

# SUPPLEMENTARY DATA 1

A *Crocodylus*-like mekosuchine (Eusuchia: Crocodilia) from the Pliocene of South Australia

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TABLE S1. Terminal taxa used in the cladistic analysis and the sources used to score them. Note that literature was consulted to provide anatomical information in the form of descriptive text, images and scores for cladistics analyses. **Abbreviations:** **AM**, Australian Museum, Sydney, Australia; **c**, indicates the specimen examined was a cast; **d**, indicates that digital scans and 3D rendered models of the specimen were examined (available at <http://digimorph.org>); **FMNH**, Field Museum of Natural History, Chicago, Illinois, U.S.A; **MNZ**, Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand; **NMV**, Museum Victoria, Melbourne, Australia; **NTM**, Museum and Art Gallery of the Northern Territory, Darwin, Australia; **QM**, Queensland Museum, Brisbane, Australia; **SAM**, South Australian Museum, Adelaide, Australia; **TMM** Texas Memorial Museum, Austin, Texas, U.S.A.

Taxon	Specimens Examined	Literature used
<i>Bernissartia fagesii</i>		Norell and Clark 1990; Buscalioni and Sanz 1990; Brochu 1999
<i>Borealosuchus formidibalis</i>		Erickson 1976; Brochu 1997, 1999
<i>Leidyosuchus canadensis</i>		Lambe 1907; Brochu 1997, 1999; Wu, Russell and Brinkman 2001
<i>Brachychampsia montana</i>		Norell, Clark and Hutchison 1994, Brochu 1999
<i>Alligator mississippiensis</i>	NTM R36716, QM J4850	Mook 1921a, Brochu 1999
<i>Prodiplocynodon langi</i>		Mook 1941, Brochu and Storrs 2010
<i>‘Crocodylus’ affinis</i>		Mook 1921b, Brochu and Storrs 2010
<i>‘Crocodylus’ depressifrons</i>		Delfino and Smith 2009, Brochu and Storrs 2010
<i>Brachyuranochampsia eversolei</i>		Zangerl 1944, Brochu and Storrs 2010

<i>Maroccosuchus zennaroi</i>		Jouve et al. 2015
<i>Dollosuchoides densmorei</i>		Brochu 2007a, Brochu and Storrs 2010
<i>Toyotamaphimeia machikanensis</i>		Kobayashi et al. 2006, Brochu and Storrs 2010
<i>Tomistoma schlegelii</i>	NTM P3142 (c), TMM M-6342(d)	Mook 1921b, Brochu and Storrs 2010
<i>'Crocodylus' megarhinus</i>		Andrews 1906, Mook 1927, Brochu and Storrs 2010
<i>Brochuchus pigotti</i>		Tchernov and Van Couvering 1978, Conrad et al. 2013
<i>Voay robustus</i>		Brochu 2007b, Bickleman and Klein 2009
<i>Osteolaemus tetraspis</i>	FMNH 98936(d)	Mook 1921b, Brochu and Storrs 2010
<i>Mecistops cataphractus</i>	TMM M-3529(d)	Mook 1921b, Brochu and Storrs 2010
<i>Crocodylus thorbjarnarsoni</i>		Brochu and Storrs 2010
<i>Crocodylus porosus</i>	NTM R12638, NTM R13139, NTM R16038, unregistered NTM material (3 specimens)	Brochu and Storrs 2010
<i>Crocodylus moreletii</i>	TMM M-4980(d)	Brochu and Storrs 2010
<i>Kambara taraina</i>		Buchanan 2009
<i>Kambara implexidens</i>	QM F29662, QM F29663, QM F30077	Salisbury and Willis 1996
<i>Kambara murgonensis</i>	QM F29665, QM F29667, QM F21129	Willis, Molnar and Scanlon 1993, Salisbury and Willis 1996
<i>Australosuchus clarkae</i>	SAM P23985, SAM P30162, SAM P33761, SAM P33942, SAM P36578, SAM P42786, SAM P42787, SAM P42788, SAM P42789,	Willis and Molnar 1991
<i>Pallimnarchus</i> ssp.	QM F1166, QM F1752, QM F2025, QM F3303, QM F11262, QM F17065	Molnar 1982, Willis and Molnar 1997
<i>Kalthifrons aurivellensis</i>	SAM P35062	
<i>Baru wickeni</i>	NTM P911, NTM P902-3, NTM P902-5, NTM P943-4, NTM P1164, NTM P8681-14, NTM P8738-1, NTM P8778-2, NTM P8778-4, NTM P8778-5, NTM P8778-16, NTM P8778-18, NTM P8778-19, NTM P91164, NTM P91170-2, NTM P91170-3, NTM P91171-1, QM F16822, QM F31071, QM F31072, QM F31075,	Willis 1997
<i>Baru darrowi</i>	NTM P908-35, NTM P908-73, NTM P908-75, NTM P2786-5, NTM P2786-7, NTM P8695-8, NTM P87110-31, NTM P87115-15, QM F30319, QM F31185	Willis, Murray and Megirian 1990
<i>Quinkana meboldi</i>	QM F31056, QM F31057, QM F31059, QM F31079	Willis 1997
<i>Quinkana timara</i>	NMV P179632 (c), NTM P894-6, NTM P895-16, NTM P895-19, NTM P904-6, NTM P2771, NTM 2775-1, NTM P8695-114, NTM P8697-2, NTM P9464-167, NTM P9464-168, NTM P9464-170, NTM P9464-	Megirian 1994

	174, NTM P9464-177, NTM P9464-187, - NTM P9464-178, NTM P9553-1	
<i>Quinkana fortirostrum</i>	AM F.57844 (c), NTM P5334, NTM P6279, NTM P6280, NTM P6281, NTM P6282, NTM P6284, NTM P6285, NTM P9540	Molnar 1981
<i>Trilophosuchus rackhami</i>	QM F16856	Willis 1993
<i>Volia athollandersoni</i>		Molnar, Worthy and Willis 2002.
<i>Mekosuchus whitehunterensis</i>	QM F31051, QM F31052, QM F31053, QM F31054,	Willis 1997
<i>Mekosuchus sanderi</i>	QM F30518, QM F31188, QM F31166	Willis 2001
<i>Mekosuchus inexpectatus</i>	Unregistered MNZ material from Pindai Cave	Balouet and Buffetaut 1987, Balouet 1991, Mead et al. 2002, Holt et al. 2007

## APPENDIX S1

### Character descriptions.

1. Anterior profile of the premaxilla in lateral view: sloping posterodorsally from alveolar margin to anterior rim of external naris (0); forms a deep, nearly vertical surface between alveolar margin and external naris (1). New character.
2. External naris shape: at least as wide as long (0); longer than wide (1). Modified from Character 161 in Brochu (1999).
3. Orientation of the external naris: opening faces anterodorsally (0); opening faces dorsally (1). Character 79 in Brochu (1999).
4. Position of the anterior margin of the incisive foramen: far from premaxillary tooth row so that it is level with second or third premaxillary tooth (0); abuts the premaxillary tooth row (1). Character 153 in Brochu (1999).
5. Position of the posterior margin of the incisive foramen: posterior to the penultimate premaxillary tooth (0); level with or anterior to penultimate premaxillary tooth (1). Modified from Character 153 in Jouve et al. (2015).
6. Laterally visible notches for the reception of anterior dentary teeth between premaxillary teeth: absent (0); present (1). Character 3 in Molnar, Worthy and Willis (2002, appendix 1).
7. Number of premaxillary teeth in all but early posthatching juveniles: five (0); four (1). Character 17 in Norell (1989).
8. Reception pit for second dentary tooth: present, located between premaxillary teeth 3 and 4 (0); present, medial to premaxillary teeth 3 and 4 (1); absent (2). Unordered. Modified from character 2 in Molnar, Worthy and Willis (2002, appendix 1).
9. Size of the penultimate premaxillary tooth: smaller than the largest maxillary tooth (0); as large or larger than the largest maxillary tooth (1). New Character.
10. Position of last premaxillary tooth relative to penultimate tooth: positioned laterally (0); in line (1); positioned medially (2). Ordered. Character 204 in Jouve et al. (2015).
11. Extent of the posterior dorsal process of the premaxilla: short, not extending posterior to the level of the third maxillary tooth (0); long, extending posterior to the level of the third maxillary tooth (1). Character 145 in Brochu (1999).

12. Participation of the maxilla in the margin of the orbit: absent (0); present (1). New character based on observations by Willis (1997b, 2001)
13. Size of maxillary foramen for palatine branch of Cranial Nerve V: small, indistinguishable from nearby nutritive foramina (0); large several times greater than surrounding nutritive foramina (1). Character 111 in Brochu (1999).
14. Posteriorly projecting process of the maxilla covering the medial surface of the anterior end of the maxillary process of the ectopterygoid: absent (0); present (1). Character 186 in Brochu and Storrs (2010).
15. Presence or absence of a canine peak in the anterior festoon of the maxilla: present, one tooth or a pair of teeth distinctly enlarged (0); no distinctly enlarged maxillary tooth in the anterior region of the maxilla (1). Modified from by separating out state 4 from character 89 in Brochu (1999).
16. Position of the canine peak in the maxillary dentition (only applicable to taxa that have a canine peak): the third and fourth maxillary alveoli are equal largest (0); the fourth alveolus is the largest (1); fifth maxillary alveolus is the largest (2). Unordered. Modified from character 89 in Brochu (1999).
17. Inter-alveolar spaces between maxillary teeth 6, 7 and 8: gaps between these teeth no larger than those between other maxillary teeth (0); gaps between these teeth distinctly enlarged in comparison to the gaps between other maxillary teeth (1). Simplified from character 235 in Jouve et al. 2014 by collapsing states 0 and 1 into state 0 and states 2 and 3 into state 1.
18. Presence or absence of a linear array of recesses along the lateral wall of the caviconchal recess: absent (0); present (1). Character 148 in Brochu (1999).
19. Tall 'alveolar wall' raised above level of the palate on the medial side of at least the first six maxillary alveoli: absent (0); present (1). Modified from character 16 in Salisbury and Willis (1996).
20. Relationship of nasals to external naris: nasals reach margin of external naris (0); nasals excluded from external narial margin by a short superficial premaxillary symphysis overlapping the nasals (1); nasals excluded from external naris by a deep, elongate premaxillary symphysis that extends for at least two tooth positions (2). Ordered. Modified from character 95 in Brochu (1999) by deleting uninformative state 0, and dividing state 2 into two new states.
21. Relationship of the nasals to the anterior end of the frontal: nasals terminating at about the level of the anterior end of the frontal (0); nasals extend posteriorly so that they deeply intrude between the prefrontals and the frontal (1). New character.
22. Orientation of the expansion of the medial process of the prefrontal pillar: dorsoventrally expanded (0); anteroposteriorly expanded (1). Character 136 in Brochu (1999).
23. Basal constriction of the medial process of the prefrontal pillar: absent (0); present (1). Character 138 in Brochu (1999).
24. Elongate preorbital ridge on the lacrimal of adults: absent (0); present (1). Modified from character 144 in Brochu (1999).
25. Deep preorbital sulcus on the lacrimal: absent (0); present (1). New character.
26. Snout depth: platyrostral (0); altirostral (1). Character 30 in Salisbury and Willis (1996).
27. Size of medial jugal foramen: small (0); large (1). Character 120 in Brochu (1999).
28. Shape of the prefrontal-frontal suture: linear to gently curved (0); L-shaped (1). New character.
29. Posterior process of the maxilla intruding between the prefrontal and lacrimal: absent (0); present (1). Modified from character 93 in Brochu (1999) by treating the separation

of the lacrimal from the nasal by a posterior process of the maxilla as an independent character from a maxillary spur in the lacrimal.

30. Posterior spur of maxilla intruding into lacrimal: absent (0); present (1). Modified from character 93 in Brochu (1999) by treating the separation of the lacrimal from the nasal by a posterior process of the maxilla as an independent character from a maxillary spur in the lacrimal.
31. Shape of the anterior end of the frontal: terminates in a simple narrow tip (0) terminates in a broad, transverse suture with the nasals (1). Character 131 in Brochu and Storrs (2010).
32. Presence or absence of median frontal ridge: absent (0); present (1). Character 188 in Brochu and Storrs (2010).
33. Anterior extent of the orbits: anterior margin of the orbit posterior to the level of the 12<sup>th</sup> maxillary tooth (0); anterior margin of the orbit anterior to the 12<sup>th</sup> maxillary tooth (1). Character 21 in Salisbury and Willis (1996).
34. Dorsal orbital rims: flush with skull roof (0); raised (1). Simplified from character 103 in Brochu (1999) by omitting state 2, which does not occur in the selected ingroup.
35. Minimum interorbital distance relative to frontal length: narrow, distance less than 25% of frontal length (0); intermediate, distance between 25 and 50% of frontal length (1); broad, greater than 50% of frontal length (2). Ordered. New character.
36. Width of the postorbital bar: massive (0); slender (1). Character 3 in Norell (1989).
37. Position of the base of the postorbital bar: flush with lateral surface of jugal to slightly inset (0); strongly inset (1). Character 1 in Salisbury and Willis (1996).
38. Orientation of the ventral ornamented area of the jugal anterior to the postorbital bar: ornamented area faces laterally to ventrolaterally (0); ventral ornamented area sharply bent to face entirely ventrally (1). New character.
39. Relationship of frontoparietal suture with supratemporal fenestra: suture entirely on skull roof and does not reach the fenestra (0); suture only just enters the fenestra, or just grazes it, so that a broad parietal-postorbital contact is maintained (1); frontoparietal suture deeply enters the fenestra and prevents the parietal from contacting the postorbital (2). Character 81 in Brochu (1999).
40. Shape of the the frontoparietal suture between the supratemporal fenestra: linear (0); bowed posteriorly (1). Polarity reversed from character 86 in Brochu (1999).
41. Shape of the supratemporal fenestrae: approximately as long as wide (0); length: width ratio greater than 1.75 (1). New character.
42. Closure of the supratemporal fenestrae in adults: dermal bones do not overhang the margin of the fenestra (0); dermal bones overhang the margin of the fenestra, partially closing it (1). Simplified from character 87 in Brochu (1999) by omitting state 2, which does not occur in the selected ingroup.
43. Distance between the parietal and squamosal under the opening of the cranioquadrate canal on the posterior wall of the supratemporal fenestra: parietal and squamosal widely separated (0); parietal and squamosal closely approaching each other (1). Simplified from character 131 in Brochu (1999) by omitting state 2, which does not occur in the selected ingroup.
44. Shape of the anterior termination of the squamosal: transversely compressed splint adpressed to the lateral surface of the postorbital, without any underplating of the postorbital (0); A narrowly tapering process that curves to face ventrally and partially underplating the postorbital (1); a wide dorsoventrally compressed plate that broadly underplates the postorbital (2). Ordered. Modified from character 163 in Brochu (1999).

45. Ventrolateral extent of the squamosal: not reaching the ventrolateral corner of the paroccipital process (1); extending laterally and posteriorly of the ventrolateral corner of the paroccipital process (2). Character 150 in Brochu (1999).
46. Shape of the lateral squamosal sulcus : parallel dorsal and ventral margins (0); anteriorly flared with diverging dorsal and ventral margins (1). Character 84 in Brochu (1999).
47. Extent of ornament into lateral squamosal sulcus: Sulcus smooth with cranial ornamentation extending no further than the dorsal rim (0); cranial ornamentation extending into the floor of the sulcus so that only the ventrolateral margin of the squamosal is smooth (1). New character.
48. Depth of the lateral squamosal sulcus: lateral side of the squamosal bearing a deeply incised and clearly-defined longitudinal sulcus (0); lateral side of the squamosal forms a flat bevelled surface that at best bears a shallow weakly defined depression (1). New character.
49. Shape of the ventral margin of the lateral squamosal sulcus in ventral view: ventral rim bears a mediolateral central widening with a faintly rugose surface (0); ventral rim forms a narrow ridge of nearly constant width along its full length (1). New character.
50. Angle of the posterior margin of ventrolateral process of the squamosal in lateral view: angled ventrally at a shallow, acute angle to the horizontal plane of the skull table (0) angled steeply ventrally at an angle close to right angles to the horizontal plane of the skull table (1). Simplified from character 20 in Molnar, Worthy and Willis (2002, appendix 1) by combining states 1 and 2 into a single derived state. .
51. Parietal contribution to the rear margin of the skull table: broad contribution (0); contribution reduced to point contact or absent altogether (1). Modified from state 3 of character 82 in Brochu (1999).
52. Exposure of the supraoccipital on the dorsal skull roof: anteroposteriorly narrow sliver on the posterior margin of the skull roof or not exposed at all (0); large triangular exposure deeply incised into parietals (1). Modified from character 82 in Brochu (1999).
53. Presence or absence of dorsally visible, paired tuberosities on the occipital surface of the supraoccipital: absent (0); present (1). Character 201 in Jouve et al. (2015).
54. Ornamentation of the lateral and posterior margins of the skull table: Ornament of the dorsal surface extending to the margin before terminating abruptly or ornamental pits gradually decreasing in size towards the margin (0); marginal ornament abruptly differentiated from the ornamentation of the dorsal skull table, consisting of a slightly raised ridge sculpted with numerous, small, deep pits (1). New Character.
55. Length of the anterior process of the quadratojugal extending along the medial surface of the lower temporal bar: a long, prong-like process (0); a very short to absent process (1). Character 83 in Brochu (1999).
56. Development of the quadratojugal spine at maturity: a well-developed spike projecting into the lower temporal fenestra (0); a barely developed bump on the margin of the lower temporal fenestra or absent altogether (1). Character 69 in Brochu (1999).
57. Position of the quadratojugal spine: low, adjacent to the posterior angle of the lower temporal fenestra (0); high, midway along the length of the posterior margin of the lower temporal fenestra (1). Character 114 in Brochu (1999).
58. Size of the exposure of the quadratojugal in the posteroventral margin of the skull: large, jugal fails to extend posteriorly to the level of the quadrate condyle (0); quadratojugal exposure severely restricted by posterior extension of the jugal to the level of the quadrate condyle (1). New character.

59. Contact of the quadrate-quadratejugal lamina with the medial side of the postorbital: quadrate-quadratejugal lamina contacts the medial side of the postorbital, regardless of which particular bone(s) of the lamina make contact (0); Neither the quadrate nor the quadratejugal contact the medial side of the postorbital (1). Modified from character 76 in Brochu (1999).
60. Nature of the quadrate-quadratejugal lamina contact with the postorbital (only applicable to taxa where the lamina contacts the postorbital): an elongate process of the quadratejugal separates the quadrate from the postorbital (0); a moderate process of the quadratejugal reaches the postorbital but also allows the quadrate to make contact (1); quadratejugal fails to reach postorbital so that the quadrate alone forms the contact with the postorbital (2). Ordered. Modified from character 76 in Brochu (1999).
61. Quadrate participation in the margin of the lower temporal fenestra: quadrate excluded by the extension of the quadratejugal to the dorsal corner of the lower temporal fenestra (0); quadrate participation is present (1). Character 80 in Brochu (1999).
62. Shape of the posterior margin of the auditory meatus: straight to gently and evenly concave (0); bowed anteriorly (1). Character 102 in Brochu (1999).
63. Size of the subtympenic foramen at maturity: small, less than half the diameter of the external auditory meatus, to absent (0); large, at least half the diameter of the external auditory meatus (1). Modified from character 23 in Salisbury and Willis (1996).
64. Presence or absence of a dorsal process of the quadrate extending up the posterior margin of the external auditory meatus: present (0); absent so that the squamosal-quadrate suture runs to the posteroventral corner of the external auditory meatus (1). Character 132 in Brochu (1999).
65. Position of the quadrate foramen aerum: on the mediodorsal angle of the quadrate (0); on the dorsal surface of the quadrate, inset from its medial margin (1). Character 121 in Brochu (1999).
66. Distance between the quadrate condyle and the ventrolateral corner of the paroccipital process: distance less than the mediolateral width of the quadrate condyle (0); distance greater than the mediolateral width of the quadrate condyle (1). New character based on observation by Molnar (1982).
67. Shape of the dorsal margin of the quadrate articular surface: medial hemicondyle not expanded dorsally so that the dorsal margin of the quadrate articular surface is straight to evenly curved, although there may be a small notch for the foramen aerum (0); medial hemicondyle is dorsally expanded so that the dorsal margin of the quadrate articular surface is markedly concave between the hemicondyles (1). Modified from character 112 in Brochu (1999).
68. Presence or absence of an occipitally facing strip of the quadrate ventrolateral to the exoccipital visible in occipital view: absent (0); present (1). New character.
69. Exoccipital contribution to basal tuber: ventrolateral process of the exoccipital terminate dorsal to the basal tuber (0); ventrolateral process of the exoccipital extends to the basal tuber (1).
70. Level of the anterior margin of the suborbital fenestra: posterior to the level ninth maxillary alveolus (0); between the seventh and ninth maxillary alveoli (1); anterior to the seventh maxillary alveolus (1). Character 14 in Salisbury and Willis (1996).
71. Presence or absence of a notch in the posterior margin of the suborbital fenestra: absent (0); present (1). Character 88 in Brochu (1999).
72. Shape of the anterior termination of the palatines: broad and blunt (0); tapering to a sharp narrow point (1). Character 118 in Brochu (1999).

73. Anterior extent of the palatines: project far anterior to the level of the anterior margins of the suborbital fenestrae (0); approximately level with the anterior margins of the suborbital fenestrae (1). Character 13 in Salisbury and Willis (1996).
74. Shape of the posterior end of the palatines: lateral margins remain close to parallel to their posterior termination (0); posterior end flares laterally (1). Character 90 in Brochu (1999).
75. Posterolateral extent of the palatine: posterolateral corner of the palatine lies anteromedial to the posterior angle of the suborbital fenestra (0); posterolateral corner of the palatine reaches the posterior angle of the suborbital fenestra (1). Character 85 in Brochu (1999).
76. Shape of the pterygoid-palatine suture: linear to flatly v-shaped (0); deeply concave with the pterygoids protruding into the palatines (1). New character.
77. Shape of the anteromedial margin of the ectopterygoid: evenly curved from anterior process to contact with the pterygoid (0); a distinct bulge on the ectopterygoid margin where the anterior process curves to meet the pterygoid causing an emargination in the outline of the suborbital fenestra (1). New character treated as distinct and independent of character 71 (presence or absence of a notch in the posterior margin of the suborbital fenestra).
78. Shape of the anterior termination of the ectopterygoid: simple, single-pointed tip (0); anterior tip forked (1). Character 109 in Brochu (1999).
79. Ectopterygoid contribution to the postorbital bar: ectopterygoid with an ascending process extending up the medial side of the postorbital bar (0); ectopterygoid terminates abruptly below the postorbital bar (1). Character 133 in Brochu (1999).
80. Relationship of the ectopterygoid to the the posterior maxillary tooth row: ectopterygoid abuts the medial side of the tooth row (0); presence of a distinct shelf of the maxilla separating the ectopterygoid from the maxillary tooth row (1). Character 91 in Brochu (1999).
81. Size of the pterygoid contribution to the posterior margin of the suborbital fenestra: broad, width of the contribution greater than half the maximum width of the suborbital fenestra (0); ectopterygoid and palatine approach so that the width of the pterygoid contribution less than half the maximum width of the suborbital fenestra (1). New character.
82. Shape of the posterior pterygoid process: dorsoventrally tall with the peak of the process directed posteroventrally (0); dorsoventrally shallow with the peak directed posteroventrally (1); dorsoventrally shallow with the peak directed posteriorly (2). Character 98 in Brochu (1999).
83. Shape of the peak of the posterior pterygoid process in ventral view: elongate finger-like process (0); short, blunt tubercle (1). New character.
84. Shape of the maxillary ramus of the ectopterygoid: an elongate prong with a subtriangular cross-section (0); a dorsoventrally flattened plate-like triangular process (1); a short tongue-like mediolaterally flattened plate adpressed against the medial surface of the maxilla (2). New character.
85. Pterygoid contribution to the narial canal between the suborbital fenestrae: palatines draw level with the posterior margin of the suborbital fenestra so that there is no contribution to the canal from the pterygoid (0); pterygoids form a short section (less than 20% of the total length) of the narial canal (1); pterygoids form at least 20% of the length of the narial canal (2). Ordered. Modified from character 20 in Salisbury and Willis (1996).
86. Presence or absence of a fossa on the pterygoid plate, anterior to the choana: absent (0); present (1). New character.



87. Presence or absence of a pair of ridges on the pterygoid plate, extending anteriorly from the lateral margins of the choana: absent (0); present (1). New character.
88. Eversion of the anterior choanal rim: choanal margin flush with the surface of the pterygoid plate (0); choanal rim everted forming a shallow neck that surrounds the anterior margin of the choana (1). Modified from character 73 in Brochu (1999).
89. Orientation of the choana in adults: choana opens posteroventrally (0); choana opens anteroventrally (1). Character 72 in Brochu (1999).
90. Internal division of the choana: choana undivided by median septum (0); choana septate (1). Simplified from character 152 in Brochu (1999) by omitting state 2.
91. Relationship between the posterior angle of the lower temporal fenestra and the quadratojugal and jugal bones: quadratojugal forms the posterior angle (0); jugal forms the posterior angle (1); quadratojugal-jugal suture intersects with the posterior angle (2). Character 75 in Brochu (1999).
92. Presence or absence of a significant ventral process of the quadrate on the lateral wall of the braincase: present (0); absent with a linear quadrate-ptyergoid suture between the lateral exposure of the basisphenoid and the trigeminal foramen (1). Character 127 in Brochu (1999).
93. Exposure of the pro-otic on the lateral braincase wall: extensive (0); restricted to narrow rim around trigeminal foramen by the expansion of the laterosphenoid and the quadrate (1). Character 5 in Norell (1989).
94. Presence or absence of a sulcus on the anterior braincase wall lateral to the basisphenoid rostrum: present (0); absent (1). Character 122 in Brochu (1999).
95. Position of the opening of the lateral carotid foramen at maturity: lateral to the basisphenoid (0); dorsal to the basisphenoid (1). Character 128 in Brochu (1999).
96. Presence or absence of an unusually large external sculpture pit at the triple junction of the postorbital, parietal and frontal: absent (0); present (1). New character based on an observation in Buchanan (2009).
97. Exposure of the basisphenoid on the braincase wall, anterior to the trigeminal foramen: limited to narrow sliver in sulcus adjacent to basisphenoid rostrum (0); broadly exposed (1). Character 129 in Brochu (1999).
98. Position of the opening of the lateral eustachian tubes: dorsal to the level of the opening of the median eustachian tube (0); level with the opening of the median eustachian tube in posterior view (1). Character 147 in Brochu (1999).
99. Anteroposterior width of the basisphenoid exposure ventral to the basioccipital: exposure is a highly compressed lamina (0); anteroposteriorly broad exposure (1). Character 113 in Brochu (1999).
100. Path of the pterygoid-quadrate suture on the lateral braincase wall: quadrate with a significant ventral lamina so that the suture is reflexed ventrally between the basisphenoid and the prootic (0); quadrate without a ventral lamina so that suture is close to linear between the basisphenoid and the prootic (1). Character 127 in Brochu (1999).
101. Dorsoventral depth of the basisphenoid exposure ventral to the median eustachian opening: deep exposure (0); exposure is a dorsoventrally reduced sliver (1). Character 119 in Brochu (1999).
102. Adult skull length: greater than 300 mm (0); less than 300 mm (1). New character.
103. Crenulation of the carinae of the tooth crowns: absent or microscopically fine and poorly developed (0); carinae bear macroscopically visible well-developed crenulations (1). Modified from character 80 in Brochu and Storrs (2010).

104. Shape of the anterior maxillary and dentary alveoli: subcircular (0); strongly labiolingually compressed (1). Simplified from character 79 in Brochu and Storrs (2010) by collapsing states 0 and 1 into a single state.
105. Degree of tooth disparity: small to moderate, diameter of the largest maxillary tooth is less than twice smallest maxillary tooth between the anterior and posterior festoons (0); high tooth disparity, largest maxillary tooth diameter greater than twice the smallest interfestoonal maxillary tooth (1). Modified from character 17 in Salisbury and Willis (1996).
106. Posterior extent of the dentary symphysis: level with the fourth or fifth dentary alveolus (0); level lies between sixth and eighth alveoli (1); extends posterior to eighth alveolus (2). Ordered. Character 49 in Brochu and Storrs (2010).
107. Size of the second dentary tooth: diameter subequal to the first (0); diameter less than 60 % of the first (1). New character.
108. Occlusion of dentary tooth 4: in open notch (0); in a closed pit (1). Character 26 in Salisbury and Willis (1996).
109. Dentary tooth occlusion: all dentary teeth (except fourth) occlude lingually to the upper teeth (0); beside the fourth dentary tooth there is another dentary tooth occluding in a pit between seventh and eighth maxillary alveolus, all other dentary teeth occlude lingually to the upper teeth (1); fully intermeshing dentition with all but the posterior most dentary teeth occluding in pits between the upper teeth (2). Ordered. Character 78 in Brochu (1999).
110. Curvature of the dentary tooth row between dentary teeth four and ten in lateral view: straight (0); gently curved (1); strongly curved (2). Character 68 in Brochu (1999).
111. Presence or absence of a lateral subalveolar shelf on the dentary bearing dorsal occlusion pits: absent (0); present (1). New character.
112. Posterior extent of the dentary: terminates anterior to the posterodorsal corner of the external mandibular fenestra (0); extends to the posterodorsal corner of the external mandibular fenestra (1). Character 65 in Brochu (1999).
113. Spacing of the fifth, sixth and seventh dentary teeth: distinct gaps between these alveoli (0); alveoli closely packed so that only a thin lamina separates them (1). New character.
114. Shape of the posterior margin of the symphyseal surface in medial view: upper and lower lobes of the surface extend posteriorly to the same level (0); upper lobe strongly overhangs the lower lobe (1); lower lobe protrudes beyond upper lobe (2). Unordered. New character.
115. Disposition of dentary teeth three and four: teeth similar sized and with confluent alveoli (0); tooth four distinctly enlarged and alveolus separated from the third alveolus (1). Character 5 in Salisbury and Willis (1996).
116. Sculpture of the posterior lateral surface of the dentary, adjacent to the external mandibular fenestra: weakly sculpted with long vascular grooves, sculpture is distinctly less well developed than on the anterior lateral surface of the dentary (0); lateral surface of the dentary bears rugose sculpture from the anterior end to the external mandibular fenestra (1). New character.
117. Shape of the ventrolateral margin of the dentary: rounded with the lateral surface of the dentary curving smoothly onto the ventral surface (0) horizontal ventral surface of the dentary offset from the lateral surface by a ventrolateral angulation or raised ridge (1). New character.
118. Participation of the splenial in the mandibular symphysis: splenial separated from symphyseal surface (0); splenial contacting dentary symphyseal surface but not forming its own symphysis (1); splenials for a short symphysis that extends for less than five

- alveoli (2); splenials form a long symphysis that extends for more than five alveoli (3). Ordered. Modified from character 43 in Brochu (1999).
119. Mediolateral compression of the splenial symphysis (only applicable to taxa that have a splenial symphysis): splenial symphysis uncompressed forming a broad 'v' in dorsal view (0); splenial symphysis forming a compressed narrow splint wedged between the dentaries (1). Modified from character 43 in Brochu (1999).
120. Relationship of the anterior tip of the splenial to the meckelian canal (character inapplicable to taxa with a splenial symphysis): anterior tip lies ventral to meckelian canal (0); anterior tip lies dorsal to the meckelian canal (1). Modified from character 43 in Brochu (1999).
121. Presence or absence of an anterior perforation of the splenial: present (0); absent (1). Character 41 in Brochu (1999).
122. Presence or absence of a posterior perforation of the splenial: absent (0); present (1). Simplified from character 42 in Brochu (1999).
123. Presence or absence of a round roughened scar on the medial surface of the splenial at approximately its midlength: absent (0); present (1). New character.
124. Relationship of the splenial to the lingual rims of the posterior dentary alveoli: splenial may closely approach the posterior dentary alveoli but their lingual rims are formed by at least a thin lamina of the dentary or an anterior spur of the surangular (0); dentary entirely excluded from the lingual rims of the posterior dentary alveoli which formed entirely by the splenial (1). New character.
125. Texture of the ventrolateral surface of the splenial: smooth (0); ornamented (1). New character.
126. Dorsal deflection of the postdentary region of the mandible: in line with dentary, or at most weakly deflected dorsally, dorsal profile of the posterior end of the splenial straight (0); postdentary region of the mandible is strongly dorsally deflected, with a concave dorsal profile of the posterior end of the splenial (1). New character.
127. Size of the external mandibular fenestra: greater than 25% of the distance from the back of the tooth row to the front margin of the glenoid socket (0); less than 25% of the distance from the back of the tooth row to the front margin of the glenoid socket (1). New character, independent of lateral exposure of foramen intermandibularis caudalis.
128. Orientation of the dorsal margin of the coronoid: slopes strongly anteroventrally (0); almost horizontal (1). Character 54 in Brochu (1999).
129. Presence or absence of an anterior spur of the surangular that forms the lingual border of at least one posterior dentary alveolus: absent (0); present (1). Character 61 in Brochu (1999).
130. Presence or absence of a laterally directed dorsal flange of the surangular: absent (0); present (1). New character.
131. Relative sizes of the two prongs of the anterior process of the surangular: unequal with the dorsal prong extending much further anteriorly than the ventral prong (0); subequal with the two prongs extending to approximately the same level (1). Character 48 in Brochu (1999).
132. Posterior extent of the surangular: terminates anterior to the posterior tip of the retro-articular process (0); extends to the posterior tip of the retro-articular process (1). Character 51 in Brochu (1999).
133. Presence or absence of a dorsally facing pit on the surangular lateral to the glenoid: absent (0); present (1). New character.
134. Dorsal extent of the surangular up the lateral side of the posterior lip of the glenoid: extends to the dorsal tip (0); truncated so that it fails to reach the dorsal tip (1). Character 106 in Brochu (1999).

135. Presence or absence of an everted flange along the posteroventral margin of the ornamented area of the angular: absent (0); present (1). New character.
136. Passage of the angular-surangular suture in relation to the external mandibular fenestra: runs to the posterior angle of the external mandibular fenestra (0); passes broadly along ventral margin of the external mandibular fenestra (1). Character 47 in Brochu (1999).
137. Path of the rugose anteromedial crest of the angular that forms the anterior medial rim of the adductor fossa: ridge flattens and broadens posteriorly to merge with rounded ventromedial margin of angular (0); ridge diverges posteriorly from rim of adductor fossa to join ventromedial edge of the angular forming a continuous sharp ridge (1). New character.
138. Path of surangular-articular suture within glenoid socket: linear (0); strongly bowed laterally (1). Character 162 in Brochu (1999).
139. Position of the lingual foramen for the articular artery and alveolar nerve: opening surrounded by the surangular (0); opening on the surangular-articular suture (1); opening surrounded by the articular (2). Ordered. Character 45 in Brochu (1999).
140. Presence or absence of a longitudinal sulcus on the anterior face of the articular, adjacent to the surangular: absent (0); present (1). Character 60 in Brochu (1999).
141. Position of the articular foramen aerum: at the extreme lingual margin of the articular (0); inset from the lingual margin (1). Character 49 in Brochu (1999).
142. Elongation of the retro-articular process: elongate, at least 1.5 times longer than its maximum width (0); short and broad, less than 1.5 times longer than its maximum width (1). New character.
143. Presence or absence of a lamina of the articular adpressed to the medial surface of the surangular, dorsal to the lingual foramen: absent (0); present (1). Simplified from character 44 in Brochu (1999) by omitting state 2.
144. Orientation of the retroarticular process in lateral view: directed posterodorsally (0); projecting directly posteriorly (1). Character 50 in Brochu (1999).
145. Shape of the dorsal projection of the hyoid cornu: broad and flared (0); narrow with parallel sides (1). Character 58 in Brochu (1999).
146. Cross-sectional shape of the dorsal projection of the hyoid cornu: flattened (0); subcircular (1). Character 57 in Brochu (1999).
147. Shaped of the fused proatlans: boomerang shaped (0); block shaped (1). Simplified from character 2 in Brochu (1999).
148. Presence or absence of an anterior process of the proatlans: present (0); absent (1). Character 10 in Brochu (1999).
149. Width of the ventrolateral tubercle of the proatlans: much wider than half the length of the dorsal symphysis (0); about half the length of the dorsal symphysis (1). Character 1 in Brochu (1999).
150. Dorsal surface of the proatlans: smooth (0); with a median keel (1). Modified from character 17 in Brochu (1999).
151. Dorsal margin of the atlantal rib: smooth or with a weak bump-like process (0); with a well-developed dorsal process (1). Character 14 in Brochu (1999).
152. Shape of the atlantal intercentrum: wedge-shaped with short parapophyses (0); dorsoventrally flattened plate with elongate parapophyses (1). Character 5 in Brochu (1999).
153. Dorsal profile of the anterior half of the axial neural spine: slopes anteriorly (0); horizontal (1). Character 11 in Brochu (1999).
154. Transverse width of the posterior half of the axial neural spine: broad (0); narrow and blade-like (1). Character 3 in Brochu (1999).

155. Presence or absence of an upturned crest at the posterior end of the axial neural spine: absent (0); present (1). Character 12 in Brochu (1999).
156. Location of the hypapophysis of the axis: in the anterior half of the centrum (0); at the midlength of the centrum (1). Polarity reversed from character 6 in Brochu (1999).
157. Shape of the tuberculum of the axial rib: broad and blunt-ended (0); narrow and acutely pointed (1). Character 20 in Brochu (1999).
158. Height of the cervical neural spines: cervical neural spines less than twice the height of the posterior centrum face (0); cervical neural spines greater than twice the height of the posterior centrum face (1). New character.
159. Anteroposterior length of the neural spine of the third cervical vertebra: long, greater than half of the centrum length (0); short, less than half of the centrum length (1). Character 9 in Brochu (1999).
160. Presence or absence of a hypapophysis on the third cervical vertebra: absent (0); present (1). Character 8 in Brochu (1999).
161. Posterior extent of the hypapophyseal keels: to the eleventh vertebra behind the axis (0); to the twelfth vertebra behind the axis (1). Character 7 in Brochu (1999).
162. Anterior projection of the capitulum of the first sacral rib: far anterior of the tuberculum and visible dorsally (0); level with the tuberculum and obscured in dorsal view (1). Character 13 in Brochu (1999).
163. Shape of the scapula blade: flared dorsally (0); subparallel margins in lateral view (1). Character 22 in Brochu (1999).
164. Shape of the scapulocoracoid facet anterior to the glenoid socket: uniformly narrow (0); posteriorly broad, tapering anteriorly tapering (1). Character 25 in Brochu (1999).
165. Dorsoventral flexure of the interclavicle in lateral view: flat (0); moderate flexure (0); strong flexure (2). Character 30 in Brochu (1999).
166. Shape of the proximal margin of the deltopectoral crest: arises smoothly from the proximal end of the humerus and is straight edged (0); arises abruptly a short distance from the proximal end and is has a concave edge (1). Character 26 in Brochu (1999).
167. Shape of the olecranon process: narrow and angular in proximal view (0); broad and rounded in proximal view (1). Character 27 in Brochu (1999).
168. Development of the preacetabular process of the ilium: distinct triangular process (0); slight bump in the anterior profile of the ilium, or absent altogether (1). Character 34 in Brochu (1999).
169. Depth of the ilium dorsal to the acetabular rim: narrow, acetabular rim almost coincident with dorsal margin of the ilium (0); deep supra-acetabular crest developed dorsal to the rim of the acetabulum (1). Character 32 in Brochu (1999).
170. Shape of the posterior dorsal margin of the ilium: simple smooth margin (0); margin with a small indentation (1); margin with a deep indentation, creating a 'wasp-waisted' shape to the postacetabular process (2). Ordered. Simplified from character 28 in Brochu (1999) by only recognising states of the dorsal indentation.
171. Differentiation of the nuchal scutum: undifferentiated from the dorsal scutum (0); Nuchal scutum connected to dorsal scutum by articulated rows of osteoderms but differentiated by a constriction in row width between the two (1); Nuchal scutum separated from dorsal scutum by non-articulating gaps, although intervening unarticulated rows of osteoderms remain (2); loss of intervening rows of osteoderms create a large gap between the nuchal and dorsal scuta (3). Ordered. Modified from character 38 in Brochu (1999).
172. Presence or absence of extra pair of intercalary nuchal osteoderms inserting laterally between primary rows: absent (0); present (1). Modified from state 2 of character 38 in Brochu (1999).

173. Shape of midline dorsal osteoderms: rectangular with long side oriented transversely (0); square (1). Character 36 in Brochu (1999)
174. Presence or absence of a low anterior process on the anterior margin of the dorsal midline osteoderms: present (0); absent (1). Character 40 in Brochu (1999).
175. Development of the dorsal keels of the dorsal osteoderms: tall, well-developed (0); weak low ridges, or osteoderms entirely lacking keels (1). Modified from character 35 in Brochu (1999).
176. Presence or absence of ventral osteoderms: present (0); absent (1). Simplified from character 39 in Brochu (1999) by treating it as a simple presence/absence character.
177. Number of contiguous osteoderms per row of the dorsal scutum at maturity: four (0); six or more (1). Simplified from character 37 in Brochu (1999) by collapsing states 1, 2 and 3 into a single derived state.
178. Iris colour: yellowish to greenish (0); brown (1). Character 182 in Brochu and Storrs (2010).

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