**All characters formulated as in Benson (2012) unless otherwise specified**

**1. Skull size:** large, greater than 30% presacral length (0); small, less than 25%

presacral length (1)

**2. Snout proportions, antorbital length in relation to temporal length:** subequal

(0); antorbital 1.1–1.8 times temporal length (1); temporal region longer (2); snout

very long, antorbital length at least twice the temporal length (3)

**3. Snout proportions, relative width/depth:** broad, wider mediolaterally than tall

dorsoventrally and nasal primarily on dorsal surface of skull (0); taller than wide,

nasal contributes to lateral surface of snout (1).

**4. External naris, length:** small, <25% preorbital length (0); moderate, 25–50%

preorbital length, narrow posterodorsal expansion pinched between nasal and maxilla

present (1); long >50% preorbital length (2)

**5. External naris, height:** 30–75% of orbital height (0); >75% orbital height,

lacrimal constricted and thus very tall and narrow (1).

**6. Temporal fenestra:** absent (0); present (1).

**7. Temporal fenestra morphology**: narrow dorsoventrally (<0.5x temporal height)

with deep temporal bar [posterior process of the jugal] (0); tall dorsoventrally with

narrow temporal bar (1); very large, opens dorsally (2); inapplicable, temporal

fenestra absent (?).

**8. Temporal (postorbital) roof orientation:** subhorizontal or weakly inclined

posteroventrally (0); strongly inclined posteroventrally, at least 45° (1).

**9. Skull, ventral outline of temporal bar in lateral view:** straight or weakly concave

(0); strongly anteroposteriorly concave (1); straight but inflected posteroventrally

relative to tooth row (2)

**10. Skull, longitudinal location of posteriormost portion of skull:** approximately at

the level of the occipital condyle (0); far posterior to occipital condyle (1).

**11. Skull table ornamentation:** absent or weak (0); unevenly spaced circular pits

present (1); evenly and densely distributed, irregular shallow pits (2);

**12. Skull, circumorbital tuberosities ornamenting jugal and likely also the**

**prefrontal:** absent (0); present (1).

**13. Premaxilla, ventral margin:** approximately horizontal (0); slopes anteroventrally

from ventral concavity on maxilla-premaxilla contact (1); slopes anterodorsally (2).

**14. Premaxilla, orientation of ascending (supranarial) process:** subvertical at base,

then slopes posterodorsally (0); slopes anterodorsally, overhanging tooth row (‘rostral

process’ present) (1); slopes posterodorsally at an angle < 75° (2).

**15. Premaxilla, narial shelf** [ventral floor of internal naris formed by the dorsal

surface of the premaxillary body] **morphology:** distinct from lateral surface of

premaxilla, which is dorsoventrally broad (0); narial shelf extends ventrolaterally to

meet the tooth row so there is no lateral surface of the premaxilla ventral to the

external naris (1).

**16. Premaxilla subnarial process:** short, maxilla forms floor of external naris (0);

greatly elongated, maxillary contribution to external naris absent or small (1).

**17. Premaxilla, marginal tooth count:** 2-3 (0); 4 (1); five–six (2). (Modified from original formulation by Brocklehurst et al. 2016)

**18. Premaxilla, marginal tooth size:** small or subequal to (non-canniniform)

maxillary teeth (0); anterior teeth large (1).

**19. Septomaxilla, shape:** curled in external naris (0); forming a pillar which divides

the external naris, septomaxillary foramen subequal in size to anterior part of external

naris (1); septomaxilla large and sheet-like (2); anteroposteriorly broad septomaxilla

resulting in reduced septomaxillary foramen (3); septomaxillary foramen absent (4).

**20. Septomaxilla, posterodorsal extension on to lateral surface of skull** [facial

process]**:** absent (0); present (1).

**21. Maxilla, lateral surface orientation:** vertical or slopes weakly dorsomedially

(0); slopes dorsolaterally, overhanging tooth row (1).

**22. Nasal-maxilla contact:** absent, lacrimal contributes to posterior margin of

external naris (0); present, lacrimal does not contact external naris, but is longer than

half the orbito-narial length (1); present, lacrimal does not contact external naris and

is shorter than half the orbito-narial length (2).

**23. Maxilla, lateral surface of anterior process bears deep depression dorsally**

**forming narial rim:** no (0); yes (1).

**24. Maxilla, subnarial foramina:** small or absent (0); present and large (1).

**25. Maxilla, postnarial/preorbital ascending process:** absent (0); present, but short

and rounded dorsally (1); tall and pointed dorsally, extensively overlapping maxilla

and extending to orbital midheight (2); tall, but also anteroposteriorly long,

accommodating deeply-implanted tooth roots (3).

**26. Maxilla, ‘lacrimal facet’ at base of dorsal process:** absent (0); present, distinct

dorsoventral ridge present on ascending process divides anterior and posterior

depressions (1).

**27. Maxilla, ventral surface:** straight or weakly convex (0); pronounced convexity

(1); strongly convex with prominent ‘precanine step’ anteriorly (2).

**28. Maxilla and dentary, medial surface adjacent to alveoli:** smooth (0): rugose,

striated bone encloses tooth bases (1).

**29. Maxilla, tooth count:** 15–25 (0); <15 (1); >25 (2).

**30. Maxilla, posterior extent of lateral dentition:** anterior to posterior orbit margin

(0); ventral to postorbital bar (1); posterior to postorbital bar (2); anterior to orbital

midlength (3).

**31. Maxillary and dentary alveolar ridges:** straight (0); twisted (helical), distal teeth

inclined laterally (1).

**32. Maxilla, precanniniform tooth count:** zero–three (0); four–five (1); six or more

(2); inapplicable, no canniniform tooth or region (?).

**33. Maxilla and dentary, anterior dentary and precanniniform maxillary tooth**

**morphology:** similar to lateral teeth (0); distinctive teardrop-shaped morphology (1).

**34. Maxilla, canniniform region/tooth:** absent, maxillary teeth approximately

subequal in size, diminishing gradually posteriorly (0); canniniform region present

(1); large canniniform tooth, or two teeth distinctly larger than other maxillary teeth

(2).

**35. Maxilla, canniniform tooth size:** less than twice the height of non-canniniform

teeth (0); more than twice the height (1).

**36. Maxilla, lateral buttress:** absent (0); dorsally oriented buttress on lateral surface

(1)

**37. Maxilla, supracanine buttress on medial surface:** absent (0); present, may be

expanded into lateral margin of internal naris [choana] (1).

**38. Maxilla, morphology of dorsal portion of supracanine buttress:**

anteroposteriorly broad region of thickened bone (0); narrow, strut-like ascending

process (1); inapplicable, supracanine buttress absent (?).

**39. Maxilla, secondary enlargement of teeth posterior to canniniforms:** absent

(0); present (1).

**40. Lateral dentition, overall tooth morphology:** conical may be laterally

compressed apically (0); spatulate/slightly bulbous (1); transversely compressed and

strongly recurved (2)

**41. Maxillary dentition, recurvature:** completely absent (0); at least slightly

recurved (1), strongly recurved, apex approximately 80-90 degrees from vertical (2).

**42. Lateral dentition, cutting edges on mesial and distal surfaces:** absent or only

present distally (0); present (1).

**43. Lateral dentition, cutting edge:** serrations absent (0); serrations present, density

high, 14–24 denticles/mm (1); serration density low, <10 serrations/mm (2);

inapplicable, cutting edges absent (?).

**44. Lateral dentition, number of apical cusps:** one (0); three (1); more than three

(2).

**45. Lateral dentition, ‘shoulder’** [or ‘heel’] **on lingual surface:** absent (0); present

(1).

**46. Lateral dentition, labyrinthine structure:** present (0); absent (1).

**47. Nasal, length:** distinctly shorter than the frontal (0); approximately equal to the

frontal (1); longer than frontal (2).

**48. Nasal, contribution to external naris:** forms posterodorsal margin (0); extends

anteroventrally as a blade-like process (‘external narial shelf’) bearing a lateral fossa

(1).

**49. Lacrimal contact with external naris:** broad (0); narrow (1); inapplicable,

contact absent (?).

**50. Lacrimal lateral surface of anterior process bears deep depression forming**

**narial rim:** no (0); yes (1).

**51. Lacrimal, contribution to orbit margin as seen in lateral view:** large (0); small,

restricted by a prominent ventral process of the prefrontal (1).

**52. Lacrimal duct, location of posterior opening:** on the posterior surface of the

lacrimal (0); on the lateral surface of the lacrimal, near the posterior edge (1); on the

lateral surface of the lacrimal more anteriorly, in concave region (2).

**53. Prefrontal-maxilla contact:** absent (0); present anterodorsal to lacrimal (1).

**54. Prefrontal, lateral surface:** approximately flat or convex (0); concave, forming

antorbital recess [prefrontal pocket] (1).

**55. Prefrontal, ventral process:** transversely narrow edge [‘tongue-like’] (0);

expanded medially forming antorbital buttress (1).

**56. Frontal, length:** less than 1.5 times parietal length (0); greater than 1.6 times

parietal length (1); greater than 2.5 times parietal length (2).

**57. Frontal width:length ratio:** <1, frontal narrow (0); >1.5, frontal transversely

broad (1).

**58. Frontal, anterior process:** width equal to that of posterior process (0); narrower

than posterior process (1).

**59. Frontal, anterior process length:** short (0); longer than posterior process (1);

very long, forming at least 2/3 length of bone (2).

**60. Frontal, orbital contact (lateral lappet):** absent, prefrontal contacts postfrontal,

excluding frontal from dorsal orbital rim (0); narrow (1); broad, >1/4 maximum

orbital length (2).

**61. Frontal, posterolateral process:** short (0); long and narrow, matching length of

postfrontal, and substantially separating parietal from postfrontal (1); completely

absent (2).

**62. Postfrontal morphology:** small, occupies approximately one-third of dorsal orbit

rim, not transversely broad, and has approximately flat or convex dorsolateral surface

(0); dorsolateral surface concave (recessed between orbit and temporal fenestra) (1);

long and broad forming prominent supraorbital shelf (2); strongly recessed

posterolateral surface forming anterior part of fossa around temporal fenestra (3).

**63. Postorbital-postfrontal contact:** overall trend approximately straight (0); incised

by postorbital (1).

**64. Postorbital-squamosal contact:** present (0); absent, parietal forming lateral

margin of skull table in dorsal view, with deeply concave lateral margin (1).

**65. Postorbital-squamosal contact:** anteroposteriorly short (0); extensive due to long

posterior process of the postorbital that obliquely overlaps the squamosal in the

posterior half of the temporal region (1).

**66. Postorbital-supratemporal contact:** present (0); absent, (1); inapplicable,

supratemporal absent (?).

**67. Postorbital, lateral process/boss at orbit margin:** absent (0); present (1).

**68. Postorbital, posterior process, length:** short (0); long, extending more than half

of temporal length (1).

**69. Postorbital, posterior process, transverse width:** broad (0); narrow (1).

**70. Postorbital and jugal, medial orbital process** (deep, dorsoventrally tall medial

flange)**:** absent (0); present (1).

**71. Jugal, contribution to ventral margin of skull:** present (0); absent, jugal

excluded from ventral margin by maxilla-quadratojugal contact achieved by a long

posterior extension of the maxilla (1); maxilla-quadratojugal contact achieved by long

anterior extension of the quadratojugal (2).

**72. Jugal, length and dorsoventral expansion of anterior ramus:** intermediate,

contacts lacrimal but a distinct anterodorsal projection is absent (0); anterodorsal

projection present, anterior process of jugal dorsoventrally deep (1); anterior process

of jugal short, terminates ventral to orbital midlength as a tapering splint and maxilla

partipates in orbit margin (2).

**73. Jugal, anteroposterior thickness of dorsal ramus** (forming postorbital bar)**:**

broad, temporal fenestra only weakly emarginates the jugal (0); narrow, jugal strongly

emarginated (1); inapplicable, temporal fenestra absent (?).

**74. Jugal-squamosal contact on posterior surface of postorbital bar:** absent (0);

present (1); inapplicable, temporal fenestra absent (?).

**75. Jugal, posterior ramus length:** short, extending to, or less than, temporal

midlength (0); long, extending to posterior end of temporal fenestra (or past temporal

midlength in taxa that lack a temporal fenestra) (1).

**76. Jugal–squamosal ventral contact, perforated by small, elongate fenestra:**

absent (0); present, upper margin enclosed by anteroventral exension of the

squamosal (1); inapplicable, jugal does not contact squamosal ventrally (?).

**77. Quadratojugal, size:** large and forms much of the ventrolateral portion of the

temporal fenestra, extending ventral to postorbital bar (anterior to anteroventral

process of the squamosal) (0); large, but only extends anteriorly to approximately

temporal midlength (1); small, confined to posteroventral angle of skull and

overlapped laterally by the squamosal (2).

**78. Quadratojugal, anterodorsal process exposed on lateral surface of skull:**

absent or covered by squamosal (0); exposed laterally and contributes to margin of

temporal fenestra (1).

**79. Squamosal, anteroposterior breadth of posttemporal portion on lateral**

**surface of skull:** narrow (0); broad, just over half the breadth of the temporal region,

restricting the posterior extent of the temporal fenestra (1); inapplicable, temporal

fenestra absent (?)

**80. Squamosal, occipital flange covers much of the posterior surface of the**

**quadrate, forming lateral parts of posterior skull surface:** present (0); very narrow

or absent, posterior surface of quadrate exposed (1).

**81. Squamosal, small posterior process** [posterodorsal process] **emerges from**

**posterodorsal part of lateral surface:** absent (0); present (1).

**82. Squamosal, contributes to lower temporal bar** [zygomatic arch]**:** no, distinct

anteroventral process absent (0); yes (1); inapplicable, temporal fenestra absent (?).

**83. Parietal, raised rim around pineal foramen:** absent (0); surrounded by raised

area forming a pineal ‘ridge’ or boss (1).

**84. Parietal, pineal foramen, size:** small, smaller than foramen magnum and less

than 0.2 times parietal width (0); large (1).

**85. Parietal, pineal foramen location:** anteriorly on parietal midline suture (0); at

parietal midlength (1); near posterior end of parietal (2)

**86. Tabular morphology:** subrectangular sheet located dorsal to posttemporal

fenestra (0); large, sheet-like, L-shaped bone comprising suborthogonal ventral and

medial processes that enclose the postemporal fenestra dorsally and laterally (1);

reduced, displaced laterally, now located dorsolateral to posttemporal fenestra, medial

portion tapering (2); tabular absent (3).

**87.** Tabular, posteromedial process that subdivides posttemporal fenestra and

contacts the supratemporal: absent (0); present (1)

**88. Supratemporal shape:** broad, subrectangular, superficial bone that extends onto

lateral surface of skull (0); large, elongate (subequal to parietal length), but placed in

groove on parietal (1); long, slender, located in groove on parietal (2); supratemporal

absent (3).

**89. Quadrate, condyles:** distinct, separate (0); confluent, forming a saddle-shaped

articular facet (1).

**90. Occiput, slope:** approximately vertical (0); inclined anterodorsally by 10-50

degrees (1); strongly inclined anterodorsally by >60 degrees (2); inclined

posterodorsally (3)

**91. Postparietals:** unfused/paired (0); fused to form a midline element (1).

**92. Supraoccipital, prominent lateral processes forming dorsal margin of**

**posttemporal fenestra:** absent, fenestra bounded dorsally by tabular only (0); present

(1)

**93. Postparietal/s, participation in margin of posttemporal fenestra:** absent (0);

present, postparietal dorsoventrally slender and transversely broad (1).

**94. Stapes, shaft:** rod-like, quadrate process small or indistinct (0); blade-like with

prominent quadrate process, substantially longer than dorsal process (1).

**95. Exoccipital, lateral wing:** tall and narrow (0); broad, extending ventral to

paraoccipital process (1).

**96. Opisthotic, paraoccipital process:** confined between squamosals, not visible in

lateral view, height less than supraoccipital (0); posterolateral flange projecting

posterior to squamosals, visible in lateral view and blade-like, taller than

supraoccipital (1); short and knob-like (2).

**97. Opisthotic, morphology and orientation of paraoccipital process:** robust,

horizontal rod (0); slender rod, extends posteroventrolaterally (1); dorsoventrally

broad sheet, extends laterally (2).

**98. Basioccipital, occipital condyle orientation:** posteriorly directed (0);

posteroventrally directed (1).

**99. Basioccipital, ventral surface anterior to occipital condyle:** smooth (0);

prominent anteroposterior ridges (1).

**100. Basal articulation** [basicranial joint]**:** present (0); absent (1).

**101. Basal articulation, position:** approximately level with transverse flange of

pterygoid (0); anterior to transverse flange (1); posterior to transverse flange (2).

**102. Basal articulation, orientation of basipterygoid process:** laterally directed (0);

anterolaterally directed (1); posteroventrally directed (2); inapplicable, basal

articulation absent (?).

**103. Basal articulation, morphology of articular surface of basipterygoid**

**process:** single, rounded articular surface (0); flat anterior facet (1); inapplicable,

basal articulation absent (?).

**104. Parasphenoid, body shape:** transversely broad, width greater than length from

basipterygoid processes to posterior end (0); transversely narrow, length greater than

width (1).

**105. Parasphenoid, expansion of body** [ventral plate] **posterior to basicranial**

**articulation:** gradual (0); abrupt (1).

**106. Parasphenoid, body** [ventral plate] **median groove:** absent, ventral surface flat

(0); or shallow concave region between cristae ventrolaterales (1); deep median sulcus

present (2).

**107. Parasphenoid body, posteroventral emargination** [basisphenoid shelf]**:** absent

(0); present (1).

**108. Parasphenoid body, median longitudinal ridge on ventral surface:** absent

(0); present (1).

**109. Parasphenoid, teeth on ventral surface:** absent (0); present (1).

**110. Parasphenoid, posterior extent of teeth:** anterior to transverse flange of

pterygoid (0); posterior to transverse flange of pterygoid (1); inapplicable,

parasphenoid edentulous (?).

**111. Parasphenoid, teeth on ventral plate:** present along edges (0); present across

width of plate, forming central denticle field (1); inapplicable, teeth absent from

ventral plate (?).

**112. Vomer, teeth:** present (0); absent (1).

**113. Vomer, internarial shape:** widest posteriorly (0); widest near middle (1).

**114. Palatine, teeth:** present (0); absent (1).

**115. Palatine, boss or ridge bears large teeth:** absent (although teeth may still be

present as a fine shagreen) (0); present (1).

**116. Pterygoid, ascending lamina/dorsal flange of the anterior ramus of the**

**pterygoid:** low [?poorly ossified] (0); tall (1).

**117. Pterygoids, interpterygoid vacuity:** anteroposteriorly long (0); short (1).

**118. Pterygoid, distinct transverse flange:** present (0); absent (1).

**119. Pterygoid, transverse flange, orientation of posterior margin:** lateral or

posterolateral (0); anterolateral (1).

**120. Pterygoid, quadrate ramus, medial shelf** (‘posteromedian flange’; ‘tympanic

flange’)**:** present (0); absent (1).

**121. Pterygoid, teeth arranged in a transverse row along posterior margin of**

**ventral surface of pterygoid flange:** present (0); absent (1).

**122. Pterygoid, teeth in anterolaterally oriented field:** present, extends

posteromedially to basicranial area (0); does not extend as far as basicranial area (1);

pterygoid heavily denticulated, forming ‘tooth plates’ (2); anterolateral field absent

(3) inapplicable, pterygoid edentulous (?).

**123. Pterygoid, teeth on transverse flange:** single row along posterior margin of

ventral surface (0); additional teeth anterior to single row (1); inapplicable, pterygoid

edentulous (?).

**124. Ectopterygoid, teeth:** present (0); absent (1); inapplicable, ectopterygoid absent

(?).

**125. Jaw suspension:** at level of maxillary tooth row (0); quadrate projects far ventral

to maxillary tooth row (1).

**126. Mandible, proportions** (not including laminar portion of the angular)**:**

intermediate proportions, dorsoventral height 0.20–0.26 total length (0); short and

robust, dorsoventral height >0.30 total length (1); very long and dorsoventrally

slender, maximum height <0.18 total length (2).

**127. Mandibular symphysis:** dorsoventrally low, mandible tapers anteriorly (0);

doroventrally thick, almost as deep as mandible at midlength of the tooth row (1).

**128. Mandible, size of Meckelian foramen:** small, <0.10 of jaw length (0); large,

>0.25 of jaw length (1).

**129. Mandible, position of coronoid eminence:** posteriorly, within posterior 1/3 of

total length (0); anteriorly, approximately 2/5 of total length from posterior end (1).

**130. Mandible, shape of coronoid eminence:** slightly convex (0); strongly convex

(1); subhorizontal/flat (2).

**131. Mandible, bone forming dorsal margin of coronoid eminence laterally:**

coronoid or surangular (0); dentary (1).

**132. Mandible, retroarticular process:** absent (0); present (1).

**133. Mandible, composition of retroarticular process:** formed by articular, angular

and surangular (0); formed only by articular, large, and curved ventrally (1);

inapplicable, retroarticular process absent (?).

**134. Dentary size:** comprises >70% the anteroposterior length of the mandible (0);

<65% (1).

**135. Dentary, enlarged anterior teeth and alveoli:** absent, teeth small or only

slightly enlarged (0); present (1).

**136. Dentary, mesialmost tooth:** not enlarged (0); enlarged (1).

**137. Lateral mandibular fenestra between dentary and angular:** absent (0);

present (1)

**138. Splenial, contribution to mandibular symphysis:** present, symphysis formed

from dentary and splenial (0); absent, symphysis formed solely by dentary (1).

**139. Splenial, exposure on lateral surface of mandible:** absent (0); narrow, foming

one-fifth or less of the lateral surface (1); broad anteriorly, forming one-third or more

of the lateral surface (2).

**140. Splenial, contact with posterior coronoid:** absent (0); present (1); inapplicable,

posterior coronoid absent (?).

**141. Coronoids, number in mandible:** two, anterior coronoid present (0); one,

anterior coronoid absent (1).

**142. Coronoid** [posterior coronoid]**, teeth:** absent (0); present (1).

**143. Angular, cross-section shape of ventral border of angular:** weakly

ridged/keeled (0); prominent, sheet-like keel with strongly convex posterior edge (1);

reflected lamina separated from mandible by a posterior notch in lateral view (2);

ventral surface of angular evenly rounded (3).

**144. Angular, reflected lamina, posterior emargination:** short (0); long with free

posterodorsal margin (1); inapplicable, reflected lamina absent (?).

**145. Surangular, transverse expansion of dorsal surface:** thin, sheet-like

surangular, unexpanded (0); transversely expanded dorsally forming broad platform

(1).

**146. Prearticular, medial surface:** nearly straight (0); twisted posteriorly (1).

**147. Prearticular and articular, pterygoideus process:** formed by articular and

prearticular (0); formed by the articular only and sheathed by the prearticular (1).

**148. Presacral vertebrae, count:** 27 or more (0); <27 (1).

**149. Cervical vertebrae, count:** 3 or fewer (0); 5 or more (1).

**150. Atlas-axis complex, atlantal and axial intercentra:** contact ventrally or in very

close proximity (0); widely separated by ventral extension of the atlantal centrum

(odontoid) (1).

**151. Axial neural spine, anteroposterior length of apex:** longer than centrum and

extends past anterior surface of centrum (0); shorter than centrum (1); short and spine

inclined anterodorsally (2).

**152. Axial neural spine, height:** low, subequal to the centrum height (0); tall, at

least 1.5 times the height of the centrum (1); very tall, many times the centrum height

(2).

**153. Cervical centra, length:** shorter than dorsal centra (0); approximately equal to

dorsal centra (1); markedly longer than dorsal centra (2).

**154. Cervicodorsal centra, ventral surface:** low, rounded ridge (0); prominent,

transversely narrow, sheet-like keel (1).

**155. Dorsal centra, anteroposterior length:** short, subequal to height (0); long, at

least 1.5 times as long as high (1).

**156. Dorsal centra (anterior–middle dorsal centra), ventral surface:** transversely

rounded (0); ventral ridge (1); strongly pinched forming transversely narrow, sheetlike

keel (2); ventrally raised platform or keel bearing longitudinal trough (3).

**157. Presacral/sacral vertebrae, intercentra:** present along entire series (0); present

only in parts of series, cartilaginous intercentra may be present in places (1); absent

(2).

**158. Dorsal transverse processes:** prominent but not elongate (0); extend far laterally (1) (Brocklehurst et al. 2016).

**159. Dorsal transverse process, location:** approximately at midlength of neural

arch (0); located anteriorly (1) (Brocklehurst et al. 2016).

**160. Dorsal prezygapophyses:** planar, do not contact on midline (0); transversely

concave, contact on midline (1); planar and inclined strongly medially, contact on

midline (2).

**161. Dorsal postzygapophyses:** widely spaced (0); contact on midline (1).

**162. Dorsal postzygapophyses, hyposphene:** absent (0); present and prominent (1).

**163. Dorsal neural arches, dorsolateral surfaces:** flat or weakly concave, not

swollen or buttressed (0); swollen and convex (1); excavated by deep depressions (2).

**164. Dorsal neural spines, height:** short, approximately 1.5 times centrum height or

lower (0); intermediate, 2–3 times centrum height (1); very tall (2).

**165. Posterior dorsal neural spines, orientation:** approximately vertical (0);

posteriormost one or two dorsal neural spines anterodorsally inclined (1); several

posterior neural spines anterodorsally inclined (2); strongly posterodorsally inclined

(3).

**166. Dorsal and sacral neural spines, dorsal end:** unexpanded (0); transversely

expanded forming spine table (1).

**167. Dorsal neural spines morphology:** consistent along column (0); alternating

(1).

**168. Dorsal and sacral neural spines, cross section:** transversely compressed,

subrectangular, blade-like spines (0); subcircular, rod-like for most of spine length

[except basally] (1).

**169. Dorsal neural spines, lateral tubercles:** absent (0); present (1)

**170. Dorsal ribs, curvature:** curved proximally, only weakly curved distally (0);

strongly arched proximally, curved throughout length enclosing expanded, ‘barrelshaped’

trunk (1)

**171. Dorsal ribs, tuberculum** (contacts diapophysis) **morphology:** well-developed

and flange-like (0); reduced to low tuberosity (1); low tuberculum with expanded,

concave, cup-like articular facet (2)

**172. Sacral vertebrae, count:** two or fewer (0); three or greater (1).

**173. Sacral ribs, morphology of first sacral rib:** hugely enlarged and braces contact

of second sacral rib with ilium (0); subequal to or only slightly larger than more

posterior sacral ribs (1).

**174.** Sacral and caudal neural spines: smooth (0); rugose with longitudinal ridges on

lateral surface and tapering apex [‘leaf-shaped’] (1).

**175. Scapulocoracoid, glenoid shape:** anteroposteriorly elongate and helical (0);

short, faces posterolaterally (1).

**176. Scapula, anteroposterior breadth of distal end:** broad (0); narrow (1).

**177. Scapula, anteroposterior breadth of proximal end** (base)**:** broad (0);

pinched/narrow (1).

**178. Scapula, posterolateral surface of blade immediately dorsal to glenoid:**

weakly concave (0); deep, triangular concavity bounded anteriorly by prominent

supraglenoid buttress (1); distinct supraglenoid buttress absent (2)

**179. Scapula, supraglenoid foramen:** present (0); absent (1)

**180. Scapula, location of supraglenoid foramen:** posterior to supraglenoid buttress

(0); anterior to supraglenoid buttress (1); on apex of supraglenoid buttress (2);

inapplicable, supraglenoid foramen absent (?)

**181. Scapula, location of supraglenoid foramen:** immediately dorsal to glenoid

(0); 1/3–1/4 blade height dorsal to glenoid (1); inapplicable, supraglenoid foramen

absent (?)

**182. Scapula, deep notch in anterior margin around midheight:** absent (0);

present (1).

**183. Scapulocoracoid, notch in anterior margin on scapulocoracoid contact**

(scapulocoracoid notch)**:** absent (0); present (1).

**184. Coracoids, number:** two (0); one (1).

**185. Coracoid, foramen on posterodorsal surface between glenoid and triceps**

**process:** absent (0); present (1).

**186. Coracoid** (posterior coracoid)**, triceps process:** small (0); large (1) (Figure A6).

**187. Clavicle, shape of ventromedial plate:** narrow (0); deep (1); intermediate (2);

narrow and short, but with additional anterior process (3).

**188. Clavicle, orientation of long axis of ventromedial plate relative to shaft:**

highly obtuse angle (0); almost perpendicular (1).

**189. Interclavicle, angle of head:** low angle, interclavicle weakly curved in lateral

view (0); head sharply upturned (1).

**190. Interclavicle, shape of anterior end:** triangular, pointed anteriorly with

‘diamond-shaped’ appearance (0); truncated anteriorly (1); trapezoidal with narrow,

straight anterior margin (2).

**191. Interclavicle, shape of posterior margin of head:** distinctly offset from shaft

by posterolateral emargination (0); grades gradually into shaft (1).

**192. Humerus, ridge connecting deltopectoral crest to head:** double, paired ridge

enclosing proximolateral fossa, deltopectoral crest anteroposteriorly expanded and

‘tuberous’ (0); single, fossa absent (1)

**193. Humerus, ventral surface of proximal end:** extends proximally forming a

low, anteroposteriorly oriented crest posteroventral to head (0); extends far

proximally, forming a prominent crest (1).

**194. Humerus, anterior surface of deltopectoral crest:** weakly concave (0);

strongly concave, bounded dorsally by a prominent, proximodistally elongate ridge

(1).

**195. Humerus, position of latissimus dorsi attachment** (Romer and Price 1940,

fig. 29)**:** proximal, adjacent to internal epicondyle (0); distal (1).

**196. Humerus, morphology of latissimus dorsi attachment:** step-like transverse

ridge or mound (0); prominent, posteriorly-directed tubercle (1).

**197. Humerus, posterior surface of shaft around exit of entepicondylar**

**foramen:** convex (0); exit foramen very large and rimmed by a longitudinal

depression, foramen only enclosed by a narrow strip of bone (1).

**198. Humerus, ectepicondylar** (radial epicondylar) **foramen:** absent, ectepicondylar

groove not enclosed and supinator process proximodistally short (0); present (1); long

supinator process, but epicondylar foramen not enclosed (2); supinator process very

low or absent (3)

**199. Humerus, entepicondyle** (ulnar epicondyle)**, transverse width:** moderate

makes up just less than half of transverse width of distal expansion (0); reduced (1);

enlarged, makes up more than 2/3 of the distal transverse width (2)

**200. Humerus, ventral surface** (faces anteroventrally) **of entepicondyle:** flat or

weakly convex (0); low, anteroproximally directed ridge on posterior margin (1).

**201. Manus, width:length ratio of radiale:** subequal or < 1.0 (0); > 1.0 (1).

**202. Manus, preaxial (lateral) centrale overlaps proximal surface of third distal**

**carpal:** no (0); yes (1).

**203. Manus, intermedium size:** larger than medial centrale (0); smaller than medial

centrale (1).

**204. Manus, ulnare proportions:** long (0); short, width >0.6–0.7 times length (1).

**205. Manus length, fourth metacarpal:radius length ratio:** <0.25 (0); 0.30–0.45

(1); >0.50 (2).

**206. Manus, metapodial shape:** long and slender, two–three times longer than

maximal width (0); short and fat with small diaphysis (1).

**207. Manus, McV:McIV length ratio:** >0.65 (0); <0.65 (1).

**208. Manus, digital formula:** X3YZ3 (0); X2YZ2 (1).

**209. Manus, phalanges in digit III:** four (0); three (1).

**210. Manus, phalanges in digit IV:** five (0); four or fewer (1).

**211. Manus, phalanges, distal articular surface orientation:** distal (0);

ventrodistal (1).

**212. Manus, ungual phalanges, height:width ratio:** low, ratio <1.1 and blood vessel

grooves may be visible on the dorsolateral surfaces of the phalanx (0); high, ratio

>1.5, strongly recurved and blood vessel grooves are located on the lateral surfaces of

the phalanx (1).

**213. Manus, ungual phalanges, flexor tubercle:** single bulbous eminence (0);

paired, medial and lateral eminences (1); absent (2).

**214. Pelvic girdle, acetabulum, outline:** suboval and shallow, lacking supracetabular

buttress (0); subcircular and deep, supracetabular buttress present (1).

**215. Ilium, medial surface:** weakly concave or flat (0); anteroventrally oriented

ridge contacts pubic articulation (1).

**216. Ilium, dorsal process morphology:** long, tapering posterodorsal blade and

anterodorsal blade small or absent (0); marked anterodorsal expansion present, dorsal

process tall and plate-like (1).

**217. Ilium, fossa on dorsal surface** [dorsal groove]**, or external shelf:** dorsal groove

present (0); external shelf present (1); both absent, ilium plate-like (2).

**218. Pubis, length relative to acetabulum:** >1.5 times (0); 1.0–1.5 times (1).

**219. Pubis, pubic tubercle anteroventral to acetabulum:** absent (0); present,

projects laterally (1); present, projects dorsally (2); broad, concave region on lateral

surface (3; new state; derived caseids); highly striated region bounded by a

longitudinal crest dorsally (4)

**220. Pubis, midline symphysial contact:** enlarged, dorsoventrally broad (0);

subequal to height of ischial midline symphysis, restricted to peripheral margin of

medial surface (1)

**221. Pubis, ventral surface of pubic apron:** flat or convex, pubes extend

ventromedially (0); strongly concave, pubes extend approximately medially (1).

**222. Ischium:** slender, tapering posteriorly (0); expanded posterodorsally (1)

**223. Ischium, dorsal margin of medial surface:** smooth (0); longitudinal crest (1).

**224. Femur, proportions:** short and broad, maximum length less than three times

distal width (0); long and slender, maximum length more than three times distal width

(1).

**225. Femur, orientation of head:** terminal and anteroposteriorly elongate (0);

inflected medially and subsherical (1).

**226. Femur, greater trochanter:** absent (0); present (1).

**227. Femur, mound-like eminence on dorsal surface of proximal end:** extensive,

prominent and longitudinally elongate (0); small (1).

**228. Femur, ventral ridge system** (internal and fourth trochanters)**:** prominent (0);

low and feebly developed (1).

**229. Femur, intertrochanteric fossa:** prominent (0); reduced or absent (1).

**230. Femur, posterior longitudinal ridge located proximally on ventral surface:**

absent, internal fossa not enclosed posteriorly (0); present, enclosing posterior margin

of internal fossa (1).

**231. Femur, prominent longitudinal ridge extending posterodistally from distal**

**end of internal fossa:** absent or low (0); present as a prominent rugose crest (1);

present as a prominent angular ridge forming the posteroventral surface of femoral

shaft (2); present but low and does not extend far distally, instead forming a distinct

fourth trochanter (3).

**232. Femur, condyles:** prominent and well-separated, posterior condyle extends

slightly further distally than anterior condyle (0); posterior condyle projects far

distally (1); condyles both low and indistinctly separated (2)

**233. Femur, anterior condyle:** dorsoventrally thick (0); dorsoventrally compressed

(1).

**234. Femur, posterior condyle, dorsal surface:** convex (0); transversely concave,

bearing longitudinal trough (1).

**235. Tibia, cnemial crest:** low (0); prominent and distinct (1).

**236. Astragalus:** absent (0); present (1).

**237. Astragalus, orientation of tibial articular suface:** mediodistal (0); anterodorsal

(1).

**238. Astragalus, proximal neck region:** short, astragulus neck less than 0.38 of the total length of the astragulus (0); long (1).

**239. Calcaneum (fibulare), proportions:** length approximately equal to width (0);

length conspicuously greater than width (1).

**240. Temporal fenestra morphology:** narrower dorsally than ventrally (0); dorsal and ventral margins of similar length, fenestra has an oblong shape (1); narrower ventrally than dorsally (2). Added by Brocklehurst et al. (2016)

**241. Webbing under transverse processes of dorsal vertebrae:** webbing extensive, extends ventrally beyond the ventralmost extent of the tips of the transverse processes and anteriorly to the forward edge of the vertebra (0); webbing slight, does not extend ventrally beyond the ventralmost extent of the tips of the transverse processes (1); webbing absent (2). Added by Brocklehurst et al. (2016)

**242. Number of dentary teeth:** 23 or less (0); at least 24 (1). Added by Brocklehurst et al. (2016)

**243. Posterior extent of the anterior caudal ribs:** ribs long, extend posterior for the length of at least two causal vertebrae (0); ribs short (1). Added by Brocklehurst et al. (2016)

**244. Dorsal ribs:** slender, proximal diameter of the shaft less than 1/ the centrum width (0); robust (1). Added by Brocklehurst et al. (2016)

**245. Presence of denticles on lateral dentition independent of carinae:** absent (0), present (1). Taxa without a cutting edge on lateral dentition scored “?”. Added by Brocklehurst and Fröbisch (2018).

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