

SUPPLEMENTAL INFORMATION

A- Phylogenetic Characters

The 253 phylogenetic characters are based on: 1-234= characters 1-234 of Wilson (2002); 234-241= characters 235-241 of Santucci & Arruda-Campos (2011); 242-253= characters 235-246 of Zaher *et al.* (2011).

1. Posterolateral processes of premaxilla and lateral processes of maxilla, shape: without midline contact (0); with midline contact forming marked narial depression, subnarial foramen not visible laterally (1).
2. Premaxillary anterior margin, shape: without step (0); with marked step, anterior portion of skull sharply demarcated (1).
3. Maxillary border of external naris, length: short, making up much less than one-fourth narial perimeter (0); long, making up more than one third narial perimeter (1).
4. Preantorbital fenestra: absent (0); present (1).
5. Subnarial foramen and anterior maxillary foramen, position: well distanced from one another (0); separated by narrow bony isthmus (1).
6. Antorbital fenestra, maximum diameter: much shorter than (0) or subequal to (1) orbital maximum diameter.
7. Antorbital fossa: present (0); absent (1).
8. External nares, position: terminal (0); retracted to level of orbit (1); retracted to a position between orbits (2).
9. External nares, maximum diameter: shorter (0) or longer (1) than orbital maximum diameter.

- 25 10. Orbital ventral margin, anteroposterior length: broad, with subcircular orbital margin (0);
26 reduced, with acute orbital margin (1).
- 27 11. Lacrimal, anterior process: present (0); absent (1).
- 28 12. Jugal–ectopterygoid contact: present (0); absent (1).
- 29 13. Jugal, contribution to antorbital fenestra: very reduced or absent (0); large, bordering
30 approximately one-third its perimeter (1).
- 31 14. Prefrontal, posterior process size: small, not projecting far posterior of frontal–nasal suture
32 (0); elongate, approaching parietal (1).
- 33 15. Prefrontal, posterior process shape: flat (0); hooked (1).
- 34 16. Postorbital, ventral process shape: transversely narrow (0); broader transversely than
35 anteroposteriorly (1).
- 36 17. Postorbital, posterior process: present (0); absent (1).
- 37 18. Frontal contribution to supratemporal fossa: present (0); absent (1).
- 38 19. Frontals, midline contact (symphysis): sutured (0) or fused (1) in adult individuals.
- 39 20. Frontal, anteroposterior length: approximately twice (0) or less than (1) minimum transverse
40 breadth.
- 41 21. Parietal occipital process, dorsoventral height: short, less than the diameter of the foramen
42 magnum (0); deep, nearly twice the diameter of the foramen magnum (1).
- 43 22. Parietal, contribution to post-temporal fenestra: present (0); absent (1).
- 44 23. Postparietal foramen: absent (0); present (1).
- 45 24. Parietal, distance separating supratemporal fenestrae: less than (0) or twice (1) the long axis
46 of supratemporal fenestra.
- 47 25. Supratemporal fenestra: present (0); absent (1).
- 48 26. Supratemporal fenestra, long axis orientation: anteroposterior (0); transverse (1).

- 49 27. Supratemporal fenestra, maximum diameter: much longer than (0) or subequal to (1) that of
50 foramen magnum.
- 51 28. Supratemporal region, anteroposterior length: temporal bar longer (0) or shorter (1)
52 anteroposteriorly than transversely.
- 53 29. Supratemporal fossa, lateral exposure: not visible laterally, obscured by temporal bar (0);
54 visible laterally, temporal bar shifted ventrally (1).
- 55 30. Laterotemporal fenestra, anterior extension: posterior to orbit (0); ventral to orbit (1).
- 56 31. Squamosal–quadratojugal contact: present (0); absent (1).
- 57 32. Quadratojugal, anterior process length: short, anterior process shorter than dorsal process (0);
58 long, anterior process more than twice as long as dorsal process (1).
- 59 33. Quadrate fossa: absent (0); present (1).
- 60 34. Quadrate fossa, depth: shallow (0); deeply invaginated (1).
- 61 35. Quadrate fossa, orientation: posterior (0); posterolateral (1).
- 62 36. Palatobasal contact, shape: pterygoid with small facet (0), dorsomedially orientated hook (1),
63 or rocker-like surface (2) for basipterygoid articulation.
- 64 37. Pterygoid, transverse flange (i.e. ectopterygoid process) position: posterior of orbit (0);
65 between orbit and antorbital fenestra (1); anterior to antorbital fenestra (2).
- 66 38. Pterygoid, quadrate flange size: large, palatobasal and quadrate articulations well separated
67 (0); small, palatobasal and quadrate articulations approach (1).
- 68 39. Pterygoid, palatine ramus shape: straight, at level of dorsal margin of quadrate ramus (0);
69 stepped, raised above level of quadrate ramus (1).
- 70 40. Palatine, lateral ramus shape: plate-shaped (long maxillary contact) (0); rod-shaped (narrow
71 maxillary contact) (1).
- 72 41. Epipterygoid: present (0); absent (1).

- 73 42. Vomer, anterior articulation: maxilla (0); premaxilla (1).
- 74 43. Supraoccipital, height: twice (0) subequal to or less than (1) height of foramen magnum.
- 75 44. Paroccipital process, ventral nonarticular process: absent (0); present (1).
- 76 45. Crista prootica, size: rudimentary (0); expanded laterally into 'dorsolateral process' (1).
- 77 46. Basispterygoid processes, length: short, approximately twice (0) or elongate, at least four
78 times (1) basal diameter.
- 79 47. Basispterygoid processes, angle of divergence: approximately 45° (0); less than 30° (1).
- 80 48. Basal tubera, anteroposterior depth: approximately half dorsoventral height (0); sheet-like,
81 20% dorsoventral height (1).
- 82 49. Basal tubera, breadth: much broader than (0) or narrower than occipital condyle (1).
- 83 50. Basisoccipital depression between foramen magnum and basal tubera: absent (0); present (1).
- 84 51. Basisphenoid/basispterygoid recess: present (0); absent (1).
- 85 52. Basisphenoid–quadrate contact: absent (0); present (1).
- 86 53. Basispterygoid processes, orientation: perpendicular to (0) or angled approximately 45° to (1)
87 skull roof.
- 88 54. Occipital region of skull, shape: anteroposteriorly deep, paroccipital processes oriented
89 posterolaterally (0); flat, paroccipital processes oriented transversely (1).
- 90 55. Dentary, depth of anterior end of ramus: slightly less than that of dentary at midlength (0);
91 150% minimum depth (1).
- 92 56. Dentary, anteroventral margin shape: gently rounded (0); sharply projecting triangular
93 process or 'chin' (1).
- 94 57. Dentary symphysis, orientation: angled 15° or more anteriorly to (0) or perpendicular to (1)
95 axis of jaw ramus.
- 96 58. External mandibular fenestra: present (0); absent (1).

- 97 59. Surangular depth: less than twice (0) or more than two and one-half times (1) maximum
98 depth of the angular.
- 99 60. Surangular ridge separating adductor and articular fossae: absent (0); present (1).
- 100 61. Adductor fossa, medial wall depth: shallow (0); deep, prearticular expanded dorsoventrally
101 (1).
- 102 62. Splenial posterior process, position: overlapping angular (0); separating anterior portions of
103 prearticular and angular (1).
- 104 63. Splenial posterodorsal process: present, approaching margin of adductor chamber (0); absent
105 (1).
- 106 64. Coronoid, size: extending to dorsal margin of jaw (0); reduced, not extending dorsal to
107 splenial (1); absent (2).
- 108 65. Tooth rows, shape of anterior portions: narrowly arched, anterior portion of tooth rows V-
109 shaped (0); broadly arched, anterior portion of tooth rows U-shaped (1); rectangular, tooth-
110 bearing portion of jaw perpendicular to jaw rami (2).
- 111 66. Tooth rows, length: extending to orbit (0); restricted anterior to orbit (1); restricted anterior to
112 subnarial foramen (2).
- 113 67. Crown-to-crown occlusion: absent (0); present (1).
- 114 68. Occlusal pattern: interlocking, V-shaped facets (0); high-angled planar facets (1); low-angled
115 planar facets (2).
- 116 69. Tooth crowns, orientation: aligned along jaw axis, crowns do not overlap (0); aligned slightly
117 anterolingually, tooth crowns overlap (1).
- 118 70. Tooth crowns, cross-sectional shape at midcrown: elliptical (0); D-shaped (1); cylindrical (2).
- 119 71. Enamel surface texture: smooth (0); wrinkled (1).

- 120 72. Marginal tooth denticles: present (0); absent on posterior edge (1); absent on both anterior
121 and posterior edges (2).
- 122 73. Dentary teeth, number: greater than 20 (0); 17 or fewer (1).
- 123 74. Replacement teeth per alveolus, number: two or fewer (0); more than four (1).
- 124 75. Teeth, orientation: perpendicular (0) or oriented anteriorly relative (1) to jaw margin.
- 125 76. Teeth, longitudinal grooves on lingual aspect: absent (0); present (1).
- 126 77. Presacral bone texture: solid (0); spongy, with large, open internal cells, 'camellate' (1).
- 127 78. Presacral centra, pneumatopores (pleurocoels): absent (0); present (1).
- 128 79. Atlantal intercentrum, occipital facet shape: rectangular in lateral view, length of dorsal
129 aspect subequal to that of ventral aspect (0); expanded anteroventrally in lateral view,
130 anteroposterior length of dorsal aspect shorter than that of ventral aspect (1).
- 131 80. Cervical vertebrae, number: 9 or fewer (0); 10 (1); 12 (2); 13 (3); 15 or greater (4).
- 132 81. Cervical neural arch lamination: well developed, with well defined laminae and coels (0);
133 rudimentary; diapophyseal laminae only feebly developed if present (1).
- 134 82. Cervical centra, articular face morphology: amphicoelous (0); opisthocoelous (1).
- 135 83. Cervical pneumatopores (pleurocoels), shape: simple, undivided (0); complex, divided by
136 bony septa (1).
- 137 84. Anterior cervical centra, height:width ratio: less than 1 (0); approximately 1.25 (1).
- 138 85. Anterior cervical neural spines, shape: single (0); bifid (1).
- 139 86. Mid-cervical centra, anteroposterior length/ height of posterior face: 2.5–3.0 (0); > 4 (1).
- 140 87. Mid-cervical neural arches, height: less than that of posterior centrum face (0); greater than
141 that of posterior centrum face (1).
- 142 88. Middle and posterior cervical neural arches, centroprezygapophyseal lamina (cp1), shape:
143 single (0); divided (1).

- 144 89. Posterior cervical and anterior dorsal neural spines, shape: single (0); bifid (1).
- 145 90. Posterior cervical and anterior dorsal bifid neural spines, median tubercle: absent (0); present
146 (1).
- 147 91. Dorsal vertebrae, number: 15 (0); 14 (1); 13 (2); 12 (3); 11 (4); 10 or fewer (5).
- 148 92. Dorsal neural spines, breadth: narrower (0) or much broader (1) transversely than
149 anteroposteriorly.
- 150 93. Dorsal neural spines, length: approximately twice (0) or approximately four times (1) centrum
151 length.
- 152 94. Anterior dorsal centra, articular face shape: amphicoelous (0); opisthocoelous (1).
- 153 95. Middle and posterior dorsal neural arches, centropostzygapophyseal
154 lamina (cpol), shape: single (0); divided (1).
- 155 96. Middle and posterior dorsal neural arches, anterior centroparapophyseal lamina (acpl): absent
156 (0); present (1).
- 157 97. Middle and posterior dorsal neural arches, prezygoparapophyseal lamina (prpl): absent (0);
158 present (1).
- 159 98. Middle and posterior dorsal neural arches, posterior centroparapophyseal lamina (pcpl):
160 absent (0); present (1).
- 161 99. Middle and posterior dorsal neural arches, spinodiapophyseal lamina (spdl): absent (0);
162 present (1).
- 163 100. Middle and posterior dorsal neural arches spinopostzygapophyseal lamina (spol) shape:
164 single (0); divided (1).
- 165 101. Middle and posterior dorsal neural arches, spinodiapophyseal lamina (spdl) and
166 spinopostzygapophyseal lamina (spol) contact: absent (0);
167 present (1).

- 168 102. Middle and posterior dorsal neural spines, shape: tapering or not flaring distally (0); flared
169 distally, with pendant, triangular lateral processes (1).
- 170 103. Middle and posterior dorsal neural arches, ‘infradiapophyseal’ pneumatopore between acdl
171 and pcdl: absent (0); present (1).
- 172 104. Middle and posterior dorsal neural spines, orientation: vertical (0); posterior, neural spine
173 summit approaches level of diapophyses (1).
- 174 105. Posterior dorsal centra, articular face shape: amphicoelous (0); opisthocoelous (1).
- 175 106. Posterior dorsal neural arches, hyosphene– hypantrum articulations: present (0); absent (1).
- 176 107. Posterior dorsal neural spines, shape: rectangular through most of length (0); ‘petal’ shaped,
177 expanding transversely through 75% of its length and then tapering (1).
- 178 108. Sacral vertebrae, number: 3 or fewer (0); 4 (1); 5 (2); 6 (3).
- 179 109. Sacrum, sacricostal yoke: absent (0); present (1).
- 180 110. Sacral vertebrae contributing to acetabulum: numbers 1–3 (0); numbers 2–4 (1).
- 181 111. Sacral neural spines, length: approximately twice (0) or four times (1) length of centrum.
- 182 112. Sacral ribs, dorsoventral length: low, not projecting beyond dorsal margin of ilium (0); high
183 extending beyond dorsal margin of ilium (1).
- 184 113. Caudal bone texture: solid (0); spongy, with large internal cells (1).
- 185 114. Caudal vertebrae, number: more than 45 (0); 35 or fewer (1).
- 186 115. Caudal transverse processes: persist through caudal 20 or more posteriorly (0); disappear by
187 caudal 15 (1); disappear by caudal 10 (2).
- 188 116. First caudal centrum, articular face shape: flat (0); procoelous (1); opisthocoelous (2);
189 biconvex (3).
- 190 117. First caudal neural arch, coel on lateral aspect of neural spine: absent (0); present (1).

- 191 118. Anterior caudal centra (excluding the first), articular face shape: amphiplatyan or
192 platycoelous (0); procoelous (1); opisthocoelous (2).
- 193 119. Anterior caudal centra, pneumatopores (pleurocoels): absent (0); present (1).
- 194 120. Anterior caudal centra, length: approximately the same (0) or doubling (1) over the first 20
195 vertebrae.
- 196 121. Anterior caudal neural arches, spinoprezygapophyseal lamina (sprl): absent (0); present and
197 extending onto lateral aspect of neural spine (1).
- 198 122. Anterior caudal neural arches, spinoprezygapophyseal lamina (sprl)-spinopostzygapophyseal
199 lamina (spol) contact: absent (0); present, forming a prominent lamina on lateral aspect of
200 neural spine (1).
- 201 123. Anterior caudal neural arches, prespinal lamina (prsl): absent (0); present (1).
- 202 124. Anterior caudal neural arches, postspinal lamina (posl): absent (0); present (1).
- 203 125. Anterior caudal neural arches, postspinal fossa: absent (0); present (1).
- 204 126. Anterior caudal neural spines, transverse breadth: approximately 50% of (0) or greater than
205 (1) anteroposterior length.
- 206 127. Anterior caudal transverse processes, proximal depth: shallow, on centrum only (0); deep,
207 extending from centrum to neural arch (1).
- 208 128. Anterior caudal transverse processes, shape: triangular, tapering distally (0); 'wing-like', not
209 tapering distally (1).
- 210 129. Anterior caudal transverse processes, diapophyseal laminae (acdl, pcdl, prdl, podl): absent
211 (0); present (1).
- 212 130. Anterior caudal transverse processes, anterior centrodiapophyseal lamina (acdl), shape:
213 single (0); divided (1).

- 214 131. Anterior and middle caudal centra, shape: cylindrical (0); quadrangular, flat ventrally and
215 laterally (1).
- 216 132. Anterior and middle caudal centra, ventral longitudinal hollow: absent (0); present (1).
- 217 133. Middle caudal neural spines, orientation: angled posterodorsally (0); vertical (1).
- 218 134. Middle and posterior caudal centra, anterior articular face shape: flat (0); procoelous (cone
219 shaped) (1); opisthocoelous (2).
- 220 135. Posterior caudal centra, shape: cylindrical (0); dorsoventrally flattened, breadth at least twice
221 height (1).
- 222 136. Distalmost caudal centra, articular face shape: platycoelous (0); biconvex (1).
- 223 137. Distalmost biconvex caudal centra, length-to-height ratio: less than 4 (0); greater than 5 (1).
- 224 138. Distalmost biconvex caudal centra, number: 10 or fewer (0); more than 30 (1).
- 225 139. Cervical rib, tuberculum–capitulum angle: greater than 90° (0); less than 90°, rib
226 ventrolateral to centrum (1).
- 227 140. Cervical ribs, length: much longer than centrum, overlapping as many as three subsequent
228 vertebrae (0); shorter than centrum, little or no overlap (1).
- 229 141. Dorsal ribs, proximal pneumatocoels: absent (0); present (1).
- 230 142. Anterior dorsal ribs, cross-sectional shape: subcircular (0); plank-like, anteroposterior
231 breadth more than three times mediolateral breadth (1).
- 232 143. ‘Forked’ chevrons with anterior and posterior projections: absent (0); present (1).
- 233 144. ‘Forked’ chevrons, distribution: distal tail only (0); throughout middle and posterior caudal
234 vertebrae (1).
- 235 145. Chevrons, ‘crus’ bridging dorsal margin of haemal canal: present (0); absent (1).
- 236 146. Chevron haemal canal, depth: short, approximately 25% (0) or long, approximately 50% (1)
237 chevron length.

- 238 147. Chevrons: persisting throughout at least 80% of tail (0); disappearing by caudal 30 (1).
- 239 148. Posterior chevrons, distal contact: fused (0); unfused (open) (1).
- 240 149. Posture: bipedal (0); columnar, obligately quadrupedal posture (1).
- 241 150. Scapular acromion process, size: narrow (0); broad, width more than 150% minimum width
242 of blade (1).
- 243 151. Scapular blade, orientation: perpendicular to (0) or forming a 45° angle with (1) coracoid
244 articulation.
- 245 152. Scapular blade, shape: acromial edge not expanded (0); rounded expansion on acromial side
246 (1); racquet-shaped (2).
- 247 153. Scapular glenoid, orientation: relatively flat or laterally facing (0); strongly bevelled
248 medially (1).
- 249 154. Scapular blade, cross-sectional shape at base: flat or rectangular (0); D-shaped (1).
- 250 155. Coracoid, proximodistal length: less than (0) or approximately twice (1) length of scapular
251 articulation.
- 252 156. Coracoid, anteroventral margin shape: rounded (0); rectangular (1).
- 253 157. Coracoid, infraglenoid lip: absent (0); present (1).
- 254 158. Sternal plate, shape: oval (0); crescentic (1).
- 255 159. Humeral proximolateral corner, shape: rounded (0); square (1).
- 256 160. Humeral deltopectoral attachment, development: prominent (0); reduced to a low crest or
257 ridge (1).
- 258 161. Humeral deltopectoral crest, shape: relatively narrow throughout length (0); markedly
259 expanded distally (1).
- 260 162. Humeral midshaft cross-section, shape: circular (0); elliptical, with long axis orientated
261 transversely (1).

- 262 163. Humeral distal condyles, articular surface shape: restricted to distal portion of humerus (0);
263 exposed on anterior portion of humeral shaft (1).
- 264 164. Humeral distal condyle, shape: divided (0); flat (1).
- 265 165. Ulnar proximal condyle, shape: subtriangular (0); triradiate, with deep radial fossa (1).
- 266 166. Ulnar proximal condylar processes, relative lengths: subequal (0); unequal, anterior arm
267 longer (1).
- 268 167. Ulnar olecranon process, development: prominent, projecting above proximal articulation
269 (0); rudimentary, level with proximal articulation (1).
- 270 168. Ulna, length-to-proximal breadth ratio: gracile (0); stout (1).
- 271 169. Radial distal condyle, shape: round (0); subrectangular, flattened posteriorly and articulating
272 in front of ulna (1).
- 273 170. Radius, distal breadth: slightly larger than (0) or approximately twice (1) midshaft breadth.
- 274 171. Radius, distal condyle orientation: perpendicular to (0) or bevelled approximately 20°
275 proximolaterally (1) relative to long axis of shaft.
- 276 172. Humerus-to-femur ratio: less than 0.60 (0); 0.60 or more (1).
- 277 173. Carpal bones, number: 3 or more (0); 2 or fewer (1).
- 278 174. Carpal bones, shape: round (0); block-shaped, with flattened proximal and distal surfaces
279 (1).
- 280 175. Metacarpus, shape: spreading (0); bound, with subparallel shafts and articular surfaces that
281 extend half their length (1).
- 282 176. Metacarpals, shape of proximal surface in articulation: gently curving, forming a 90° arc (0);
283 Ushaped, subtending a 270° arc (1).
- 284 177. Longest metacarpal-to-radius ratio: close to 0.3 (0); 0.45 or more (1).
- 285 178. Metacarpal I, length: shorter than (0) or longer than (1) metacarpal IV.

- 286 179. Metacarpal I, distal condyle shape: divided (0); undivided (1).
- 287 180. Metacarpal I distal condyle, transverse axis orientation: bevelled approximately 20°
288 proximodistally (0) or perpendicular (1) with respect to axis of shaft.
- 289 181. Manual digits II and III, phalangeal number: 2- 3-4-3-2 or more (0); reduced, 2-2-2-2-2 or
290 less (1); absent or unossified (2).
- 291 182. Manual phalanx I.1, shape: rectangular (0); wedge-shaped (1).
- 292 183. Manual nonungual phalanges, shape: longer proximodistally than broad transversely (0);
293 broader transversely than long proximodistally
294 (1).
- 295 184. Pelvis, anterior breadth: narrow, ilia longer anteroposteriorly than distance separating
296 preacetabular processes (0); broad, distance between preacetabular processes exceeds
297 anteroposterior length of ilia (1).
- 298 185. Ilium, ischial peduncle size: large, prominent (0); low, rounded (1).
- 299 186. Iliac blade dorsal margin, shape: flat (0); semicircular (1).
- 300 187. Iliac preacetabular process, orientation: anterolateral to (0) or perpendicular to (1) body axis.
- 301 188. Iliac preacetabular process, shape: pointed, arching ventrally (0); semicircular, with
302 posteroventral excursion of cartilage cap (1).
- 303 189. Pubis, ambiens process development: small, confluent with (0) or prominent, projecting
304 anteriorly from (1) anterior margin of pubis.
- 305 190. Pubic apron, shape: flat (straight symphysis) (0); canted anteromedially (gentle S-shaped
306 symphysis) (1).
- 307 191. Puboischial contact, length: approximately one third (0) or one-half (1) total length of pubis.
- 308 192. Ischial blade, length: much shorter than (0) or equal to or longer than (1) pubic blade.

- 309 193. Ischial blade, shape: emarginate distal to pubic peduncle (0); no emargination distal to pubic
310 peduncle (1).
- 311 194. Ischial distal shaft, shape: triangular, depth of ischial shaft increases medially (0); bladelike,
312 medial and lateral depths subequal (1).
- 313 195. Ischial distal shafts, cross-sectional shape: Vshaped, forming an angle of nearly 50° with
314 each other (0); flat, nearly coplanar (1).
- 315 196. Femoral fourth trochanter, development: prominent (0); reduced to crest or ridge (1).
- 316 197. Femoral lesser trochanter: present (0); absent (1).
- 317 198. Femoral midshaft, transverse diameter: subequal to (0), 125–150%, or (1) at least 185% (2)
318 anteroposterior diameter.
- 319 199. Femoral shaft, lateral margin shape: straight (0); proximal one-third deflected medially (1).
- 320 200. Femoral distal condyles, relative transverse breadth: subequal (0); tibial much broader than
321 fibular (1).
- 322 201. Femoral distal condyles, orientation: perpendicular or slightly bevelled dorsolaterally (0) or
323 bevelled dorsomedially approximately 10° (1) relative to femoral shaft.
- 324 202. Femoral distal condyles, articular surface shape: restricted to distal portion of femur (0);
325 expanded onto anterior portion of femoral shaft (1).
- 326 203. Tibial proximal condyle, shape: narrow, long axis anteroposterior (0); expanded
327 transversely, condyle subcircular (1).
- 328 204. Tibial cnemial crest, orientation: projecting anteriorly (0) or laterally (1).
- 329 205. Tibia, distal breadth: approximately 125% (0) or more than twice (1) midshaft breadth.
- 330 206. Tibial distal posteroventral process, size: broad transversely, covering posterior fossa of
331 astragalus (0); shortened transversely, posterior fossa of astragalus visible posteriorly (1).

- 332 207. Fibula, proximal tibial scar, development: not well-marked (0); well-marked and deepening
333 anteriorly (1).
- 334 208. Fibula, lateral trochanter: absent (0); present (1).
- 335 209. Fibular distal condyle, size: subequal to shaft (0); expanded transversely, more than twice
336 midshaft breadth (1).
- 337 210. Astragalus, shape: rectangular (0); wedged-shaped, with reduced anteromedial corner (1).
- 338 211. Astragalus, foramina at base of ascending process: present (0); absent (1).
- 339 212. Astragalus, ascending process length: limited to anterior two-thirds of astragalus (0);
340 extending to posterior margin of astragalus (1).
- 341 213. Astragalus, posterior fossa shape: undivided (0); divided by vertical crest (1).
- 342 214. Astragalus, transverse length: 50% more than (0) or subequal to (1) proximodistal height.
- 343 215. Calcaneum: present (0); absent or unossified (1).
- 344 216. Distal tarsals 3 and 4: present (0); absent or unossified (1).
- 345 217. Metatarsus, posture: bound (0); spreading (1).
- 346 218. Metatarsal I proximal condyle, transverse axis orientation: perpendicular to (0) or angled
347 ventromedially approximately 15° to (1) axis of shaft.
- 348 219. Metatarsal I distal condyle, transverse axis orientation: perpendicular to (0) or angled
349 dorsomedially to (1) axis of shaft.
- 350 220. Metatarsal I distal condyle, posterolateral projection: absent (0); present (1).
- 351 221. Metatarsal I, minimum shaft width: less than (0) or greater than (1) that of metatarsals II–IV.
- 352 222. Metatarsal I and V proximal condyle, size: smaller than (0) or subequal to (1) those of
353 metatarsals II and IV.
- 354 223. Metatarsal III length: more than 30% (0) or less than 25% (1) that of tibia.

- 355 224. Metatarsals III and IV, minimum transverse shaft diameters: subequal to (0) or less than
356 65% (1) that of metatarsals I or II (1).
- 357 225. Metatarsal V, length: shorter than (0) or at least 70% (1) length of metatarsal IV.
- 358 226. Pedal nonungual phalanges, shape: longer proximodistally than broad transversely (0);
359 broader transversely than long proximodistally (1).
- 360 227. Pedal digits II–IV, penultimate phalanges, development: subequal in size to more proximal
361 phalanges (0); rudimentary or absent (1).
- 362 228. Pedal unguals, orientation: aligned with (0) or deflected lateral to (1) digit axis.
- 363 229. Pedal digit I ungual, length relative to pedal digit II ungual: subequal (0); 25% larger than
364 that of digit II (1).
- 365 230. Pedal digit I ungual, length: shorter (0) or longer (1) than metatarsal I.
- 366 231. Pedal ungual I, shape: broader transversely than dorsoventrally (0); sickle-shaped, much
367 deeper dorsoventrally than broad transversely (1).
- 368 232. Pedal ungual II–III, shape: broader transversely than dorsoventrally (0); sickle-shaped, much
369 deeper dorsoventrally than broad transversely (1).
- 370 233. Pedal digit IV ungual, development: subequal in size to unguals of pedal digits II and III (0);
371 rudimentary or absent (1).
- 372 234. Osteoderms: absent (0); present (1).
- 373
- 374
- 375 235. Apex of the convexity of the posterior articulation on anterior and middle caudal vertebrae:
376 (0) concentric or slightly displaced above the centrum midline; (1) strongly displaced
377 upward, so that the apex of the posterior articulation is flushed to the level of the dorsal
378 margin of the centrum.

- 379 236. Anterior margin of the anterior caudal vertebrae: (0) vertical; (1) strongly inclined forward.
- 380 237. Articular facets of the prezygapophyses on anterior and middle caudal vertebrae: (0) normal,
381 not expanded; (1) wide, with a dorsal and a ventral expansion or protuberance.
- 382 238. Prezygapophyses curved downward on anteriormost caudal vertebrae: (0) absent; (1)
383 present.
- 384 239. Postzygapophyses located on the anterior half of the centrum on anterior and middle caudal
385 vertebrae: (0) absent; (1) present.
- 386 240. Haemal arches with double articular facets set in a concave posterodorsal surface: (0)
387 absent; (1) present.
- 388 241. Length proportions of the prezygapophyses with respect to the centrum length in middle
389 caudal vertebrae: (0) less than 40%; (1) between 40-50%; (2) more than 50% .
390
391
- 392 242. maxilla, jugal process: (0) robust, broadly contacting the jugal; (1) tapering posteriorly
- 393 243. Ventral edge of anterior surface of the quadratojugal: (0) straight, not expanded ventrally;
394 (1) concave due to a ventral expansion of the anterior region.
- 395 244. Lacrimal, anterior process: (0) short, less than 50% of the length of the ventral process; (1)
396 long, at least 75% of the length of the ventral process.
- 397 245. Prefrontal, anterior process: (0) absent; (1) present.
- 398 246. Prefrontal, width at the level of the frontal contact: (0) large, equal or longer than the
399 anteroposterior length of the prefrontal; (1) narrow, less than half the anteroposterior length
400 of the prefrontal.
- 401 247. Pterygoid, sutural contact with ectopterygoid: (0) on the lateral surface of the ectopterygoid;
402 (1) on the medial surface of the ectopterygoid.

- 403 248. Pterygoid, sutural contact with ectopterygoid: (0) broad, along the medial or lateral surface;
404 (1) narrow, restricted to the anterior tip of the ectopterygoid.
- 405 249. Basisphenoid, sagittal ridge between basiptyergoid processes: (0) absent; (1) present.
- 406 250. Squamosal, participation in supratemporal fenestra: (0) present; (1) present
- 407 251. Maxilla, foramen anterior to the preantorbital fenestra: (0) absent; (1) present
- 408 252. Postorbital, posterior margin articulating with the squamosal: (0) with tapering posterior
409 process; (1) with a deep posterior process.
- 410 253. Preantorbital fenestra, deep and large anteroposteriorly oriented fossa: (0) opening directly
411 on the lateral side of the maxilla or recessed in a small and shallow fossa; (1) recessed into
412 a deep and large anteroposteriorly oriented fossa.

413

414 **B- Operational Taxonomic Units**

415 The numbers [1], [2] and [3] indicate original scores and taxa on analysis of Wilson (2002),

416 Santucci & Arruda-Campos (2011), and Zaher *et al.* (2011), respectively;

417 Theropoda (outgroup) [1], [2], [3]

418 Prosauropoda [1], [2], [3]

419 *Vulcanodon* [1], [2], [3]

420 *Barapasaurus* [1], [2], [3]

421 *Omeisaurus* [1], [2], [3]

422 *Shunosaurus* [1], [2], [3]

423 *Patagosaurus* [1], [2], [3]

424 *Mamenchisaurus* [1], [2], [3]

425 *Apatosaurus* [1], [2], [3]

426 *Barosaurus* [1], [2], [3]

- 427 *Brachiosaurus* [1], [2], [3]
428 *Camarasaurus* [1], [2], [3]
429 *Dicraeosaurus* [1], [2], [3]
430 *Diplodocus* [1], [2], [3]
431 *Haplocanthosaurus* [1], [2], [3]
432 *Amargasaurus* [1], [2], [3]
433 *Euhelopus* [1], [2], [3]
434 *Jobaria* [1], [2], [3]
435 *Malawisaurus* [1], [2], [3]
436 *Nigersaurus* [1], [2], [3]
437 *Rayososaurus* [1], [2], [3]
438 *Rebbachisaurus* [1], [2], [3]
439 *Alamosaurus* [1], [2], [3]
440 *Nemegtosaurus* [1], [2], [3]
441 *Neuquensaurus* [1], [2], [3]
442 *Opisthocoelicaudia* [1], [2], [3]
443 *Rapetosaurus* [1], [2], [3]
444 *Saltasaurus* [1], [2], [3]
445 *Isisaurus colberti* [1], [2], [3]
446 *Baurutitan britoi* [2]
447 *Maxakalisaurus topai* [2]
448 *Aeolosaurus maximus* [2]
449 *Aeolosaurus rionegrinus* [2]
450 *Aeolosaurus colhuehuapensis* [2]

- 451 *Gondwanatitan faustoi* [2]
452 *Rinconsaurus caudamirus* [2]
453 *Muyelensaurus pecheni* [2]
454 *Panamericansaurus schroederi* [2]
455 *Tapuiasaurus* [3]
456 *Phuwiangosaurus* [3]
457 *Tangvayosaurus* [3]
458 *Diamantinasaurus* [3]

459

460 **C- Phylogenetic Matrix**

461 'THEROPODA'

462 0000000000000000000000000000000000?00000000000000000000000000000000?0000

463 0000000010?000000?000000000000000000?000000000000000000000000?00000?00

464 00010000000000001100?00?

465 ?00000000000000?000000001100000?0?

466 'PROSAUROPODA'

467 0000000000000000000000000000000000?00000000000000000000000000000000?0000

468 0000000110?000000?1000000000000000000000?00000000000000000000000000?00000?00

469 000000000000000001000?000000000001000

470 0000000000000000?000000001100000?0?

471 'Vulcanodon'

472 ???????????????0??0???

473 ??????????????????????1????0??0?00??????100001?????????????00??10??????????10

498 ?401?101011031010?1?1?10?00002?????01101000000010000?000???10001100?01?????
499 ?????01010111101001?????????????1100?????01011101001101?1101110?11?????1?11?1??1
500 ??00000000??????????0?
501 'Apatosaurus'
502 00111112011?111?010111?101011111100020?1?0000100000011??????????221202121?
503 ??01140110101111510111111100000021?1100110000111101111100000111110011001
504 011001100000101011010100111110000111110011010001110100110111011110111111
505 1111?1111?1110000000000000??00?0?
506 'Barosaurus'
507 ???01??0
508 11?111?11?101?????11000000?????0?110111111011111110011?????01?00?01?????????
509 0?????????????????????????????????????11???0?000
510 000?????????????
511 'Brachiosaurus'
512 111100111111000101011000010111111100101111000000011001100111111211100112
513 10001103011001100?31010111111100100211010?100000001100100000000???1011??10
514 ??11010100000101011110100111111111011110101110111111001101111111001111
515 0111?11?1??11?0?0000000000000?0000
516 'Camarasaurus'
517 111100111111000101011001010111001101101111000000001001100111111111101112
518 1000010201101010103101011011110010021101001000000011011000000000??100?101
519 010110101000001010111101001111110011111100011101111101001101110111100111
520 1011111111111110?00000000000000000000

521 'Dicraeosaurus'
522 00?11?????0??00?0111111011111?????1?0??10001110101011110??????221202121?0
523 0011201101010113111110011100000121?1?0?11000010110111000000011?11001?00??1
524 10001000?0101011110????1????????????110011010001110100110111011110??111111?1
525 1????11??0?000000?????????0???

526 'Diplodocus'
527 001111120111111101011101010111111000201110000100001011110101101?22120212
528 1110011401101111115101111111000000211100110111111101111111001111100110
529 010110001000001010111101001????????????11100110100011101011101?101111001111
530 111111111?111100000000000001100000

531 'Haplocanthosaurus'
532 ???????????????0???01?3
533 011000100?21010110111100000211010?10000000110010000000????1100??10??100001
534 000????????????????????????????????111000101011110100?????????????????????????????????0
535 ?00000???????????????

536 'Amargasaurus'
537 ??????????1?00101111?1101111?????????????00111011?011?????????????????????????0
538 01301??1010105111????1??0000?12??1???0?????????????????????0??????0?????1??0?1??
539 ??0101011010?001????????????1100????????1110?00?????????????????????????????????0?
540 ?0?000?????????0???

541 'Euhelopus'
542 01110?11??1????10??????0??????11??011????????????????1001??????111011121?101
543 1?40111011011210101111011001?03??01????????????????????????????1011??????110010

544 000?110101????????????????????111?01?0111111001101?10111?00?11101?11?1?1?11

545 ??0????????????????0000

546 'Jobaria'

547 1111001111100010101100001011101110?10?11?000?000?001000????????111011100

548 00001?3011000100?310101111111000002110100100000001100100000000??10001?001

549 011010100000101011110100101110000111110001010111110100110111011110011110

550 11111???????0?000000?????????00

551 'Malawisaurus'

552 11?????1??1??100?????????1?1??11210?011?

553 ?1100011?0??10101?01?1101110?????????1??10?001110100001000??101?0?11??1?????0

554 0011101011000100??1??111?????????????111?111?????11110?????????1????????????????1??

555 11000001???????0????

556 'Nigersaurus'

557 0011??1100??0011?001??1??1?1110??????0001?00??01110?100????22110212010

558 101??0110001?0??1100????????1020?0

559 ???

560 ???00???????????

561 'Rayososaurus'

562 ?????????01?0011?00110?1??110?110?0????100101011011?????????????1??212??1

563 01??011000100??1?10??1110000?1?????0010000000110110000000011?1?????1??1102

564 0?000101000111101001?????????????11??01010111110?00?10??1?1??0??10001111?????

565 ???0?00000?????????????

566 'Rebbachisaurus'

567 ???1???

568 ??????0?11?11111000011??110201?????1?
569 0??011??0?????????
570 ??????????
571 'Alamosaurus'
572 ???11?1
573 100001?0??1010110101101110??????1231100001101100001010????????0?11111101111
574 ?1111101100111??111112?????????0111???00
575 000000?????????????
576 'Nemegtosaurus'
577 01?1?011?10100010101010101010111211111?11000100010110111??01?111?02121
578 000???
579 ??
580 ???01?10??01111
581 'Neuquensaurus'
582 ???11??0
583 10?001?0??101??1?1?0111031?0?1??3010?0011?110000101110?????????????111010111
584 1111101101111?????????????111101?01111211111111?1011101??1110?????1??????
585 100000?0?????????????
586 'Opisthocoelicaudia'
587 ???1??
588 ??????010410101110110111031?0?1221200001101100001020100??110?11111100111
589 1111111011011111??111112??1111?01101111211101111101110111110111110111111011111110
590 11110?000000?????????????

591 'Rapetosaurus'
592 0011?111?10?000?000101010101010?1112111???11?0100?110100111?????1111021210
593 0011??110?011?0??10101?01011011103?????????1??0??????00??1????1?????????1110
594 ??10011101101?00110?????1?1????11101011011111?1101?????????????????????????
595 ???101000??1?1110110000

596 'Saltasaurus'
597 ???????????00??101?00101??????????????01000101??1??????????????????????11
598 ??011000110??10101?1101101110312011????10?00111110000101110?1?????11?011101
599 01111111101101111????????????1111101101111121111111110?????????????????????
600 ???10000000????????????

601 'Aeolosaurus_maximus'
602 ??1??0
603 ??????????????????0??11?????0??10?000000100?01211??0110?11?01??????????
604 ?1?????????????????????????????????1?112110?????????????????????????????????0101112
605 ????????????

606 'Aeolosaurus_rionegrinus'
607 ??
608 ??????????????????????????????????11?00?1??100?012?????????0?10?11?0?0?????1?
609 1111?01?????????10?????????????????1?1?????????????????????????????????1111112
610 ????????????

611 'Aeolosaurus_colhuehuapensis'
612 ??
613 ??????????????????????????????0?1??110001??100?0121?????????0?1??01????????????

614 ???0111112??

615 ??????????

616 'Gondwanatitan_faustoi'

617 ???11???

618 ?????????101???0??0011103???0??0?10000?1?0100?01211?????1?0?1???1???1?????1

619 10111????????????????????????1?????11??????001?????????????????????????????????01001

620 ?2????????????

621 'Muyelensaurus_pecheni'

622 ??????????????????0??00?00?????????????????01????0????????????????????1?1?????11??

623 110??11?0??101011010000?110????????????10?0011?0?????01????11?????????1100?????1

624 11?????????????????????????????????011011111?11??1?????1?????????????????????????????0100

625 0?1????????????

626 'Tapuiasaurus'

627 00?1?111?10?100101?10??10101110111??111??11?0?00?110?001?0??1??111102121?

628 0011??01??11??10?0110101??011??11?????1?????

629 10?1???1??110011?????1?????????????????????1?2?????????1?????????????????1110?111?

630 ???????111111111111

631 'Phuwiangosaurus'

632 ????????????????10101????0?????0?110???????100011010001?????????????110212??00

633 1?0110011010?1010111101100100?1?0100?00000?0110010000000010011110?101?110

634 111???10101011?011101?????????????11101011111112110111011111?????????111?????1??

635 ?????0?????????????01?0?

636 'Tangvayosaurus'

637 ???1???

638 1????????????01?11??0?10?????00?00000?0??11100000000100???10?111?1?????????
639 ?????????????????????????????01101111121?0?110111011100???1001111?111001110??
640 ?????????????????
641 'Diamantinasaurus'
642 ???11??
643 ???11??
644 111101???1??11?111111111110110111112100111111111100????????????????????????????
645 ?????????????
646 'Baurutitan_britoi'
647 ???
648 ?????????????????????????????????????131100001100100?0101?????????0?11????????????
649 ???0000001??
650 ?????????
651 'Isisaurus_colberti'
652 ???1??1
653 10000100??101011010100?1103120?????10?001101100001010???1??10?11?0101010??
654 ??1101111101????????????????111110110111???
655 00000????????????
656 'Rinconsaurus_caudamirus'
657 ??????????????0??2??0?1??
658 010?00110??10????????????110????????????10?????????0?00011?????????1??1????0?1?1?
659 101?1??000000
660 1????????????

661 'Panamericansaurus_schroederi'

662 ???

663 ???100????????00?0?21?????????0?1????????????????110?

664 ?1??00100?1???

665 ??????????

666 'Maxakalisaurus_original'

667 ??1

668 1????1?0????????????????????1????????????10????????00?01?11??1??0?11????????????1?10

669 ???100???1???

670 ??????????

671 'Maxakalisaurus_new'

672 ???10?????????1?11?212?0???????

673 11????1?0????????????????????1????????????10????????00?01?11??1??0?11????????????1?1

674 0??100???1???

675 ????????????

676 **D- References**

677 Santucci RM, Arruda-Campos AC. 2011. A new sauropod (Macronaria, Titanosauria) from the
678 Adamantina Formation, Bauru Group, Upper Cretaceous of Brazil and the phylogenetic
679 relationships of Aeolosaurini. *Zootaxa* 3085: 1-33.

680 Wilson JA. 2002. Sauropod dinosaur phylogeny: critique and cladistica analysis. *Zoological*
681 *Journal of the Linnean Society* 136 (2): 217–276. doi:10.1046/j.1096-3642.2002.00029.x

682 Zaher H, Pol D, Carvalho AB, Nascimento PM, Riccomini C, Larson P, Juarez-Valieri R, Pires-
683 Domingues R, Da Silva NJ, Campos DA. 2011. A Complete Skull of an Early Cretaceous

684 Sauropod and the Evolution of Advanced Titanosaurians. *PLoS ONE* 6(2): e16663.

685 doi:10.1371/journal.pone.0016663

686