Fassanian	Illyrian/Fassanian
<i>Nothosaurus</i>	<i>haasi</i>	Sauropterygia	Illyrian/Fassanian	Illyrian/Fassanian
<i>Nothosaurus</i>	<i>tchernovi</i>	Sauropterygia	Illyrian/Fassanian	Illyrian/Fassanian
<i>Tanystropheus</i>	<i>langobardicus</i>	Protorosauria	Illyrian/Fassanian	Illyrian/Fassanian
<i>Lariosaurus</i>	<i>curionii</i>	Sauropterygia	Ladinian_question	Ladinian_question
<i>Askeptosaurus</i>	<i>italicus</i>	Thalattosauriformes	Fassanian	Fassanian
<i>Anshunsaurus</i>	<i>wushaensis</i>	Thalattosauriformes	Longobardian	Longobardian
<i>Ceresiosaurus</i>	<i>calcagnii</i>	Sauropterygia	Longobardian	Longobardian
<i>Ceresiosaurus</i>	<i>lanzi</i>	Sauropterygia	Longobardian	Longobardian
<i>Glyphoderma</i>	<i>kangi</i>	Sauropterygia	Longobardian	Longobardian
<i>Keichousaurus</i>	<i>hui</i>	Sauropterygia	Longobardian	Longobardian
<i>Lariosaurus</i>	<i>balsami</i>	Sauropterygia	Longobardian	Longobardian
<i>Lariosaurus</i>	<i>valceresii</i>	Sauropterygia	Longobardian	Longobardian
<i>Lariosaurus</i>	<i>xingyiensis</i>	Sauropterygia	Longobardian	Longobardian
<i>Macrocnemus</i>	<i>fuyuanensis</i>	Protorosauria	Longobardian	Longobardian
<i>Neusticosaurus</i>	<i>staubi</i>	Sauropterygia	Longobardian	Longobardian
<i>Neusticosaurus</i>	<i>toeplitschi</i>	Sauropterygia	Longobardian	Longobardian
<i>Nothosaurus</i>	<i>cymatosauroides</i>	Sauropterygia	Longobardian	Longobardian
<i>Nothosaurus</i>	<i>youngi</i>	Sauropterygia	Longobardian	Longobardian
<i>Psephosaurus</i>	<i>suevicus</i>	Sauropterygia	Longobardian	Longobardian

<i>Qianichthyosaurus</i>	<i>xingyiensis</i>	Ichthyopterygia	Longobardian	Longobardian
<i>Qianxisaurus</i>	<i>chajiangensis</i>	Sauropterygia	Longobardian	Longobardian
<i>Wangosaurus</i>	<i>brevirostris</i>	Sauropterygia	Longobardian	Longobardian
<i>Yunguisaurus</i>	<i>liae</i>	Sauropterygia	Longobardian	Longobardian
<i>Nothosaurus</i>	<i>edingerae</i>	Sauropterygia	Longobardian/Julian	Longobardian/Julian
<i>Anshunsaurus</i>	<i>huangguoshuensis</i>	Thalattosauriformes	Julian	Julian
<i>Bobosaurus</i>	<i>forojuliensis</i>	Sauropterygia	Julian	Julian
<i>Concavispina</i>	<i>biseridens</i>	Thalattosauriformes	Julian	Julian
<i>Guanlingsaurus</i>	<i>liangae</i>	Ichthyopterygia	Julian	Julian
<i>Guizhouichthyosaurus</i>	<i>tangae</i>	Ichthyopterygia	Julian	Julian
<i>Henodus</i>	<i>chelyops</i>	Sauropterygia	Julian	Julian
<i>Miodentosaurus</i>	<i>brevis</i>	Thalattosauriformes	Julian	Julian
<i>Protenodontosaurus</i>	<i>italicus</i>	Sauropterygia	Julian	Julian
<i>Psephochelys</i>	<i>polyosteoderma</i>	Sauropterygia	Julian	Julian
<i>Qianichthyosaurus</i>	<i>zhoui</i>	Ichthyopterygia	Julian	Julian
<i>Sinocyamodus</i>	<i>xinpuensis</i>	Sauropterygia	Julian	Julian
<i>Xinpusaurus</i>	<i>bamaolinensis</i>	Thalattosauriformes	Julian	Julian
<i>Xinpusaurus</i>	<i>sunii</i>	Thalattosauriformes	Julian	Julian
<i>Placochelys</i>	<i>placodonta</i>	Sauropterygia	Julian/Tuvalian	Julian/Tuvalian
<i>Californosaurus</i>	<i>perrini</i>	Ichthyopterygia	Tuvalian	Tuvalian
<i>Nectosaurus</i>	<i>halinus</i>	Thalattosauriformes	Tuvalian	Tuvalian
<i>Shastasaurus</i>	<i>pacificus</i>	Ichthyopterygia	Tuvalian	Tuvalian
<i>Shonisaurus</i>	<i>popularis</i>	Ichthyopterygia	Tuvalian	Tuvalian
<i>Thalattosaurus</i>	<i>alexandrae</i>	Thalattosauriformes	Tuvalian	Tuvalian
<i>Toretocnemus</i>	<i>californicus</i>	Ichthyopterygia	Tuvalian	Tuvalian
<i>Toretocnemus</i>	<i>zitteli</i>	Ichthyopterygia	Tuvalian	Tuvalian

<i>Endennasaurus</i>	<i>acutirostris</i>	Thalattosauriformes	Alaunian	Alaunian
<i>Macgowania</i>	<i>janiceps</i>	Ichthyopterygia	Alaunian	Alaunian
<i>Psephoderma</i>	<i>alpinum</i>	Sauropterygia	Alaunian	Rhaetian
<i>Shonisaurus</i>	<i>sikanniensis</i>	Ichthyopterygia	Alaunian	Alaunian
<i>Himalayasaurus</i>	<i>tibetensis</i>	Ichthyopterygia	Lacian/Alaunian	Lacian/Alaunian
<i>Callawayia</i>	<i>neoscapularis</i>	Ichthyopterygia	Lacian	Lacian
<i>Hudsonelpidia</i>	<i>brevirostris</i>	Ichthyopterygia	Lacian	Lacian
<i>Sikannisuchus</i>	<i>huskyi</i>	Archosauria	Lacian	Lacian
<i>Macroplacus</i>	<i>raeticus</i>	Sauropterygia	Rhaetian	Rhaetian
<i>Psephoderma</i>	<i>anglicum</i>	Sauropterygia	Rhaetian	Rhaetian

Supplementary Method

Bayesian phylogenetic analysis

We used MrBayes 3.2.6¹ for Bayesian inference of phylogeny approximately following the settings used by Slater (2013)². The character coding was treated as “variable” to account for the lack of autapomorphies and constant characters in the data. Gamma distribution was used to account for the variation in rates among characters. The clock was set as fossilization to take advantage of the fossilized birth-death process model. The fossiltip option was used to treat all taxa as terminal. Independent Gamma Rate (IGR) model was used to treat each branch as having an independent rate drawn from a gamma distribution³. The clock rate prior was set as a lognormal distribution around the mean rate that was calculated from the character steps and time duration along the longest stretch of branches in a parsimony tree. Varying this value, however, had minimal effects on the result.

The age of each taxon was calibrated based on the stratigraphic record, derived from the Paleobiology Database and the Geologic Time Scale 2012⁴. Specifically, the prior age range of a taxon was defined as a uniform distribution spanning the geologic substage of its first occurrence, as well as the substage before. Geologic stages were used instead for Paleozoic taxa, because geologic substages are not officially defined.

Default options were employed for other priors. Outgroup topology was constrained. Each search was based on four runs, each with four chains. The analysis was stopped when the standard deviation of marginal split frequencies reached 0.01, which took about 19 to 22 million generations. Convergence of topology was confirmed in RWTY (<https://github.com/danlwarren/RWTY>). The first 25% of the data were discarded as burn-in during posterior calculations of parameters and consensus topology.

- 1 Ronquist, F. *et al.* MrBayes 3.2: Efficient Bayesian Phylogenetic Inference and Model Choice Across a Large Model Space. *Systematic Biol* **61**, 539-542, doi:10.1093/sysbio/sys029 (2012).
- 2 Slater, G. J. Phylogenetic evidence for a shift in the mode of mammalian body size evolution at the Cretaceous-Palaeogene boundary. *Methods Ecol Evol* **4**, 734-744, doi:10.1111/2041-210x.12084 (2013).
- 3 Lepage, T., Bryant, D., Philippe, H. & Lartillot, N. A general comparison of relaxed molecular clock models. *Mol Biol Evol* **24**, 2669-2680, doi:10.1093/molbev/msm193 (2007).
- 4 Gradstein, F. M., Ogg, J. G., Schmitz, M. D. & Ogg, G. M. *The Geologic Time Scale 2012*. (Elsevier, 2012).

Supplementary NEX File Data1 -- NEX file data for the phylogenetic analysis to show the position of the new taxon among Ichthyosauriformes

#NEXUS

BEGIN TAXA;

TITLE Taxa;

DIMENSIONS NTAX=73;

TAXLABELS

Petrolacosaurus Claudiosaurus Thadeosaurus Hovasaurus Wumengosaurus
Nanchangosaurus Eohupehsuchus Hupehsuchus Parahupehsuchus Eretmorhipis Sclerocormus
Cartorhynchus Chaohusaurus_geishanensis Chaohusaurus_chaoxianensis
Chaohusaurus_zhangjiawanensis Utatusaurus Grippia Gulosaurus Parvinatator
Mixosaurus_panxianensis Mixosaurus_cornalianus Mixosaurus_kuhnschnyderi
Phalarodon_atavus Phalarodon_fraasi Phalarodon_callawayi Cymbospondylus_piscosus
Cymbospondylus_buchseri Cymbospondylus_nicholli Xinminosaurus Besanosaurus
Guizhouichthyosaurus Callawayia_wolonggangensis Guanlingsaurus Shastasaurus
Shonisaurus_popularis Shonisaurus_sikanniensis Californosaurus Toretocnemus
Qianichthyosaurus_zhoui Qianichthyosaurus_xingyiensis Callawayia_neoscapularis
Hudsonelpidia Macgowania Suevoleviathan Temnodontosaurus Leptonectes_tenuirostris
Leptonectes_moorei Leptonectes_olei Excalibosaurus Eurhinosaurus Ichthyosaurus
Stenopterygius Aegirosaurus Acamptoneustes Maiaspondylus Arthropterygius Athabascasaurus
Sveltonectes Brachypterygius Caypullisaurus Malawania Mollesaurus Leninia Chacaicosaurus_
Hauffiopteryx Platypterygius_australis Platypterygius_americanus Cryopterygius
Ophthalmosaurus_iceicus Ophthalmosaurus_natans Thalattoarchon Palvennia Sisteronia

;

END;

BEGIN CHARACTERS;

TITLE Character_Matrix;

DIMENSIONS NCHAR=195;

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

CHARSTATELABELS

1 Premaxilla_dorsal_process / long short, 2 Premaxilla_ventral_process / long short,
3 Maxilla_anterior_process / reduced
extending_anteriorly_as_far_as_nasal_or_further_anteriorly, 4 Maxilla_dorsal_lamina / absent
present, 5 Maxilla_prefrontal_contact / absent present, 6 Maxilla_external_naris_contact /
present absent, 7 Maxilla_longer_than_premaxilla / TRUE FALSE, 8 External_naris_orientation
/ lateral dorsal, 9 Shallow_groove_anterior_to_the_exn / absent present, 10 Narial_shelf /
absent present, 11 Nasal_anteriorly_extending_beyond_exn / FALSE TRUE, 12
Nasal_parietal_contact_lateral_to_frontal / absent present, 13 Nasal_postfrontal_contact /
no_contact 'contact extensive, posterior extension of nasal separates frontal from prefrontal in
dorsal view' eliminated_by_prefrontal_medially_extension, 14
Descending_process_of_the_nasal_on_the_dorsal_border_of_the_nares / absent present, 15
Nasals_rostrally_reaching_snout_tip / FALSE TRUE, 16 Processus_narialis_of_prefrontal /

absent present, 17 Supraorbital_crest_on_prefrontal_and_postfrontal / absent present, 18 'Prefrontal-postfrontal contact' / absent present, 19 Prefrontal_exposure_in_UTF / absent present, 20 Anterior_orbital_margin / of_regular_rounded_shape irregular, 21 Postfrontal_medial_extension / over_the_anteriormost_margin_of_utf not_over_the_anteriormost_margin_of_utf, 22 'Supratemporal antero-medial extension' / short long, 23 'Supratemporal-postorbital contact' / absent present, 24 'Supertemporal / squamosal relative size' / equal_or_st_smaller st_clearly_larger, 25 Sagittal_eminence / absent 'present but small, involving only the parietal' 'present and large, involving the parietal, frontal and nasal', 26 Frontal_dorsal_exposure / clearly_present nearly_absent, 27 Frontal_participation_in_utf / absent present, 28 Squamosal_triangular_shape / FALSE TRUE squamosal_absent, 29 Squamosal_participation_in_utf / present absent squamosal_absent, 30 'Squamosal-quadrata articulation' / present absent, 31 'Postorbital postero-dorsal corner' / 'narrow, giving triradiate shape' broad_and_triangular absent_or_round, 32 Postorbital_participation_in_utf / present absent, 33 Jugal_anterior_margin / 'tapering, between lacrimal and maxilla' 'broad and fan-like, covering ma', 34 'Jugal/quadratojugal lateral contact' / present absent, 35 Lower_temporal_arch_between_jugal_and_quadratojugal / present lost, 36 Quadratojugal / longer_than_tall taller_than_long., 37 Quadratojugal_exposure / quadratojugal_small extensive 'small, largely covered by squamosal and postorbital', 38 Parietal_ridge / absent present, 39 Parietal_supratemporal_process / short long, 40 Parietal_anterior_processes / 'contacting each other anteriorly, eliminating frontal from pineal foramen' 'narrowly separated anteriorly, forming parietal fork, and frontal dorsally visible along the pineal foramen' 'widely open, resulting in absence of clear fork', 41 'Parietal-frontal suture inter-digitation' / absent present, 42 Anterior_terrace_of_utf / absent present_but_small present_and_large, 43 Basioccipital_peg / clearly_present absent_or_extremely_reduced, 44 Basioccipital_extracondylar_area / wide reduced_to_a_narrow_band_of_concavity, 45 'Basioccipital/atlas articulation convexity' / flat_or_anterior posterior, 46 Ventral_notch_in_the_extracondylar_area_of_the_basioccipital / present absent, 47 'Pterygoid, transverse flange' / 'antero-lateral' not_well_defined 'postero-lateral', 48 Basipterygoid_processes / 'short, giving basisphenoid a square outline in dorsal view' 'markedly expanded laterally, being wing-like, giving basisphenoid a marked pentagonal shape in dorsal view', 49 Interpterygoid_vacuity / present absent_or_extremely_reduced, 50 Ectopterygoid / present absent, 51 Shape_of_the_paroccipital_process_of_the_opisthotic / short_and_robust elongated_and_slender, 52 Stapes_proximal_head / 'slender, much smaller than opisthotic proximal head' 'massive, as large or larger than opisthotic', 53 Cheek_orientation / lateral posterior, 54 Overbite / absent_or_very_slightly present, 55 Prenarial_snout_longer_than_the_postorbital_skull / FALSE TRUE, 56 Snout_extremely_slender / no yes, 57 'Snout, constriction' / absent present, 58 Snout_flattened / FALSE TRUE, 59 'Scleral ring extensively ossified, filling or almost filling the orbit' / FALSE TRUE, 60 Pineal_foramen_posterior_to_or_between_orbits / posterior between, 61 Angular_lateral_exposure_at_its_maximum_depth / 'semi-equal to surangular' clearly_shallower_than_surangular much_deeper_than_surangular, 62 Coronoid_region / slightly_elevated_or_high flat, 63 Root_striations / present absent, 64 Plicidentine / absent at_least_partly_present, 65 Bony_fixation_of_teeth / present absent, 66 Tooth_horizontal_section / circular 'disto-medially compressed' lateral_compressed, 67

Tooth_size_relative_to_the_skull_width / over_0.1 below_0.05, 68
 Dentigerous_region_in_adult / complete largely_reduced edentulous, 69 Dental_groove /
 present_throughout_jaw_margin only_present_anteriorly absent, 70 Anterior_sockets / present
 absent, 71 Maxilla_multiple_tooth_row / absent present, 72 Dentary_labial_shelf / present
 absent, 73 Posterior_tooth_crown / conical rounded flat, 74
 Tooth_crown_surface_of_at_least_one_maxillary_tooth_with_mesiodistal_ridge / FALSE
 TRUE, 75 Ossified_sternum / absent present, 76 Ossified_cleithrum / present absent, 77
 Clavicle_orientation_at_proximal_end / oblique_to_sagittal_plane transverse, 78
 Clavicle_scapular_process_length_distal_to_clavicular_main_body / short long, 79
 Interclavicle_anterior_process_separating_clavicles / present absent, 80
 Interclavicle_posterior_process / 'rod-like' triangular absent, 81 Scapular_blade_shaft / absent
 present_at_least_proximally, 82 Scapula_anterior_flange / complete emarginated absent, 83
 'Scapula antero-proximal extension toward clavicle' / absent present, 84
 rominent_acromion_process_of_scapula / absent present, 85 Scapula_posterior_extension /
 present absent, 86 Scapular_axis_and_glenoid_facet_orientations / nearly_parallel
 at_60_degrees_or_more, 87 Coracoid_facet_on_scapula / fused_scapulocoracoid absent
 equal_or_smaller_than_glenoid_facet_of_scapula twice_as_large_as_glenoid_facet, 88
 Coracoid_parasagittal_length_vs_transverse_width / 'semi-equal or longer than wide'
 clearly_wider_than_long, 89 Coracoid_foramen / present absent, 90
 Coracoid_anterior_notch_or_concavity / absent present, 91
 Coracoid_posterior_notch_or_concavity / absent present, 92 Intercoracoid_facet / 'short,
 medial margin round shaped' 'long, medial margin relatively straight', 93 Humerus_anterior_flange
 / absent present_and_complete 'present but reduced proximally, leaving leading edge tuberosity',
 94 'Plate-like dorsal ridge on humerus' / absent present, 95
 Protruding_triangular_deltopectoral_crest_on_humerus / present_but_small 'present and very
 large, bordered by concave areas', 96 Humerus_distal_proximal_width_ratio / nearly_equal
 distal_wider, 97
 Humerus_with_posterodistally_deflected_ulnar_facet_and_distally_facing_radial_facet /
 ulnar_facet_contains_convexity_in_lateral_view absent present, 98
 Humerus_distal_articular_facets / not_terminal radial_facet_larger_than_ulna_facet
 two_facet_nearly_equal three_facets, 99
 Humerus_anterodistal_facet_for_accessory_zeugopodial_element_anterior_to_radius / absent
 present, 100 'Humerus/intermedium contact' / absent present, 101 Radius_peripheral_shaft /
 complete_or_nearly_complete notch_or_absent, 102 Radius_contiguous_shaft /
 about_half_or_more_of_radial_length notch_or_absent, 103 Ulna_peripheral_shaft /
 complete_or_nearly_complete notch_or_absent, 104 Ulna_contiguous_shaft /
 complete_or_nearly_complete notch_or_absent, 105 Shape_of_the_posterior_surface_of_the_ulna
 / radius_not_discoidal rounded_or_straight_and_nearly_as_thick_as_the_rest_of_the_element
 'concave with a thin, blade-like margin', 106 'Radius/ulna relative size' / nearly_equal
 radius_much_larger_than_ulna ulna_larger_than_radius, 107 'Radio-ulnar foramen' / present
 absent, 108 'Radiale, anterior notch' / absent present, 109 Manual_pisiform / present absent,
 110 'Manual pisiform 2 (neomorph)' / absent present, 111 Intermedium / longer_than_wide
 as_wide_as_long_or_wider_than_long, 112 Proximal_carpals / packed 'small, round and
 separated', 113 Distal_carpal_1 / ossified unossified absent, 114 Distal_carpal_2 / ossified

unossified absent, 115 Manual_centralia / present absent, 116 Mc_I_peripheral_shaft /
 complete notch_or_largely_reduced absent mc_1_not_ossified, 117 Mc_III_shaft / present
 absent, 118 Mc_V / present not_ossified, 119 Manual_digit_2_distal_elements_peripheral_shaft
 / complete 'notch or absent;', 120
 Forelimb_hyperphalangy_with_more_than_five_phalanges_ossified_in_longest_digit / absent
 present, 121 'Notching of anterior facet of leading edge elements of forefin in adults, except
 radiale' / elements_not_discoidal present absent, 122
 First_preaxial_accessory_digits_on_forelimb / absent present, 123
 Postaxial_accessory_digit_on_forelimb / absent only_one more_than_one, 124 'Proximal
 manual phalanges proximo-distal packing' / 'well-packed' not_packed, 125 'Manual digit S4-5' /
 absent present, 126 'Propodial + epipodial versus manus length' / 'propodial + epipodial longer'
 manus_longer, 127 'Forelimb/hindlimb ratio' / nearly_equal_or_hind_longer
 forelimb_longer_but_less_than_twice_as_hindlimb forelimb_longer_twice_as_much_as_hindlimb,
 128 Forelimb_Zeugopodium_flattened / FALSE TRUE, 129 Manual_anterior_sesamoid /
 absent present, 130 Second_preaxial_accessory_digit_of_forelimb / absent present, 131
 Delayed_mesopodial_ossification / present absent, 132
 Forelimb_hypophalangy_with_less_than_five_digits_ossified_in_longest_digit / absent present,
 133 'Carpus elongated, as long as the more distal forelimb part or longer' / FALSE TRUE, 134
 Extra_preaxial_carpal_proximally / absent present, 135 Interdigital_separation / present absent,
 136 Iliac_blade_shape / with_thick_shaft 'plate-like' narrow_and_styloid, 137 'Iliac
 antero-medial prominence' / absent present, 138 'Ilium-pubis relative proximo-distal length' /
 'semi-equal' ilium_clearly_shorter, 139 'Pubis, styloid or plate-like' / 'plate-like' styloid, 140
 Pubis_obturator_foramen / completely_enclosed_in_pubis
 mostly_in_pubis_but_open_on_one_side part_of_obturator_fossa, 141
 Pubis_and_ischium_median_symphysis / present not_well_defined, 142
 Pubis_and_ischium_fused_in_adult / complete absent present_only_medially
 present_medially_and_distally, 143 Pubis_ischium_relative_size /
 nearly_equal_or_ischium_slightly_larger pubis_twice_as_large_as_ischium, 144 'Ischium,
 styloid or plate-like' / 'plate-like, longer sagittally than wide transversely' 'plate-like, wider
 transversely than long sagittally' styloid, 145 Thyroid_fenestra / absent one_median_opening
 'two openings, being medially separated', 146 'Femur strongly constricted medially, forming a
 slender shaft region, proximal width remarkably larger than medial width' / present absent, 147
 'Femur antero-distal expansion, forming a distinctive structure at the distal end' / absent present.,
 148 'Prominent, ridge-like dorsal and ventral processes demarcated from the head of the femur and
 extending up to mid-shaft' / absent present, 149 Wide_distal_femur_blade / 'absent, the
 proximal and distal extremity of the femur being sub-equal in dorsal view' present, 150
 Femur_distal_facets / two three, 151 'Femur/astragalus contact' / absent present, 152
 Femur_anterodistal_facet_for_accessory_zeugopodial_element_anterior_to_tibia / absent
 present, 153 Tibia_contiguous_shaft / complete_or_nearly_complete notch_or_absent, 154
 Tibia_peripheral_shaft / complete_or_nearly_complete notch_or_absent, 155 'Tibia
 antero-proximal end nearly rectangular, forming a deep notch on the anterior margin' / absent
 present, 156 Fibula_posterior_extent / 'not fixed, fibula being mobile relative to femur'
 much_posterior_to_femur about_the_same_level_as_femur, 157 Fibula_contiguous_margin /
 concave nearly_straight_or_convex, 158 Fibula_posterior_flange / absent present, 159

Thadeosaurus ??????0????????????????????????????????????
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Wumengosaurus
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1210002011100000020000000000100111100000000001000000001000110000000000000000
0200??100000??0000000000000000?000000

Eohupehsuchus
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0010?0000?10?01200000000001000001000??000???1001?00000?0?????10010?000010000???
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Parahupehsuchus ???
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Sclerocormus

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Qianichthyosaurus_xingyiensis

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Callawayia_neoscapularis

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Hudsonelpidia

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Macgowania

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Suevoleviathan

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3?110120?11200111110101010201310112010{0
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Temnodontosaurus

10100110001110000110000111011121001111{0
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2}00112001111101010102013111110{0 1}00111001000120?121{1
2}01211010001102101010111210101?10101?10011210001?0000

Leptonectes_tenuirostris

1000?110?0111000010000?101011121001111021010??1?01??1011101??01110100101000111101
2101030110100011200111110{0
1}010102013101120000111001000120012110220001000110210111011?121010111010??100112
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Leptonectes_moorei

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0001120011111010101020131011200001?10010001????11?????0?00?00000000000000000000?
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Leptonectes_solei

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Excalibosaurus

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1103?11012001120011111011101020131111101001?1001000120???11?1?10010001102101110?1
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Eurhinosaurus

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2101030110?20?112001111101100102013111110100111001000120012110121001000110210111

Ichthyosaurus 100001100010200001100011000{1
2}212100112102100010200100001010111101100001010001111012101030111100001200111110
10{0 1}01020131011201101210010001200121{1 2}022100000011021001101111?101111101{0
1}1{0 1}1001121110110000

Stenopterygius 10000{0 1}10001{0 1}200001100011100111210011210210?010200101001010111111000010100011110121110301101000112001111101100102013101110{0 1}1{0 1}1210010001201121302210?00001102100110111121111110100{0 1}1(0 1)0112111110000

Aegirosaurus
1000011000101110111200?01?0111121101?2??2?0??????????0111011201???00?0?0?00?1?0???
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Acamptonectes ???0???????1?????????????????????0?????111?1?
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Arthropterygius ???110?0???
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Athabascasaurus
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Sveltonectes
1?0001100010111?111?0????001????2?1?1?01????11120???1?01010?0111?0?0?0?00?000001021
1103011010110120011????100?1020131011211001?110?0?01???12130121010000110210012111
?1210???1?0?0??10012???1????00

Brachypterygius
11100110?????1???1?0???1??????1111??????11111?1????0010101?0?1110000?0?00?????????1
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Caypullisaurus 00100{0
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?1??0110131011111010101020131111212001?11110001?????????10100001102100121?11??1??
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    Leninia                ???00?0????11?111?00?01?00?11110??01110?110?
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    Chacaicosaurus_        ??????10????????????????????????????????????1011???
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    Hauffiopteryx          ??00001000100001?1?00001?0011021011?1?02??001??
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011001??1121202210?100011021011??111121?11?1?0100?100??????110000
    Platypterygius_australis
10111010001011001100101?10122?21101111020001112101010010101120111000010?00?????1
211103011012110131011111010001020131111212001?10111001???121302?1010101110110012
{0 1}1111?101111?0?00?001??11?1?0000
    Platypterygius_americanus
101001100010?10011?0?0?0?22?21?0111????????????10010101101?1?00010?00?????121
110?????211013001111010001020?31?????????10?1?001???121302?1011100?????????1?
?1011?1?0?0?0?00?????????00
    Cryopterygius
1011001000???1?0?1?0???????????1011?????????????????0010?01?20?1?000?0?000111?01211
102011012?1022001111?010101020131011211001?10011?0120112120221010000110?10?1???
1121?11?1?010??100??2?1?1???00
    Ophthalmosaurus_icenicus
110001100010110011?0001100011121101021020011102{0
1}011100101011001110?0010?00011110121110301101211023101112010001020131011211001
210011?01201121302210100001102100120111121{0 1}1111010{0 1}?1001121111?0000
    Ophthalmosaurus_natans
110000100010110??1?0001?1001102110112?0200111?2101?00101011?011?0000?0?000111101
2111030110121?113101111?01?001020?310?????0???1??11001?????????10?111011021001201
11??1?11?1?0?01?100?????????000
    Thalattoarchon         ???0?????0???0?1?0111?101?10100????00201??????
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    Palvennia              ??0?0?10??101?0??1?000?000????1?????020?1?11??
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    Sisteronia             ??1????????????????????????????????????????111?0?0
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;
END;
begin PAUP;
    log file = SI_D1.paup.log replace = Yes start;
SET AUTOCLOSE = YES;

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SET INCREASE = NO;
SET MAXTREES = 30000;
SET CRITERION = PARSIMONY;
SET WARNTREE = NO;
SET WARNTSAVE = NO;
SET WARNROOT = NO;
SET WARNREDEF = NO;
SET WARNRESET = NO;
    assume ancestates = standard;
    ctype unord : all;
    constraint younginiform ( monophyly ) = ( ( 3 , 4 ) );
    DEFAULTS CONTREE / STRICT MAJRULE LE50 INDICES Outroot = paraphyl File
= consensus.tr;
    DEFAULTS HSEARCH ADDSEQ = RANDOM NREPS = 100 SWAP = TBR HOLD =
50 ENFORCE = NO;
    DEFAULTS BANDB ADDSEQ = FURTHEST ENFORCE = NO;
    DEFAULTS BOOTSTRAP NREPS = 1000 CONLEVEL = 50 METHOD =
HEURISTIC;
    DEFAULTS DESCRIBE ChgList = YES;
    export file = SI_D1.tnt.nex format = nexus interleaved = no;
    delete Parvinator Acamptonectes Maiaspondylus Arthropterygius Malawania Chacaicosaurus
Mollesaurus Leninia Thalattoarchon Palvennia Sisteronia;
    export file = SI_D1_small.tnt.nex format = nexus interleaved = no;
    undelete Parvinator Acamptonectes Maiaspondylus Arthropterygius Malawania
Chacaicosaurus Mollesaurus Leninia Thalattoarchon Palvennia Sisteronia;
    OUTGROUP 1;
    hsearch constraints = younginiform enforce = yes;
    savetrees file = SI_D1.paup.tre replace = Yes;
    contree / file = SI_D1.paup.con.tre replace = Yes;
    gettrees file = SI_D1.paup.tre duptrees = Eliminate;
    describe 1 / LabelNode = No ChgList = No CMShowEq = No Plot = None;
END;
BEGIN ASSUMPTIONS;
    TYPESET * UNTITLED = unord: 1 - 195;
    EXSET * UNTITLED = ;
END;
BEGIN NOTES;
    SUT TAXA = Taxa TAXON = 26 NAME = color INTEGER = 14;
    SUT TAXA = Taxa TAXON = 27 NAME = color INTEGER = 14;
    SUT TAXA = Taxa TAXON = 28 NAME = color INTEGER = 14;
    SUT TAXA = Taxa TAXON = 29 NAME = color INTEGER = 14;
    SUT TAXA = Taxa TAXON = 30 NAME = color INTEGER = 5;
    SUT TAXA = Taxa TAXON = 31 NAME = color INTEGER = 5;
    SUT TAXA = Taxa TAXON = 32 NAME = color INTEGER = 5;

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SUT TAXA = Taxa TAXON = 33 NAME = color INTEGER = 5;
 SUT TAXA = Taxa TAXON = 34 NAME = color INTEGER = 5;
 SUT TAXA = Taxa TAXON = 35 NAME = color INTEGER = 5;
 SUT TAXA = Taxa TAXON = 36 NAME = color INTEGER = 5;
 SUT TAXA = Taxa TAXON = 46 NAME = color INTEGER = 11;
 SUT TAXA = Taxa TAXON = 47 NAME = color INTEGER = 11;
 SUT TAXA = Taxa TAXON = 48 NAME = color INTEGER = 11;
 SUT TAXA = Taxa TAXON = 49 NAME = color INTEGER = 11;
 SUT TAXA = Taxa TAXON = 50 NAME = color INTEGER = 11;
 SUT TAXA = Taxa TAXON = 61 NAME = color INTEGER = 16;
 SU T = 58 C = 2 N = color I = 5;
 SU T = 60 C = 5 N = color I = 5;
 SU T = 60 C = 6 N = color I = 5;
 SU T = 62 C = 6 N = color I = 5;
 SU T = 28 C = 7 N = color I = 17;
 SU T = 29 C = 7 N = color I = 2;
 SU T = 19 C = 8 N = color I = 5;
 SU T = 44 C = 12 N = color I = 5;
 SU T = 63 C = 13 N = color I = 5;
 SU T = 63 C = 14 N = color I = 5;
 SU T = 65 C = 14 N = color I = 5;
 SU T = 29 C = 15 N = color I = 17;
 SU T = 72 C = 15 N = color I = 5;
 SU T = 63 C = 16 N = color I = 5;
 SU T = 31 C = 19 N = color I = 5;
 SU T = 22 C = 21 N = color I = 5;
 SU T = 26 C = 23 N = color I = 5;
 SU T = 63 C = 23 N = color I = 5;
 SU T = 22 C = 26 N = color I = 5;
 SU T = 58 C = 27 N = color I = 5;
 SU T = 16 C = 29 N = color I = 5;
 SU T = 35 C = 29 N = color I = 5;
 SU T = 62 C = 30 N = color I = 17;
 SU T = 63 C = 30 N = color I = 5;
 SU T = 29 C = 31 N = color I = 5;
 SU T = 39 C = 31 N = color I = 5;
 SU T = 60 C = 31 N = color I = 5;
 SU T = 22 C = 32 N = color I = 5;
 SU T = 35 C = 32 N = color I = 5;
 SU T = 38 C = 33 N = color I = 5;
 SU T = 57 C = 33 N = color I = 5;
 SU T = 60 C = 36 N = color I = 5;
 SU T = 22 C = 38 N = color I = 5;
 SU T = 22 C = 39 N = color I = 5;

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 SU T = 41 C = 44 N = color I = 5;
 SU T = 63 C = 46 N = color I = 5;
 SU T = 17 C = 49 N = color I = 5;
 SU T = 22 C = 54 N = color I = 5;
 SU T = 29 C = 55 N = color I = 2;
 SU T = 22 C = 56 N = color I = 4;
 SU T = 57 C = 59 N = color I = 5;
 SU T = 57 C = 60 N = color I = 5;
 SU T = 44 C = 61 N = color I = 5;
 SU T = 21 C = 62 N = color I = 5;
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 SU T = 54 C = 62 N = color I = 5;
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 SU T = 44 C = 77 N = color I = 7;
 SU T = 44 C = 78 N = color I = 7;
 SU T = 30 C = 79 N = color I = 5;
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 SU T = 22 C = 81 N = color I = 5;
 SU T = 44 C = 81 N = color I = 7;
 SU T = 22 C = 82 N = color I = 5;
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 SU T = 22 C = 107 N = color I = 5;
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 SU T = 42 C = 111 N = color I = 5;
 SU T = 62 C = 112 N = color I = 17;
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 SU T = 62 C = 115 N = color I = 17;

SU T = 33 C = 120 N = color I = 5;
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SU T = 3 C = 133 N = color I = 4;
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 SU T = 25 C = 147 N = color I = 5;
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 SU T = 25 C = 150 N = color I = 5;
 SU T = 25 C = 151 N = color I = 5;
 SU T = 25 C = 152 N = color I = 5;
 SU T = 58 C = 152 N = color I = 5;
 SU T = 25 C = 153 N = color I = 5;

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SU  T = 25 C = 154 N = color I = 5;
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SU  T = 25 C = 157 N = color I = 5;
SU  T = 25 C = 158 N = color I = 5;
SU  T = 25 C = 159 N = color I = 5;
SU  T = 70 C = 159 N = color I = 5;
SU  T = 25 C = 160 N = color I = 5;
SU  T = 25 C = 161 N = color I = 5;
SU  T = 25 C = 162 N = color I = 5;
SU  T = 44 C = 162 N = color I = 5;
SU  T = 25 C = 163 N = color I = 5;
SU  T = 25 C = 164 N = color I = 5;
SU  T = 66 C = 164 N = color I = 5;
SU  T = 62 C = 166 N = color I = 5;
SU  T = 44 C = 167 N = color I = 5;
SU  T = 65 C = 167 N = color I = 5;
SU  T = 73 C = 170 N = color I = 5;
SU  T = 22 C = 171 N = color I = 5;
SU  T = 22 C = 172 N = color I = 5;
SU  C = 173 N = selected B = TRUE;
SU  T = 44 C = 173 N = color I = 5;
SU  T = 62 C = 175 N = color I = 2;
SU  T = 26 C = 179 N = color I = 4;
SU  T = 62 C = 181 N = color I = 17;
SU  T = 62 C = 182 N = color I = 17;
SU  T = 56 C = 183 N = color I = 5;
SU  T = 58 C = 185 N = color I = 5;
SU  T = 21 C = 189 N = color I = 5;
SU  T = 39 C = 191 N = color I = 5;
SU  T = 65 C = 191 N = color I = 5;
SU  T = 62 C = 195 N = color I = 17;
END;
BEGIN LABELS;
  CHARGROUPLABEL 01Cranium COLOR = (RGB 1 0.03529412 0.41960784) ;
  CHARGROUPLABEL 02Mandible COLOR = (RGB 0.80784314 0.03529412 1) ;
  CHARGROUPLABEL 03Dentition COLOR = (RGB 1 0.03529412 0.03529412) ;
  CHARGROUPLABEL 04PectoralGirdle COLOR = (RGB 0.03529412 0.03529412 1) ;
  CHARGROUPLABEL 05Forelimb COLOR = (RGB 0.03529412 0.61176471 1) ;
  CHARGROUPLABEL 06PelvicGirdle COLOR = (RGB 0.03529412 1 0.61176471) ;
  CHARGROUPLABEL '07Hind_limb' COLOR = (RGB 0.80784314 1 0.03529412) ;
  CHARGROUPLABEL 08Axial COLOR = (RGB 1 0.61176471 0.03529412) ;
  CHARGROUPLABEL 09Dermal COLOR = (RGB 1 0.41960784 0.03529412) ;
END;

```

```

BEGIN SETS;
    CHARPARTITION * UNTITLED = 01Cranium : 1 - 60, 02Mandible : 61 - 62,
03Dentition : 63 - 74, 04PectoralGirdle : 75 - 92, 05Forelimb : 93 - 135,
06PelvicGirdle : 136 - 145, '07Hind_limb' : 146 - 164, 08Axial : 165 -
190, 09Dermal : 191 - 195;
END;
BEGIN MESQUITECHARMODELS;
    ProbModelSet * UNTITLED = 'Mk1 (est.)' : 1 - 195;
END;
Begin MESQUITE;
    MESQUITESCRIPTVERSION 2;
    TITLE AUTO;
    tell ProjectCoordinator;
    timeSaved 1460677565168;
    getEmployee #mesquite.minimal.ManageTaxa.ManageTaxa;
    tell It;
        setID 0 7121830078017352332;
        tell It;
            setSelected 2;
            setDefaultOrder 0 2 1 3 10 4 5 6 7 8 9 11 12 13 14 15 16 17 18
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70
71 72;
            attachments ;
        endTell;
    endTell;
    getEmployee
#mesquite.charMatrices.ManageCharacters.ManageCharacters;
    tell It;
        setID 0 2516980770027965603;
        tell It;
            setSelected 173;
            setDefaultOrder 0 1 2 3 4 5 165 6 7 8 9 10 11 12 183 13 14 15
166 16 17 18 19 169 20 21 22 23 24 168 25 26 27 28 29 30 31 32 33 34 167 35 36
37 38 39 40 41 42 43 44 45 48 49 164 50 163 188 170 184 46 47 51 52 53 54 55
56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81
82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 177 174 175 176 101 102
103 104 105 106 107 108 109 110 111 112 171 172 173 178 179 185 189 100 113 114
180 115 116 118 119 120 117 121 122 123 124 125 126 127 128 129 130 131 132 133
134 135 136 137 138 139 140 141 142 159 143 144 145 146 147 148 157 190 149 150
151 152 181 193 194 154 155 156 158 160 161 162 182 153 186 187 191 192;
            attachments ;
        endTell;
    mqVersion 304;

```

```

checksumv 0 3 2246349582 null getNumChars 195 numChars 195
getNumTaxa 73 numTaxa 73 short true bits 2305843009213694031 states 79
sumSquaresStatesOnly 32109.0 sumSquares -1.4757395258967641E20
longCompressibleToShort false usingShortMatrix true NumFiles 1 NumMatrices
1;

mqVersion;
endTell;
getWindow;
tell It;
suppress;
setResourcesState false false 147;
setPopoutState 400;
setExplanationSize 0;
setAnnotationSize 0;
setFontIncAnnot 0;
setFontIncExp 0;
setSize 1583 1066;
setLocation -2 0;
setFont SanSerif;
setFontSize 10;
getToolPalette;
tell It;
endTell;
desuppress;
endTell;
getEmployee #mesquite.minimal.ManageTaxa.ManageTaxa;
tell It;
showTaxa #7121830078017352332
#mesquite.lists.TaxonList.TaxonList;
tell It;
setTaxa #7121830078017352332;
getWindow;
tell It;
newAssistant
#mesquite.lists.TaxonListCurrPartition.TaxonListCurrPartition;
setExplanationSize 30;
setAnnotationSize 20;
setFontIncAnnot 0;
setFontIncExp 0;
setSize 1436 994;
setLocation -2 0;
setFont SanSerif;
setFontSize 10;
getToolPalette;

```

```

        tell It;
            setTool
mesquite.lists.TaxonList.TaxonListWindow.arrow;
        endTell;
    endTell;
    showWindow;
    getEmployee #mesquite.lists.ColorTaxon.ColorTaxon;
    tell It;
        setColor Magenta;
        removeColor off;
    endTell;
    getEmployee
#mesquite.lists.TaxonListAnnotPanel.TaxonListAnnotPanel;
    tell It;
        togglePanel off;
    endTell;
endTell;
endTell;
getEmployee
#mesquite.trees.BasicTreeWindowCoord.BasicTreeWindowCoord;
    tell It;
        makeTreeWindow                                #7121830078017352332
#mesquite.trees.BasicTreeWindowMaker.BasicTreeWindowMaker;
    tell It;
        suppressEPCResponse;
        setTreeSource #mesquite.trees.StoredTrees.StoredTrees;
        tell It;
            setTreeBlock 1;
            toggleUseWeights off;
        endTell;
        setAssignedID 935.1455299445086.6002950344002218511;
        getTreeWindow;
        tell It;
            setExplanationSize 30;
            setAnnotationSize 20;
            setFontIncAnnot 0;
            setFontIncExp 0;
            setSize 1436 994;
            setLocation -2 0;
            setFont SanSerif;
            setFontSize 10;
            getToolPalette;
            tell It;
            endTell;

```

```

        getTreeDrawCoordinator
#mesquite. trees. BasicTreeDrawCoordinator. BasicTreeDrawCoordinator;
        tell It;
            suppress;
            setTreeDrawer
#mesquite. trees. SquareLineTree. SquareLineTree;
        tell It;
            setNodeLocs
#mesquite. trees. NodeLocsStandard. NodeLocsStandard;
        tell It;
            branchLengthsToggle on;
            toggleScale on;
            toggleBroadScale off;
            toggleCenter on;
            toggleEven on;
            setFixedTaxonDistance 0;
        endTell;
        setEdgeWidth 4;
        showEdgeLines on;
        orientUp;
    endTell;
    setBackground White;
    setBranchColor Black;
    showNodeNumbers off;
    showBranchColors on;
    labelBranchLengths off;
    centerBrLenLabels on;
    showBrLenUnspecified on;
    showBrLenLabelsOnTerminals on;
    setBrLenLabelColor 0 0 255;
    setNumBrLenDecimals 6;
    desuppress;
    getEmployee
#mesquite. trees. BasicDrawTaxonNames. BasicDrawTaxonNames;
    tell It;
        setFontSize 18;
        setColor Black;
        toggleColorPartition off;
        toggleColorAssigned on;
        toggleShadePartition off;
        toggleShowFootnotes on;
        toggleNodeLabels on;
        toggleCenterNodeNames off;
        toggleShowNames on;

```

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namesAngle ?;
endTell;
endTell;
setTreeNumber 2;
setTree
' (1:0.9234831, ((4:14.25266, (3:4.514811, 2:4.604786):9.601883):14.64353, (5:39
.59726, ((6:13.72827, ((7:5.538208, 8:5.549427):3.485887, (9:2.844809, 10:2.9442
56):6.168474):4.719481):18.44112, ((11:10.20773, 12:10.11602):17.16676, ((13:7
.538427, 14:7.575328, 15:7.545774):16.04869, ((16:9.983254, (17:4.725165, 18:4.7
43107):5.316873):10.1417, ((19:10.62683, (28:9.799832, 29:11.93106, 71:13.10332
, (26:2.945482, 27:6.219088):6.882901):2.302205):6.399617, ((21:6.4125, (20:2.5
27387, 22:3.666646):2.741084):5.742898, (23:5.7483, (24:3.080747, 25:3.162838):
2.687751):3.089472):9.654351, ((30:8.401217, 31:10.13796, 32:14.84348, 33:14.91
571, (34:5.759099, (35:1.471234, 36:4.815767):4.789123):11.85078):4.804461, (41
:21.08138, ((40:2.954525, (38:6.795291, 39:4.032479):3.245529):4.171259, (37:9.
976843, (42:4.880057, (43:4.565558, ((45:9.591676, ((49:2.568422, 50:17.25893):8
.29251, ((46:2.388347, 47:12.12656, 48:8.176731):2.527138, (65:7.92546, (61:41.0
6722, 64:3.984093):18.14757):15.128):3.241694):4.36457):5.161783, (44:28.1237
6, (51:3.342737, (52:7.83566, (54:47.58846, 56:17.33788, 57:62.77426, 60:27.75169
, 62:10.51983, 68:31.23149, 69:15.76705, 70:22.66994, 72:31.23018, (73:14.52449, (
66:11.12571, 67:10.36175):2.724454):49.17971, (53:9.992952, 59:7.407002, (55:25
.82897, 58:14.50977, 63:16.83062):18.65066):17.82318):12.00393):13.85847):6.7
45672):6.907801):8.20571):6.218167):10.13689):4.345229):2.755162):5.424514)
:8.588199):3.116697):3.441235):3.72404):4.877922):3.830148):10.19395):13.26
325);';

setDrawingSizeMode 0;
toggleLegendFloat on;
scale 0;
toggleTextOnTree off;
togglePrintName on;
showWindow;
endTell;
desuppressEPCResponse;
getEmployee #mesquite.trees.ColorBranches.ColorBranches;
tell It;
setColor Red;
removeColor off;
endTell;
getEmployee #mesquite.ornamental.BranchNotes.BranchNotes;
tell It;
setAlwaysOn off;
endTell;
getEmployee
#mesquite.ornamental.ColorTreeByPartition.ColorTreeByPartition;

```

```

        tell It;
            colorByPartition off;
        endTell;
        getEmployee
#mesquite.ornamental.DrawTreeAssocDoubles.DrawTreeAssocDoubles;
        tell It;
            setOn on;
            setDigits 4;
            writeAsPercentage off;
            toggleCentred off;
            toggleHorizontal on;
            toggleWhiteEdges on;
            setFontSize 10;
            setOffset 0 0;
        endTell;
        getEmployee
#mesquite.ornamental.DrawTreeAssocStrings.DrawTreeAssocStrings;
        tell It;
            setOn on;
            toggleCentred on;
            toggleHorizontal on;
            setFontSize 10;
            setOffset 0 0;
        endTell;
        getEmployee #mesquite.trees.TreeInfoValues.TreeInfoValues;
        tell It;
            panelOpen false;
        endTell;
    endTell;
endTell;
getEmployee
#mesquite.charMatrices.BasicDataWindowCoord.BasicDataWindowCoord;
    tell It;
        showDataWindow #2516980770027965603
#mesquite.charMatrices.BasicDataWindowMaker.BasicDataWindowMaker;
        tell It;
            getWindow;
            tell It;
                setExplanationSize 30;
                setAnnotationSize 20;
                setFontIncAnnot 0;
                setFontIncExp 0;
                setSize 1436 994;
                setLocation -2 0;
            endTell;
        endTell;
    endTell;
endTell;

```

```

        setFont SanSerif;
        setFontSize 10;
        getToolPalette;
        tell It;
            setTool
mesquite.charMatrices.ColorCells.ColorCells.ColorCells;
        endTell;
        setTool
mesquite.charMatrices.ColorCells.ColorCells.ColorCells;
        colorCells
#mesquite.charMatrices.ColorCells.ColorCells;
        tell It;
            setColor Pink;
            removeColor off;
        endTell;
        colorRowNames
#mesquite.charMatrices.TaxonGroupColor.TaxonGroupColor;
        colorColumnNames
#mesquite.charMatrices.CharGroupColor.CharGroupColor;
        colorText #mesquite.charMatrices.NoColor.NoColor;
        setBackground White;
        toggleShowNames off;
        toggleShowTaxonNames on;
        toggleTight off;
        toggleThinRows off;
        toggleShowChanges on;
        toggleSeparateLines off;
        toggleShowStates on;
        toggleAutoWCharNames on;
        toggleAutoTaxonNames off;
        toggleShowDefaultCharNames off;
        toggleConstrainCW on;
        toggleBirdsEye off;
        toggleShowPaleGrid off;
        toggleShowPaleCellColors off;
        toggleShowPaleExcluded off;
        togglePaleInapplicable on;
        toggleShowBoldCellText off;
        toggleAllowAutosize on;
        toggleColorsPanel off;
        toggleDiagonal on;
        setDiagonalHeight 80;
        toggleLinkedScrolling on;
        toggleScrollLinkedTables off;

```

```

        endTell;
        showWindow;
        getWindow;
        tell It;
            forceAutosize;
        endTell;
        getEmployee
#mesquite.charMatrices.ColorByState.ColorByState;
        tell It;
            setStateLimit 9;
            toggleUniformMaximum on;
        endTell;
        getEmployee
#mesquite.categ.StateNamesEditor.StateNamesEditor;
        tell It;
            makeWindow;
            tell It;
                setExplanationSize 30;
                setAnnotationSize 20;
                setFontIncAnnot 0;
                setFontIncExp 0;
                setSize 1436 994;
                setLocation -2 0;
                setFont SanSerif;
                setFontSize 10;
                getToolPalette;
                tell It;
                    endTell;
                    rowsAreCharacters on;
                    toggleConstrainChar on;
                    toggleConstrainCharNum 3;
                    togglePanel off;
                    toggleSummaryPanel off;
                endTell;
                showWindow;
            endTell;
        getEmployee #mesquite.categ.StateNamesStrip.StateNamesStrip;
        tell It;
            showStrip on;
        endTell;
        getEmployee #mesquite.charMatrices.AnnotPanel.AnnotPanel;
        tell It;
            togglePanel off;
        endTell;

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        getEmployee
#mesquite.charMatrices.CharReferenceStrip.CharReferenceStrip;
        tell It;
            showStrip off;
        endTell;
        getEmployee
#mesquite.charMatrices.QuickKeySelector.QuickKeySelector;
        tell It;
            autotabOff;
        endTell;
        getEmployee
#mesquite.charMatrices.SelSummaryStrip.SelSummaryStrip;
        tell It;
            showStrip off;
        endTell;
        getEmployee
#mesquite.categ.SmallStateNamesEditor.SmallStateNamesEditor;
        tell It;
            panelOpen true;
        endTell;
    endTell;
endTell;
getEmployee
#mesquite.charMatrices.ManageCharacters.ManageCharacters;
    tell It;
        showCharacters #2516980770027965603
#mesquite.lists.CharacterList.CharacterList;
    tell It;
        setData 0;
        getWindow;
        tell It;
            newAssistant
#mesquite.lists.DefaultCharOrder.DefaultCharOrder;
            newAssistant
#mesquite.lists.CharListInclusion.CharListInclusion;
            newAssistant
#mesquite.lists.CharListPartition.CharListPartition;
            newAssistant
#mesquite.parsimony.CharListParsModels.CharListParsModels;
        setExplanationSize 30;
        setAnnotationSize 20;
        setFontIncAnnot 0;
        setFontIncExp 0;
        setSize 1436 994;
    endTell;
endTell;

```

```

        setLocation -2 0;
        setFont SanSerif;
        setFontSize 10;
        getToolPalette;
        tell It;
            setTool
mesquite.lists.CharacterList.CharacterListWindow.ibeam;
        endTell;
        setActive;
    endTell;
    showWindow;
    getEmployee
#mesquite.lists.CharListAnnotPanel.CharListAnnotPanel;
    tell It;
        togglePanel off;
    endTell;
endTell;
endTell;
endTell;
end;

```


Lanthanolania

10????000?000?01????0?0???001?1???????012???????0????????????????????????0?????0???
??????1????????0????02??
????????????????????0?0???????3?????0???

Orovenator

10?0000?100000000010000?010001???0{02}101???1{12}?????0?0?????0?10?00?0????000100
000?000000?10??0?00001?01?000000000?0?00????????????????????????????????????
????????????????????????0???000????????3?????0???

Sophineta

000000101000?101000?11102000?01?11001?11022000010???????1111???????????01?0?10???
0000010?0?0?????310?0000???0?0?00?1??1?0010?0???01????????????????????????????
??????0?0????????????000?????00???????010???????0??

Pamelina

010000101000??11110000000101?10?1020101102220?0113???????1111?????????11?01?0?0???
00?0101?0?0?????010?00?0?010?0?10?0?0?0101?11?02????????????????????????????
????????????????????0??1??00?????????11?????????

Tanystropheus

11000011?1000?01011?00100010010111101111012201?00001001101110111?1111?10010010000
0000201010010100110100000011210001012110(012)?01100101020000?00?0001100011000000
0001012100120101111011100011110020000010010200001310010100000

Choristodera

211000010101010111(01)00?1100000010?(01)211110110?(01)001001011101110111?0011?0??1
10010001000011010010?0??10110000010100001110100010(01)100110010001100?0011100010
1?00010001(0 2)1120010010(0 1)0?101110?1011101010010010001000100110100000

Macrocnemus

11000011?1000?01?11?0?1?01?000001021111101210?????0?0?1?1011?11?01?1110?1?0?0?0?
0???0101001?1001101?0000010110001012110?00100101?10011?00000011000110000000001?
122001?00011110111000011101000000100102000?131?010100000

Hovasaurus

????????????????0?00?101?0??1?0?0?002011?00?10????01???01
?0???1????????????2?????1????????????0?0???00000?0?0?0?0?01?10002??0?000010??
???10001000120?2?010?10000?01?10000?0??101020???00000000?300?100?0010

Pachypleurosaurs

1000001000(01)00??2010?0?00100111111001(01)11022010111?0?10?1011101??1???11?100111
1?0111???0?010010?111?11000000102100010101110101000110020002?00?0011001211?0200(0
1)1101(0 1)01(1 2)001201000110110000110000011(0 1)10??? (0 1)?????0???????1000?0

Simosaurus

2000001010100??2010?0?00000011011111011022010111?010011001101??1???10?1000111?01
1000211011010?11??110001101121100111011101010?111102000?00?001100121000200111011
112001201?0011?110000110000211?10?????????0?2?????000?0

Placodus

0010011101010??2010?11?00101010111101111002010?01?010010011101??1?1?1101102001101
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0112001201000110111000110000(0 2)11220???????0??2??0??100000

Pistosauridae

10?0001010100??2011?0??01100011011131011012011??1?0?0111001101??1???11?1001011?01
10?0?1?0???10?11??1000011011210001110??1010100?1?102(01)0??? (01)0?0(01)11101?1??020
0?11011112011001010(0 1)?01?000????001?0(0 1 2)1????????2?????00000

Askeptosaurus

100001110010000100100?001010101010001111012101??0101?11101111?11?01?1?0001?0?0100
00112110001100111?01000000112100010101101101000101010?000000?001000010000000001
0121011001000?101110000111000102?1??0?0?00000?????100000

Clarazia

0011001100100??001?0????11011100?00?1110122?1??010??111?1111??????1?000110?010??0
?1?0111011?000?311000011101110?0?0110?0010?0?01010?01?000???110?0100000000?0????2
001?00?00?11110?01110000110?0?????000?0?????100000

Thalattosaurus

1011001100100??011?01?0?110?1100?00?111012201??010??111?1111??????1??01?0?01???0
?1?111101100011121100001?12011?1010?00?10??00?01????????????????????100?00????????
1????????01????????01???1?????0?00?0?????1000??

Helveticosaurus

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1?010000100110??111000?11320?0????0??0?????0?0000

Largocephalosaurus

00?0001?00000??201110?100110001011310111020210?1?10?0?0??0010????????1?0?1?21?100?
0???100000?000??01?0(01)0?0??2??01101?1110?101000(01)??2(23)2?00100011110121000200
1?101(0 2)1210110010(0 1)00?0011?0(0 1)100??(0 2)10100????????????????0000?0

Sinosaurosphargis

00?0001000000??01110?1001110?00??300111020210?1??0??0???010?????1?00?0??210100?
0002110000??0??01?00010?121001?00?1??2?20??0??0?202??10102111012??????1?10????1
0110000????????????2??100????????????????100???

Wumengosaurus

10?0011100001?0100110?00010?(01)010?1??0110221?0111??????1?01?0?????????????????0?
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0220010010100?0110?0?0000?11311????????0????????00000

Nanchangosaurus

10?0?01?0?000?0100110?00011110011110101102210011001?00??00?0????????????????1?????
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?11?1?00?0001????????01020?????????????????01000

Hupehsuchus

10?0?01101000?0100111?00011110011110001102210011001?0?0??00?0????????????0??11?0??1
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1111110001?001001001000001020?????????????????010{0 1}0

Chaohusaurus

10?0011101001?0100111?00112000010100101102210011001?0?0??0110?????????0??0?01?100?
1???0?00001?001?01?100001121010100?110?0210100(01)101000010000021000210?00000001
13122111(0 1)011000?101000011100001(0 1)001????????????????00100

Utatusaurus

1100000101000?010110000001100001100011110120001100010011011100111?0001001000
000?01010110101001101000000101000010120100?0110010111?012?00?001100011000000000
10122001101011010111001011101000200000?020000031001010000?

Trilophosaurus

110000???0000???00111??1101000???1231111010?0?0?0?11111?01?110111000?100111?01
00??2101011100??101002?0?11210001(1
2)100100?01??0101110000100?0??110001?1?000100?10020?00100011010111001011101000100
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Rhynchosauria

0111101000000?01111101101000001111231111112100111000001111110011?0011100110010000
1010101011101111121102001102000010110100?00100101110012100?0?011000111001010001
011000110001101011101011101100300000112?0000110010100?00

Archosauriformes (0 1)1(0 1)(0 1)101(0 1)(0 1)1000(0 1)0101110000(0 1)(0 1)00001010(0
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Claudiosaurus

100000?110000?11010?0?0001?001101100101102201001100?001000?10?00010010100
000120100001?10010010000001010000?0110000?01000101010000100000011000100?0001000
1102000100100001011000000000001010000010000010111011100000

Coelurosauravus

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02?0?00???101000000000010100100100?0000110010?00???

Kuehneosauridae

0100001010000011110?00000100010010201011022200011301010001111???001??1000110?001
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02120?00???00?10211001??100?01?10000???0000011100?1000?00

Acerosodontosaurus

1???0??10????00????0?00?0?0??0?1?????002001?????????0?0?0?????????????????0???
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Tangasaurus

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Youngina

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00100?01?????00??10000001010000000?0?0000?10??0?01001?????00???0?1010?01?00100?
?0?0?0?0001??1?????000?10?0000000(0 1)???1??03????0?0?000

Thadeosaurus

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0?01000120?20010000000?011100?0?0?1?1000???00?000000?10?100?0?00

Lanthanolania

10????000?000?01????0?0???001?1???????012???????0????????????????????????0?????0???
??????1????????0????02??
????????????????????0?0???????3?????0???

Orovenator

10?0000?100000000010000?010001???0{02}101???1{12}?????0?0?????0?10?00?0????000100
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????????????????????????0???000????????3?????0???

Sophineta

000000101000?101000?11102000?01?11001?11022000010???????1111???????????01?0?10???
0000010?0?0?????310?0000???0?0?00?1??1?0010?0???01????????????????????????????
??????0?0????????????000?????00???????010???????0??

Pamelina

010000101000??11110000000101?10?1020101102220?0113???????1111?????????11?01?0?0???
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????????????????????0??1??00?????????11?????????

Tanystropheus

11000011?1000?01011?00100010010111101111012201?0001001101110111?1111?10010010000
0000201010010100110100000011210001012110(012)?01100101020000?00?0001100011000000
0001012100120101111011100011110020000010010200001310010100000

Choristodera

211000010101010111(01)00?1100000010?(01)2111110110?(01)001001011101110111?0011?0??1
10010001000011010010?0??10110000010100001110100010(01)100110010001100?0011100010
1?00010001(0 2)1120010010(0 1)0?101110?1011101010010010001000100110100000

Macrocnemus

11000011?1000?01?11?0?1?01?000001021111101210?????0?0?1?1011?11?01?1110?1?0?0?0?
0???0101001?1001101?0000010110001012110?00100101?10011?00000011000110000000001?
122001?00011110111000011101000000100102000?131?010100000

Hovasaurus

????????????????0?00?101?0??1?0?0?002011?00?10????01???01
?0???1????????????2?????1????????????0?0???00000?0?0?0?0?01?10002??0?000010??
???10001000120?2?010?10000?01?10000?0??101020???00000000?300?100?0010

Pachypleurosaurs

1000001000(01)00??2010?0?00100111111001(01)11022010111?0?10?1011101??1???11?100111
1?0111???0?010010?111?11000000102100010101110101000110020002?00?0011001211?0200(0
1)1101(0 1)01(1 2)001201000110110000110000011(0 1)10??? (0 1)?????0???????1000?0

Simosaurus

2000001010100??2010?0?00000011011111011022010111?010011001101??1???10?1000111?01
1000211011010?11??110001101121100111011101010?111102000?00?001100121000200111011
112001201?0011?110000110000211?10?????????0?2?????000?0

Placodus

0010011101010??2010?11?00101010111101111002010?01?010010011101??1?1?1101102001101
10?01001101111000111101101102101000101101011001101020001?00?11111011100000011101
0112001201000110111000110000(0 2)11220???????0??2??0??100000

Pistosauridae

10?0001010100??2011?0??01100011011131011012011??1?0?0111001101??1???11?1001011?01
10?0?1?0???10?11??1000011011210001110??1010100?1?102(01)0??? (01)0?0(01)11101?1??020
0?11011112011001010(0 1)?01?000????001?0(0 1 2)1????????2?????00000

Askeptosaurus

100001110010000100100?001010101010001111012101??0101?11101111?11?01?1?0001?0?0100
00112110001100111?01000000112100010101101101000101010?000000?001000010000000001
0121011001000?101110000111000102?1??0?0?00000?????100000

Clarazia

0011001100100??001?0????11011100?00?1110122?1??010??111?1111??????1?000110?010??0
?1?0111011?000?311000011101110?0?0110?0010?0?01010?01?000???110?0100000000?0????2
001?00?00?11110?01110000110?0?????000?0?????100000

Thalattosaurus

1011001100100??011?01?0?110?1100?00?111012201??010??111?1111??????1??01?0?01???0
?1?111101100011121100001?12011?1010?00?10??00?01????????????????????100?00????????
1????????01????????01???1?????0?00?0?????1000??

Helveticosaurus

00?1001?1?????0?000?0?1?0????1??11??0?0??
0?0?001?0000?00?0000????00?0?01101?101001?10200?1?00?10011000100000010001?11100
1?010000100110??111000?11320?0????0??0?????0?0000

Largocephalosaurus

00?0001?00000??201110?100110001011310111020210?1?10?0?0??0010????????1?0?1?21?100?
0???100000?0000?01?0(01)0?0??2?01101?1110?101000(01)??2(23)2?00100011110121000200
1?101(0 2)1210110010(0 1)00?0011?0(0 1)100??(0 2)10100????????????????0000?0

Sinosauropsphargis

00?0001000000??01110?1001110?00??300111020210?1??0??0???010?????1?000??210100?
0002110000??0??01?00010?121001?00?1??2?20??0??0?202??10102111012??????1?10????1
0110000????????????2??100????????????????100???

Wumengosaurus

10?0011100001?0100110?00010?(01)010?1??0110221?0111??????1?01?0?????????????????0?
?????0?01001?0000??1?10000????00101?110?0100001?020?00?0000001011010002000?0013
0220010010100?0110?0?0000?11311????????0????????00000

Nanchangosaurus

10?0?01?0?000?0100110?00011110011110101102210011001?00??00?0????????????????1?????
???0??100???0?????02???????0?1?1??10?00100000002010111012121100?1??0000?00113122
?11?1?00???001????????01020?????????????????01000

Hupehsuchus

10?0?01101000?0100111?00011110011110001102210011001?0?0??00?0????????????0??11?0??1
???0?0100???0?0???02???12100?101?110?00100000002010111012121100?1??0000?00113122
1111110001?001001001000001020?????????????????010{0 1}0

Chaohusaurus

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