This is an electronic appendix to the paper by Yates & Kitching 2003 The earliest known Sauropod dinosaur and the first steps towards Sauropod locomotion. *Proc. R. Soc. Lond.* B **270**, 1753–1758. (DOI 10.1098/rspb.2003.2417.)

Electronic appendices are refereed with the text. However, no attempt has been made to impose a uniform editorial style on the electronic appendices.

Electronic Appendix A

This character list is a slightly modified version of the list given in Yates (in press). The sources are provided in that reference.

Character List

1. Skull to femur ratio: greater than (0), or less than (1), 0.5.
2. Lateral plates appressed to the labial side of the premaxillary, maxillary and dentary teeth: absent (0) or present (1).
3. Distal end of the dorsal premaxillary process: tapered (0) or transversely expanded (1).
4. Caudolateral process of premaxilla: present (0) or absent (1).
5. Dorsal profile of the snout: straight to gently convex (0) or with a depression behind the naris (1).
6. Relationship between caudolateral process of the premaxilla and the rostroventral process of the nasal: broad sutured contact (0), point contact (1) or separated by maxilla (2). Ordered
7. Ratio of narial diameter to orbital diameter: less than (0), or greater than (1), 0.5.
8. Narial position: near terminus of snout (0) or retracted caudodorsally so that the dorsal margin is level with the dorsal margin of the orbit (1).
9. Profile of premaxilla: convex (0) or with an inflection at the base of the dorsal process (1).
10. Rostrocaudal length of the antorbital fossa: greater (0), or less (1), than that of the orbit.
11. Anterior profile of the maxilla: slopes continuously towards the rostral tip (0) or with a strong inflection at the base of the ascending ramus, creating a rostral ramus with parallel dorsal and ventral margins (1).
12. Length of rostral ramus of the maxilla: less than (0), or greater than (1), its dorsoventral depth.
13. Size of the neurovascular foramen at the caudal end of the lateral maxillary row: not larger than the others (0) or distinctly larger than the others in the row (1).
14. Direction that the neurovascular foramen at the caudal end of the lateral maxillary row opens: rostrally, ventrally, laterally (0) or caudally (1).
15. Arrangement of lateral maxillary neurovascular foramina: linear (0) or irregular (1).
16. Shape of the rostral margin of the antorbital fenestra: strongly concave, roughly parallel to the rostral margin of the antorbital fossa, creating a narrow antorbital fossa (0) or straight to gently concave creating a broad, subtriangular antorbital fossa (1).
17. Dorsally open neurovascular canal on the floor of the antorbital fossa: absent (0) or present (1).
18. Nasal contribution to the margin of the antorbital fenestra: absent (0) or present (1).
19. Pointed caudolateral process of the nasal overlapping the lacrimal: absent (0) or present (1).
20. Dorsal exposure of the lacrimal: present (0) or absent (1).
21. Length of the rostral ramus of the lacrimal: greater than (0), or less than (1), half the length of the ventral ramus.
22. Extension of the antorbital fossa onto the ventral end of the lacrimal: present (0) or absent (1).

23. Length of the caudal process of the prefrontal: short (0), or elongated (1), so that total prefrontal length is equal to the rostrocaudal diameter of the orbit.
24. Jugal contribution to the antorbital fenestra: absent (0) or present (1).
25. Shape of the rostral end of the jugal: blunt (0) or sharply tapered (1).
26. Ratio of the minimum depth of the jugal below the orbit to the distance between the rostral end of the jugal and the rostroventral corner of the lower temporal fenestra: less than (0), or greater than (1), 0.2.
27. Transverse width of the ventral ramus of the postorbital: less than (0), or greater than (1), its rostrocaudal width at mid shaft.
28. Position of the rostral margin of the lower temporal fenestra: behind the orbit (0), extends under the rear half of the orbit (1) or extends as far forward as the midlength of the orbit (2). Ordered.
29. Frontal contribution to the supratemporal fenestra: present (0) or absent (1).
30. Orientation of the long axis of the supratemporal fenestra: longitudinal (0) or transverse (1).
31. Length of the quadratojugal ramus of the squamosal relative to the width at its base: less than (0) or greater than (1) four times its width.
32. Squamosal-quadratojugal contact: present (0) or absent (1).
33. Angle of divergence between jugal and squamosal rami of quadratojugal: close to 90º (0) or close to parallel (1).
34. Length of jugal ramus of quadratojugal: no longer than (0), or longer than (1), the squamosal ramus.
35. Shape of the rostral end of the jugal ramus of the quadratojugal: tapered (0) or dorsoventrally expanded (1).
36. Rounded, heel-like caudoventral process of the quadratojugal: present (0) or absent (1).
37. Position of the quadrate foramen: deeply incised into, and partly encircled by, the quadrate (0) or on the quadrate-quadratojugal suture (1).
38. Proportion of the length of the quadrate that is occupied by the pterygoid wing: at least 70% (0) or less than 70% (1).
39. Shape of jugal process of ectopterygoid: gently curved (0) or strongly recurved and hook-like (1).
40. Pneumatic fossa on the ventral surface of the ectopterygoid: present (0) or absent (1).
41. Position of the maxillary articulating surface of the palatine: along the lateral margin of the bone (0) or at the end of a narrow anterolateral process (1).
42. Medial process of the pterygoid forming a hook around the basipterygoid process: absent (0), flat and blunt-ended (1) or bent upwards and pointed (2). Ordered.
43. Ridge formed along the junction of the parabasisphenoid and the basioccipital, between the basal tuberae: present with a smooth rostral face (0), present with a median fossa on the rostral face (1), or absent with the basal tuberae being separated by a deep caudally opening U-shaped fossa (2). Unordered.
44. Ossification of the extremity of the basal tuber: complete so that the basioccipital and parabasispenoid form a single rugose tuber (0), or unossified with the basioccipital forming a ventrally facing platform of unfinished bone that abuts a similarly unfinished, caudally facing wall of the parabasisphenoid (1).
45. Shape of basal tuberae: knob-like, with basisphenoidal component rostral to basioccipital component (0), or forming a transverse ridge with the basisphenoidal component lateral to the basioccipital component (1).
46. Dorsoventral depth of the parashenoid rostrum: much less than (0) or about equal to its transverse width (1).
47. Deep septum spanning the interbasipterygoid space: absent (0) or present (1).

48. Shape of the floor of the braincase in lateral view: relatively straight with the basal tubera, basipterygoid processes and parasphenoid rostrum roughly aligned (0), bent with the basipterygoid processes and the parasphenoid rostrum below the level of the basioccipital condyle and the basal tuberae (1) or bent with the basal tuberae lowered below the level of the basioccipital and the parasphenoid rostrum raised above it (2). Unordered.
49. Length of the basipterygoid processes (from the top of the parasphenoid to the tip of the process): less than (0), or greater than (1), the height of the braincase (from the top of the parasphenoid to the top of the supraoccipital).
50. Location of the posttemporal fenestra: between the parietal, the supraoccipital and the exoccipital-opisthotic complex (0) or fully enclosed by the suproccipital (1).
51. Fontanelle between the supraoccipital and the parietals: absent (0) or present (1).
52. Shape of the supraoccipital: diamond-shaped, at least as high as wide (0), or semilunate and wider than high (1).
53. Position of jaw joint: no lower than the level of the dorsal margin of the dentary (0) or depressed well below this level (1).
54. Shape of upper jaws in ventral view: narrow with an acute rostral apex (0) or broad and U-shaped (1).
55. Caudal end of dentary tooth row medially inset with a thick lateral ridge on the dentary forming a buccal emargination: absent (0) or present (1).
56. Orientation of the symphyseal end of the dentary: in line with the long axis of the dentary (0) or strongly curved ventrally (1).
57. Position of first dentary tooth: adjacent to symphysis (0) or inset one tooth's width from the symphysis (1).
58. Height: length ratio of the dentary: less than (0), or greater than (1), 0.2.
59. Dorsoventral expansion at the symphyseal end of the dentary: absent (0) or present (1).
60. A stout, triangular, medial process of the articular, behind the glenoid: present (0) or absent (1).
61. Length of the retroarticular process: less than (0), or greater than (1), than the depth of the mandible below the glenoid.
62. Strong medial embayment behind glenoid of the articular in dorsal view: absent (0), or present (1).
63. Orientation of the dentary tooth crowns: erect (0) or procumbent (1).
64. Orientation of the maxillary tooth crowns: erect (0) or procumbent (1).
65. Number of dentary teeth (in adults): less than 18 (0), 18 or more (1).
66. Teeth with basally constricted crowns: absent (0) or present (1).
67. Tooth – tooth occlusion: absent (0) or present (1).
68. Mesial and distal serrations of the teeth: fine and set at right angles to the margin of the tooth (0) or coarse and angled upwards at an angle of 45° to the margin of the tooth (1).
69. Long axis of the tooth crowns distally recurved: present (0) or absent (1).
70. Texture of the enamel surface: smooth (0) or finely wrinkled (1).
71. Lingual concavities of the teeth: absent (0) or present (1).
72. Longitudinal labial grooves on the teeth: absent (0) or present (1).
73. Distribution of the serrations along the mesial and distal carinae of the tooth: extend along most of the length of the crown (0) or are restricted to the distal half of the crown (1).
74. Shallow, dorsally facing fossa on the atlantal neurapophysis: absent (0) or present (1).
75. Posterior margin of the axial postzygapophyses: overhang the axial centrum (0) or are flush with the caudal face of the axial centrum (1).
76. Dorsal excavation of the cervical parapophyses: absent (0) or present (1).
77. Strong lateral compression of the cranial cervical vertebrae: absent (0) or present (1).
78. Number of cervical vertebrae: 9 to 10 (0), 12-13 (1) or more than 13 (2). Ordered.

79. Length of the centrum of the third cervical vertebra: less than (0), or more than (1), 2.5 times the height of its cranial face.
80. Relative length of the mid cervical vertebrae: less than (0), or greater than (1), five times the height of the centrum.
81. Ventral keels on cranial cervical centra: present (0) or absent (1).
82. Lamination of the cervical neural arches 4 to 8: well developed with a diapophyseal-postzygapophyseal lamina (0) or weakly developed with no diapophyseal-postzygapophyseal lamina (1).
83. Short cranially projected pedicels bearing axial prezygapophyses: absent (0) or present (1).
84. Epipophyses overhanging the rear margin of the postzygapophyses: present in at least some postaxial cervical vertebrae (0), or absent (1).
85. Caudal ends of cranial, postaxial epipophyses: with a free pointed tip (0) or joined to the postzygapophysis along their entire length (1).
86. Cervical centra: amphicoelous (0) or opisthocoelous (1).
87. Laterally expanded tables at the midlength of the distal surface of the neural spines: absent in all vertebrae (0), present on the pectoral vertebrae (1) or present on the pectoral and cervical vertebrae (2). Ordered
88. Dorsoventral height of the hyposphenes: much less than (0), or equal to (1), the dorsoventral height of the neural canal.
89. Height of the dorsal neural spines: greater than (0), or less than (1), 1.5 times the length of the base of the spine.
90. Lateral surfaces of the dorsal centra: with at most a vague, shallow depressions (0), with deep fossae that approach the midline (1) or with invasive, sharp-rimmed pleurocoels (2). Ordered
91. Diapo-prezygapophyseal lamina and associated anterior triangular fossa (chonos): present on all dorsals (0) or absent in mid dorsals (1).
92. Cross sectional shaped of dorsal neural spines: narrow and elliptical (0) or broad and triangular (1).
93. Composite lateral spinal laminae on dorsal neural spines: absent (0) or present (1).
94. Spinoprezygapophyseal laminae: absent (0), present as low ridges on caudal dorsal vertebrae (1), or present as thin laminae on most dorsals (2). This is an ordered transformation series.
95. Dorsal centra: entirely amphicoelous to amphiplatyan (0) first two dorsals are opisthocoelous (1), or cranial half of dorsal column is opisthocoelous (2). Ordered.
96. Excavations of the cranial face of the dorsal neural arches, surrounding the neural canal; absent (0) or present (1).
97. Well developed suprapostzygapophyseal laminae: absent (0), present on the caudal dorsal vertebrae (1), present on all dorsal vertebrae (2).
98. Supradiapophyseal laminae on dorsal vertebrae: absent (0) or present (1).
99. Accessory infrapostzygapophyseal lamina in dorsal vertebrae: present (0) or absent (1).
100. Last presacral rib: free (0) or fused to vertebra (1).
101. Caudosacral vertebra: absent (0) or present (1)
102. Number of dorsosacral vertebrae: none (0), one (1) or two (2).
103. Strong constriction between the sacral rib and the transverse process of the first primordial sacral rib (and dorso-sacral if present) in dorsal view: absent (0) or present (1).
104. Length of first caudal centrum: less than (0), or greater than (1), its height.
105. Length of base of the proximal caudal neural spines: greater than (0), or less than (1), half the length of the neural arch.

106. Position of postzygapophyses in proximal caudal vertebrae: protruding with an interpostzygapophyseal notch visible in dorsal view (0) or placed on either side of the caudal end of the base of the neural spine without any interpostzygapophyseal notch (1).
107. A hyposphenal ridge on caudal vertebrae: absent (0) or present (1).
108. Midcaudal chevrons with a ventral slit: absent (0) or present (1).
109. Length of midcaudal centra: greater than (0), or less than (1), twice the height of their proximal faces.
110. Longitudinal ventral sulcus on caudal centra: absent (0) or present (1).
111. Length of the longest chevron: is less than (0), or greater than (1), the length of the preceding centrum.
112. Longitudinal ridge on the dorsal surface of the sternal plate: absent (0) or present (1).
113. Craniocaudal length of the acromion process of the scapula: less than (0), or greater than (1), one and a half times the minimum width of the scapula blade.
114. Minimum width of the scapula: is less than (0), or greater than (1), 20% of its length.
115. Scapula blade in lateral view: with a strap- shaped midsection that has straight, subparallel margins (0) or waisted with curved margins (1).
116. Caudal margin of the acromion process of the scapula: rises from the blade at angle that is less than (0), or greater than (1), 65° from the long axis of the scapula, at its steepest point.
117. Flat caudoventrally facing surface on the coracoid between the glenoid and the coracoid tubercle: absent (0) or present (1).
118. Coracoid tubercle: present (0) or absent (1).
119. Length of the deltopectoral crest of the humerus: less than (0), or greater than (1), 50% of the length of the humerus.
120. Deltopectoral crest of the humerus: is a tall, sharp-edged crest (0) or is a low, rounded ridge (1).
121. Length of the humerus: less than 55% (0), 55-65% (1), 65%-80% (2), or greater than 80% (3), of the length of the femur. Ordered.
122. Craniolateral margin of the deltopectoral crest of the humerus: straight (0) or strongly sinuous (1).
123. Well-defined, semicircular fossa on the distal flexor surface of the humerus: present (0) or absent (1).
124. Transverse width of the distal humerus: is less than (0), or greater than (1), 33% of the length of the humerus.
125. Deep radial fossa on proximal ulna: absent (0) or present (1).
126. Olecranon process on proximal ulna: present (0) or absent (1).
127. Length of the cranial condylar process of the proximal ulna: approximately equal to (0), or much greater than (1), the lateral condylar process.
128. Length of the radius: less than (0), or greater than (1), 80% of the length of the humerus.
129. Shape of caudal margin of distal radius: rounded (0), or flat (1).
130. Maximum linear dimensions of the ulnare and radiale: exceed that of at least one of the first three distal carpals (0) or are less than any of the distal carpals (1).
131. Transverse width of the first distal carpal: less than (0), or greater than (1), 120% of the transverse width of the second distal carpal.
132. Lateral end of first distal carpal: abuts (0), or overlaps (1), second distal carpal.
133. Proximal end of first metacarpal: flush with other metacarpals (0) or inset into the carpus (1).
134. Second distal carpal: does (0), or does not (1), completely cover the proximal end of the second metacarpal.
135. Length of the manus: greater than 45% (0), 45-40% (1), or less than 38% of the humerus + radius.

136. Proximal width of first metacarpal: less than (0), or greater than (1), the proximal width of the second metacarpal.
137. Proximal width of the first metacarpal: less than 65% (0), between 65% and 80% (1), or greater than 80% (2), of its length. Ordered.
138. Strong assymetry in the lateral and medial distal condyles of the first metacarpal: absent (0) or present (1).
139. Shape of the fifth metacarpal: longer than wide at the proximal end with a flat proximal surface (0) or close to as wide as it is long with a strongly convex proximal articulation surface (1).
140. Length of the fifth metacarpal: less than (0), or greater than (1), 75% of the length of the third metacarpal.
141. Deep distal extensor pits on the second and third metacarpals: present (0) or absent (1).
142. Ventrolateral twisting of the transverse axis of the distal end of the first phalanx of manual digit one relative to its proximal end: absent (0), present but much less than 60° (1) or 60° (2). Ordered.
143. Length of manual digit one: less than (0), or greater than (1), the length of manual digit two.
144. Length of the ungual of manual digit two: greater than the length of the ungual of manual digit one (0), 75-100% of the ungual of manual digit one (1), less than 75% of the ungual of manual digit one (2) or the ungual of manual digit two is absent (3). Ordered.
145. Shape of non-terminal manual phalanges: longer than wide (0) or as long as wide (1).
146. Phalangeal formula of manual digits four and five: less than (0), or greater than (1), 2-0, respectively.
147. Strongly convex dorsal margin of the ilium: absent (0) or present (1).
148. Cranial extent of preacetabular process of ilium: does not (0), or does (1), project further forward than cranial end of the pubic peduncle.
149. Buttress between preacetabular process and the supra-acetabular crest of the ilum: present (0) or absent (1).
150. Shape of the preacetabular process: blunt and rectangular (0) or with a pointed, projecting cranioventral corner and a rounded dorsum (1).
151. Length of the postacetabular process of the ilium: greater than (0), or less than (1), 30% of the total length of the ilium.
152. Depth of the preacetabular process of the ilium: much less than (0), or subequal to (1), the depth of the ilium above the acetabulum.
153. Length of preacetabular process of the ilium: less than (0), or greater than (1), twice its depth.
154. Medial bony wall of the acetabulum: at least partially present (0) or absent (1).
155. Well developed brevis fossa with sharp margins on the ventral surface of the postacetabular process of the ilium: absent (0) or present (1).
156. Length of the pubic peduncle of the ilium: less than (0), or greater than (1), twice the craniocaudal width of its distal end.
157. Caudally projecting ‘heel’ at the distal end of the ischial peduncle: absent (0) or present (1).
158. Length of the ischial peduncle of the ilium: similar to (0), or much shorter than (1), the pubic peduncle.
159. Shape of the caudal margin of the postacetabular process of the ilium: rounded to bluntly pointed (0), square ended (1) or with a pointed ventral corner and a rounded caudodorsal margin (2). Unordered
160. Notch separating caudoventral end of the ischial obturator plate from the ischial shaft: present (0) or absent (1).
161. Elongate interischial fenestra: present (0) or absent (1).
162. Length of ischium: less than (0) or greater than (1) that of the pubis.

163. Shape of the transverse section of the ischial shaft: ovoid to subrectangular (0) or triangular (1).
164. Orientation of the long axes of the transverse section of the distal ischia: meet at an angle (0) or are coplanar (1).
165. Depth of the transverse section of the ischial shaft: at least as great as (0), or much less than (1), the transverse width of the section.
166. Transverse width of the conjoined distal ischia: greater than (0), or less than (1), their sagittal depth.
167. Pubic tubercle on the lateral surface of the proximal pubis: present (0) or absent (1)
168. Width of the conjoined pubes: less than (0), or greater than (1), 75% of their length.
169. Lateral margins of the pubic apron in cranial view: straight (0) or concave (1).
170. Orientation of the pubic blades: transverse (0) or twisted caudomedially (1).
171. Minimum transverse width of the pubic apron: much more than (0), or less than (1), 40% of the width across the iliac peduncles of the ilium.
172. Craniocaudal length of the distal pubic expansion: less than (0), or greater than (1) 15% of the length of the pubis.
173. Length of the hindlimb: greater than (0), or less than (1), the length of the trunk.
174. Longitudinal axis of the femur in lateral view: strongly bent with an offset between the proximal and distal axes greater than 15° (0), weakly bent with an offset of less than 10° (1) or straight (2). Ordered.
175. Shape of the cross section of the midshaft of the femur: subcircular (0) or strongly elliptical with the long axis oriented mediolaterally (1).
176. Form of the lesser trochanter: low ridge (0) or a tall crest, with height exceeding thickness (1).
177. Height of the fourth trochanter: tall crest (0) or a low rugose ridge (1).
178. Shape of the lesser trochanter: small rounded tubercle (0), elongate ridge that is oriented dorsoventrally (1) or absent (2). Unordered
179. Angle between the long axis of the femoral head and the transverse axis of the distal femur: about 30° (0) or close to 0° (1).
180. Shelf-like ridge associated with lesser trochanter: present (0) or absent (1).
181. Position of the fourth trochanter along the length of the femur: in the proximal half (0) or straddling the midpoint (1).
182. Profile of the fourth trochanter of the femur: rounded and symmetrical (0) or asymmetrical with a steeper distal slope than the proximal slope and distinct corners (1).
183. Postion of fourth trochanter along the mediolateral axis of the femur: centrally located (0) on the medial margin (1).
184. Tibia: femur length ratio: greater than 1.0 (0), between 1.0 and 0.6 (1) or less than 0.6 (2). Ordered.
185. Extensor depression on the distal femur: absent (0) or present (1).
186. Lateral margin of descending caudoventral process of the distal tibia: protrudes laterally at least as far as (0), or set well back from (1), the craniolateral corner of the distal tibia.
187. Transverse width of the distal tibia: subequal to (0), or greater than (1), its craniocaudal length.
188. A triangular rugose area on the medial side of the fibula: absent (0) or present (1).
189. A tubercle on the lateral side of the fibula shaft: absent (0) or present (1).
190. Ossified distal tarsals: present (0) or absent (1).
191. Depth of the medial end of the astragalar body in cranial view: roughly equal to the lateral end (0) or much shallower creating a wedge shaped astragalar body.

192. Shape of the caudomedial margin of the astragalus in dorsal view: forming a moderately sharp corner of a subrectangular astragalus (0) or evenly rounded without the formation of a caudomedial corner (1).
193. Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus: present (0) or absent with a largely vertical fibular facet (1).
194. Vascular foramina set in a fossa at the base of the ascending process of the astragalus: present (0) or absent (1).
195. A lateral horizontal groove on the calcaneum: absent (0) or present (1).
196. Transverse width of the calcaneum: greater than (0), or less than (1), 30% of the transverse width of the astragalus.
197. Length of the third metatarsal: greater than 40% (0), between 40-30% (1), or less than 30% (2) of the length of the tibia.
198. Width of the midshaft of the first metatarsal: is no greater than (0), or greater than (1), the width of the midshaft of the second metatarsal.
199. Shape of the medial margin of the proximal surface of the second metatarsal: straight (0) or concave (1).
200. Shape of the lateral margin of the proximal surface of the second metatarsal: straight (0) or concave (1).
201. Transverse width of the proximal end of the fourth metatarsal: less than (0), or at least (1), twice the craniocaudal depth of the proximal end.
202. Transverse width of the proximal end of the fifth metatarsal: less than 25% (0), between 30 and 49 % (1), or greater than 50% (2), of the length of the fifth metatarsal. Ordered
203. Length of the ungual of pedal digit two: greater than (0), between 100% and 90% (1), or less than 90% (2), of the length of the ungual of pedal digit one. Ordered.
204. Length of the ungual of pedal digit one: less than the first phalanx of digit one and metatarsal one (0), greater than the first phalanx but less than metatarsal one (1), or greater than both (2). Ordered.
205. Minimum shaft diameters of third and fourth metatarsals: greater than (0), or less than (1), 60% of the minimum shaft diameter of the second metatarsal.
206. Shape of the ungual of pedal digit one: shallow, pointed, with convex sides and a broad ventral surface (0), or deep, abruptly tapering, with flattened sides and a narrow ventral surface (1).
207. Size of the ungual of pedal digit three: greater than (0), or less than (1), 85% of the ungual of pedal digit two in all linear dimensions.
208. Number of phalanges in pedal digit four: four (0) or fewer than four (1).
209. Phalanges of pedal digit five: absent (0) or present (1).
210. Pedal digit five: reduced, non-weight bearing (0), or robust and weight bearing (1).
211. Orientation of the pedal unguals: directed forwards (0) or strongly deflected laterally so that the proximal articular facet is only visible on the lateral side (1).
212. Adult length of the femur: less than 200 mm (0), 200-399 mm (1), 400-599 mm (2), 600-799 mm (3), 800-1000 mm (4), or greater than 1000 mm (5). Ordered.

Character Taxon Matrix

Herrerasaurus ischigualastensis
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??10000000?000000000101000000000000000001000000?1002

Neotheropoda
00(0,1)0020000(0,1)000000010000(0,1)1000000(01)0001(0,1)0100000000000000000000000000
000000000000001010000000100000000001(1,2)000000010000(0,1)000000000000000010000000?0
000(1,2)00011001011000100000000100010000000000000000100000000100?0000000000002

Saturnalia tupiniquim
10?????????000?????00????????1?????00????00?0000?????00010???00010010000??00??0?1???
0001010000000100001 1???????101110001001 00000?????????????????0?0?00?01100211010100
00000100000000101000000000000000000010?00?000000

Thecodontosaurus spp.
10??0??00???(0,1)(0,1)0?1000000?100?00?????0(0,1)0100000100010?100(0,1)01100000000110110
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Efraasia minor
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1000000000000000101010100 1000001?1000??111100001002

Riojasaurus incertus
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1?1001010100000001101100000 10??00101010211100000 11111?1111011021?001100011110201
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Plateosaurus engelhardti
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1020001001000000000001010101101000001010001011110000 1004

Coloradisaurus brevis
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10000?0101000000001101100 10?????0001101011 01??????????????????????00110001?110?11110
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Massospondylus carinatus
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0101002010100000000011011(0,1)0000011?000(0,1)1010100100000011111112110121201001 10001
0100011010011010011000011101011010000010100011122100101002

Lufengosaurus huenei
10?0121001111100???1101111?100101??0??010110??0?0??010???0011?1011011000???0001001
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10001010011000011101011010000 01?10001112210010 1002

Anchisaurus polyzelus
10?0???0011111?01???11101112101?????1?0???21010200111 01?000100?1010111?0110??0?001
010??0101000??00??010?????????100(01)??00201000?00???1?2111101202010(01)1100110100?
11?01101000101000011 10(01)11111?0000??0100???11100000001

Melanorosaurus readi
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00100000001?1100000?10??0100??10201010?0?????????21????????0011000101001???10001000
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Blikanasaurus cromptoni
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Antetonitrus ingenipes
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Kotasaurus yamanpalliensis
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1?2101111001111110?1111??11????21?01???15

Isanosaurus attavipachi
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Vulcanodon karibaensis
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1101111111 2??1101111101111012220 11?1105

Barapasaurus tagorei
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0101121121??11000?1??0??010101?1????111?1?????????????????1111110101010??1101011011
1?2101211 1?????11?????????????????????15

Shunosaurus lii
1101021111000002?00111000102000101111 1??1221??020001010000110011111111111?1?1100
0001110?0111021?21?011?0001110?1?01?01013011?11011000?211?011013111111110101010 1
1110101 1?111121012110002 1?1?110?1101211002220 1111105

Omeisaurus spp.
1101021111100012000111010 1?2110101111 1??1??1?00?00011100001??011011111111?011211
0001110102011221 21??120000111011101101013010 1?101???0?2001011????1111110101010 11
1?0??1101111210121110021??11?0011??2110022211111115

Neosauropoda
11010211(0,1)1(0,1)010120001110(0,1)011211010111110112210002(0,1)0011100001100110111
11(0,1)11(0,1)0101101001110102011221211012000010101010010101(2,3)01(0,1)111111100020
0001101311111111101010101 11(0,1)1101101111210121110121111111111012100022211111115

Synapomorphy List

The following list describes the synapomorphies of the single tree obtained by condensing the five most-parsimonious trees after pruning *Blikanasaurus* from them.

Sauropodomorpha

Unambiguous synapomorphies

1. Skull less than half the length of the femur.
31. Length of the quadratojugal ramus of the squamosal exceeds four times its width.
66. Teeth with basally constricted crowns.
69. Loss of recurved of tooth crowns.
82. Weakly developed lamination of cervical neural arches 4 to 8 with no diapophyseal-postzygapophyseal lamina.
89. Low dorsal neural spines (height is less than one and a half times the anteroposterior length at the base).
91. Diapo-prezygapophyseal lamina and its associated anterior chonos is absent from the mid dorsal vertebrae.
104. Elongate first caudal centrum (length greater than height).
105. Length of the base of the proximal caudal neural spines less than half the length of their neural arches.
117. Flat, caudoventrally facing surface on the coracoid between the glenoid and the coracoid tubercle.
121. Length of the humerus is greater than 55% of the femur.
124. Transverse width of the distal humerus greater at least 33% of the length of the humerus.
156. Length of the pubic peduncle of the ilium is twice its craniocaudal width at the distal end.

Synapomorphies with ACCTRAN

3. Distal end of the dorsal premaxillary process transversely expanded.
7. Narial diameter exceeds half the orbital diameter.
10. Rostrocaudal length of the antorbital fossa is less than half that of the orbit.
11. Anterior profile of the maxilla with a strong inflection creating a rostral ramus.
12. Length of the rostral ramus of the maxilla is greater than its dorsoventral depth.
17. Dorsally open neurovascular canal on the floor of the antorbital fossa.
28. Rostral margin of the lower temporal fenestra extends under the rear half of the orbit.
45. Basal tubera form a transverse ridge where the basisphenoidal component lies laterally to the basioccipital component.
51. Fontanelle between the supraoccipital and the parietals.
52. Semilunate supraocciptal wider than it is high.
58. Height of the dentary greater than 20% of its length.
74. Shallow dorsally facing fossa on the atlantal neurapophysis.
75. Posterior margin of the axial postzygapophysis is flush with the caudal face of the axial centrum.
115. Waisted scapula blade with concave margins.
130. Proximal carpals are smaller than distal carpals I-III in all linear dimensions.
136. Proximal width of metacarpal I exceeds that of metacarpal II.
142. Transverse axis of the distal end of manual phalanx I1 twisted ventrolaterally relative to the proximal end.
150. Preacetabular process of the ilium with a pointed and projecting cranioventral corner and a rounded dorsal margin.
173. Hindlimb shorter than the trunk.
203. Pedal ungual of digit I at least as large as the pedal ungual of digit II.

Thecodontosaurus + (Efraasia + (*Prosauropoda* + *Sauropoda*))

Unambiguous synapomorphies

57. First dentary tooth inset one tooth width from the symphysis.
65. More than 18 dentary teeth in adults.
68. Teeth with coarse serrations angled upwards at 45º from the margin of the tooth.
103. Strong constriction between the first primordial sacral rib and the transverse process in dorsal view.
149. Loss of buttress between preacetabular process and supracetabular crest of ilium.
178. Lesser trochanter is a dorsoventrally elongate ridge.
180. Loss of trochanteric shelf associated with lesser trochanter.
193. Fibular facet on astragalus vertical, without horizontal shelf.
199. Concave medial margin of the proximal articulating surface of metatarsal II.
200. Concave lateral margin of the proximal articulating surface of metatarsal II.
202. Transverse width of the proximal end of metatarsal V is greater than 30% of its length.

Synapomorphies with DELTRAN

17. Dorsally open neurovascular canal on the floor of the antorbital fossa.
45. Basal tubera form a transverse ridge where the basisphenoidal component lies laterally to the basioccipital component.
52. Semilunate supraocciptal wider than it is high.
130. Proximal carpals are smaller than distal carpals I-III in all linear dimensions.
136. Proximal width of metacarpal I exceeds that of metacarpal II.
142. Transverse axis of the distal end of manual phalanx I1 twisted ventrolaterally relative to the proximal end.
150. Preacetabular process of the ilium with a pointed and projecting cranioventral corner and a rounded dorsal margin.
203. Pedal ungual of digit I at least as large as the pedal ungual of digit II.

Synapomorphies with ACCTRAN

13. Neurovascular foramen at the caudal end of the maxillary row larger than all others in the row.
14. Neurovascular foramen at the caudal end of the maxillary row opens caudally.
49. Length of the basipterygoid processes greater than the height of the braincase.
55. Caudal end of the dentary tooth row is medially inset forming a buccal emargination.
121. Length of humerus exceeds 65% of the femur.
195. Calcaneum with a horizontal groove on the lateral side.

Efraasia + (*Prosauropoda* + *Sauropoda*)

Unambiguous synapomorphies

53. Jaw joint well below the level of the dorsal margin of the dentary.
60. Loss of a triangular medial process on the articular.
84. No postaxial cervical epipophyses overhang the rear margin of the postzygapophyses.
102. Dorsosacral vertebrae added to the sacrum.
109. Short midcaudal centra (length less than twice the height of the proximal face).
111. The longest chevron exceeds twice the length of the preceding centrum.
137. Proximal width of metacarpal I is greater than 65% of its length.
141. Loss of distal extensor pits on metacarpals II and III.
146. Manual digit IV and manual digit V with more than two and zero phalanges, respectively.
154. Complete loss of the medial bony wall of the acetabulum.
187. Transverse width of the distal tibia greater than its craniocaudal length.
203. Length of pedal ungual I greater thyan pedal phalanx I1.

Synapomorphies with DELTRAN

11. Anterior profile of the maxilla with a strong inflection creating a rostral ramus.
12. Length of the rostral ramus of the maxilla is greater than its dorsoventral depth.
99. Loss of accessory infrapostzygapophyseal laminae in dorsal vertebrae.
121. Length of humerus exceeds 65% of the femur.

Synapomorphies with ACCTRAN

40. Loss of pneumatic fossa on ventral surface of ectopterygoid.
42. Medial process of the pterygoid forming a flat, horizontal and blunt-ended hook around the basipterygoid process.
47. Deep septum spanning the interbasipterygoid space.
58. Reversal to a dentary that has a height less than 20% of its length.
119. Deltopectoral crest over half the length of the humerus.
132. Lateral end of distal carpal I overlaps distal carpal II.
133. Proximal end of metacarpal I inset into carpus.

Prosauropoda + Sauropoda

Unambiguous synapomorphies

38. Pterygoid wing of the quadrate extends for less than 70% of the length of the quadrate
104. Reversal to a short first caudal centrum (length less than its height).
105. Reversal to long bases of the proximal caudal neural spines that are greater than half the length of their neural arches
135. Manus less than 45% of humerus + radius.
144. Ungual of manual digit II is shorter than the ungual of manual digit I.
167. Loss of pubic tubercle on proximal pubis.
179. Fully inturned femoral head (long axis of femoral head parallel with transverse axis of distal femur).
185. Distal femur with an extensor depression.

Synapomorphies with DELTRAN

7. Narial diameter greater than half the orbital diameter.
10. Rostrocaudal length of the antorbital fossa is less than that of the orbit.
28. Rostral margin of the lower temporal fenestra extends under the rear half of the orbit.
40. Loss of pneumatic fossa on the ventral surface of the ectopterygoid.
42. Medial process of the pterygoid forming a flat, horizontal and blunt-ended hook around the basipterygoid process.
133. Metacarpal I inset into carpus.
173. Hind limb less than the length of the trunk.

Synapomorphies with ACCTRAN

6. Caudolateral process of the premaxilla and the rostroventral process of the nasal are separated by the maxilla.
23. Caudal process of the prefrontal elongated so that the length of the prefrontal is equal to the rostrocaudal diameter of the orbit.
26. Deep infraorbital bar of the jugal (depth is greater than 20% of the length from the rosatral end to the lower temporal fenestra).
43. Median fossa on the rostral face of the ridge between the basal tubera.
49. Reversal to short basipterygoid processes that are less than the height of the braincase.
123. Loss of semicircular fossa on the distal flexor surface of the humerus.
139. Fifth metacapal almost as wide as it is long with a strongly convex proximal articulating surface.
183. Fourth trochanter placed on the medial margin of the femur in caudal view.
202. Transverse width of the proximal end of the fifth metatarsal greter than 50% of its length.

Prosauropoda

16. Broad, subtriangular antorbital fossa with a straight to gently concave rostral margin of the antorbital fenestra.
53. Reversal to a tall, diamond-shaped supraoccipital.
62. Marked medial excavation of the articular, behind the glenoid in dorsal view.
87. Lateral expansions in the middle of the distal ends of the neural spines of the pectoral vertebrae.
100. Last presacral rib fused to vertebra.
134. Distal carpal II does not completely cover the proximal end of metacarpal II.
157. Caudally projecting heel at the distal end of the ischial peduncle of the ilium.
159. Postacetabular process of the ilium with a pointed ventral corner and a rounded caudodorsal corner.

Synapomorphies with DELTRAN

13. Neurovascular foramen at the caudal end of the maxillary row larger than all others in the row.
14. Neurovascular foramen at the caudal end of the maxillary row opens caudally.
23. Caudal process of the prefrontal elongated so that the length of the prefrontal is equal to the rostrocaudal diameter of the orbit.
43. Median fossa on the rostral face of the ridge between the basal tubera.
47. Deep septum spanning the interbasipterygoid space.
51. Fontanelle between the supraoccipital and the parietals.
119. Deltopectoral crest over half the length of the humerus.
132. Lateral end of distal carpal I overlaps distal carpal II.
139. Fifth metacapal almost as wide as it is long with a strongly convex proximal articulating surface.

Synapomorphies with ACCTRAN

50. Posttemporal fenestra fully enclosed by the supraoccipital.
122. Strongly sinuous craniolateral margin of the deltopectoral crest.
160. Reversal to the presence of a notch separating the caudoventral end of the ischial obturator plate from the ischial shaft.

Plateosauria

5. Dorsal profile of the skull with a depression behind the naris.
18. Nasal contributes to the margin of the antorbital fenestra.
19. Pointed caudolateral process of the nasal overlapping the lacrimal.
33. Jugal and squamosal rami of the quadratojugal are close to parallel.
56. Symphyseal end of the dentary is strongly curved ventrally.
61. Retroarticular process is longer than the depth of the mandible below the glenoid.
79. Third cervical centrum greater than 2.5 times as long as its cranial face is high.
87. Lateral expansions of the distal ends of the neural spines extend onto the cervical vertebrae.
110. Longitudinal ventral sulcus on the centra of the caudal vertebrae.
121. Reversal to a humerus that is less than 65% of the length of the femur.
142. Ventrolateral twisting of the distal end of manual phalanx I1 relative to the proximal end is greater than 60º.
166. Transverse width of the conjoined distal ischia is less than their sagittal depth.

Synapomorphies with DELTRAN

3. Transversely expanded distal end of the dorsal premaxillary process.
26. Deep infraorbital bar of the jugal (depth is greater than 20% of the length from the rosatral end to the lower temporal fenestra)

50. Posttemporal fenestrae are fully enclosed by the supraoccipital.
55. Caudal end of the dentary tooth row is medially inset forming a buccal emargination.
74. Shallow, dorsally facing fossa on the atlantal neurapophysis.
209. Phalanges of pedal digit V present.

Synapomorphes with ACCTRAN

48. Ventral margin of the braincase L-shaped with the basipterygoid processes and the parasphenoid rostrum placed below the level of the occipital condyle and the basal tubera.
123. Reversal to the presence of a semicircular fossa on the distal flexor surface of the humerus.
183. Reversal to a fourth trochanter that is placed well away from the medial margin of the femoral shaft in caudal view.

Massospondylidae

Unambiguous synapomorphies

46. Broad parasphenoid rostrum (width equal to dorsoventral depth).
81. Reversal to the presence of ventral keels on the cranial cervical centra.
116. Caudal margin of the acromion process rises from the scapular blade at an angle greater than 65º.
169. Lateral margins of the pubic apron are concave in cranial view.
172. Craniocaudal length of the distal pubic expansion is greater than 15% of the length of the pubis.
203. Length of pedal ungual II less than 90% of pedal ungual I.
207. Pedal ungual III less than 85% of pedal ungual II in all linear dimensions.

Synapomorphies with DELTRAN

6. Caudolateral process of premaxilla widely separated from the rostroventral process of the nasal by a broad exposure of the maxilla in the narial margin.
202. Transverse width of the proximal end of metatarsal V greater than 50% of its length.

Synapomorphies with ACCTRAN

21. Rostral ramus of the lacrimal is less than half the length of the ventral ramus.
24. Jugal contribution to the margin of the antorbital fenestra.
75. Reversal to axial postzygapophyses that overhang the caudal face of the axial centrum.
115. Reversal to a scapula blade with a midsection that has parallel margins.
137. Proximal width of metacarpal I greater than 80% of its length.
143. Manual digit I longer than manual digit II.
160. Loss of notch separating caudoventral end of ischial obturator plate from the ischial shaft.

Massospondylus + Lufengosaurus

Unambiguous synapomorphies

16. Reversal to a strongly concave rostral margin of the antorbital fenestra with a narrow antorbital fossa.
47. Reversal to the absence of a deep septum spanning the interbasipterygoid space.
63. Procumbent dentary tooth crowns.
157. Reversal to the loss of a caudally projecting heel on the ischial peduncle of the ilium.

Synapomorphies with DELTRAN

21. Rostral ramus of the lacrimal is less than half the length of the ventral ramus.
137. Proximal width of metacarpal I greater than 80% of its length.
143. Manual digit I longer than manual digit II.
195. A horizontal groove across the lateral surface of the calcaneum.

Synapomorphies with ACCTRAN

34. Jugal ramus of the quadratojugal longer than the squamosal ramus.

48. Reversal to a straight ventral floor of the braincase with the basal tubera, basipterygoid processes and parasphenoid rostrum roughly aligned in lateral view.
73. Serrations are restricted to the distals half of the tooth crowns.

Sauropoda

Unambiguous synapomorphies

21. Rostral ramus of the lacrimal is less than half the length of the ventral ramus.
22. Loss of caudoventral extension of the antorbital fossa onto the lacrimal.
28. Rostral margin of the lower temporal fenestra extends as forward for 50% of the length of the orbit.
37. Quadrate foramen not incised into the lateral margin of the quarate.
43. Deep caudally opening U-shaped fossa between the basal tubera.
44. Extremities of the basal tubera are unossified, forming a transverse notch bounded by unfinished bone.
45. Reversal to knob-like basal tubera with the basisphenoidal component placed rostral to the basioccipital component.
48. Ventral margin of the braincase V-shaped with the base of the basipterygoid processes placed well below the basal tubera and the parasphenoid rostrum.
57. Reversal to a first dentary tooth that is adjacent to the symphysis.
64. Procumbent maxillary tooth crowns.
70. Teeth with wrinkled enamel.
73. Serrations are restricted to the distal half of the tooth crowns.
103. Loss of a strong constriction between the transverse process and the sacral rib of the first primordial sacral.
124. Reversal to a humerus with a transverse width of the distal end that is less than 33% of the length of the humerus.
135. Length of the manus is less than 38% of the humerus + radius.
186. Caudoventral process of the distal tibia does not extend as far laterally as the cranilateral corner of the distal tibia.
196. Calcaneum less than 30% of the transverse width of the astragalus.

Synapomorphies with DELTRAN

26. Deep infraorbital bar of the jugal (depth is greater than 20% of the length from the rosatral end to the lower temporal fenestra).
123. Loss of semicircular fossa on distal flexor surface of the humerus.
183. Fourth trochanter placed on the medial margin of the femur in caudal view.

Synapomorphies with ACCTRAN

20. Loss of dorsal exposure of the lacrimal.
27. Transverse width of the ventral ramus of the postorbital at midshaft greater than its rostrocaudal width.
29. Loss of frontal contribution to the supratemporal fenestra.
32. Loss of squamosal-quadratojugal contact.
34. Jugal ramus of the quadratojugal longer than the squamosal ramus.
35. Rostral end of the jugal ramus of the quadratojugal is dorsoventrally expanded.
36. Loss of caudoventral, heel-like process of the quadratojugal.
41. Maxillary articulating surface of the palatine at the end of a narrow anterolateral process.
42. Medial process of the pterygoid forming an upturned and pointed hook.
47. Reversal to the absence of a deep septum spanning the interbasipterygoid space.
63. Procumbent dentary tooth crowns.
65. Reversal to less than 18 dentary teeth in adults.
71. Tooth crowns with lingual concavities.

75. Reversal to axial postzygapophyses that overhang the caudal face of the axial centrum.
112. Longitudinal ridge on the dorsal surface of the sternal plate.
115. Reversal to a scapula blade with a midsection that has parallel margins.
117. Reversal to the absence of a flat caudoventrally facing surface on the coracoid, in front of the glenoid.
118. Loss of the coracoid tubercle.
119. Reversal to a deltopectoral crest that extends for loess than half the length of the humerus.
127. Cranial condylar process of the proximal ulna much greater than the lateral condylar process.
132. Reversal to a distal carpal I with a lateral end that abuts but does not overlap distal carpal II
162. Ischium longer than the pubis.
165. Transverse width of the ischial shaft greater than its depth.
182. Profile of the fourth trochanter rounded and symmetrical.
195. Reversal to the absence of a horizontal groove on the lateral surface of the calcaneum.

Melanorosaurus + (Antetonitrus + (Isanosaurus + (Kotasaurus + (Vulcanodon + *Eusauropoda*))))

Unambiguous synapomorphies

88. Dorsoventral height of the hyposphenes equal to the dorsoventral height of the neural canal.
89. Reversal to tall dorsal neural spines that are greater than 1.5 times the length of their bases.
101. Caudoscaral vertebra added to the sacrum.
125. Deep radial fossa on the proximal ulna.

Synapomorphies with ACCTRAN

2. Length of pedal ungual I greater than metatarsal I.
4. Loss of caudolateral process of premaxilla.
8. Naris retracted so that the dorsal margin is level with that of the orbit.
9. Profile of the premaxilla with an inflection at the base of the dorsal process.
12. Reversal to a rostral ramus of the maxilla is deeper than it is long.
13. Reversal to the caudal neurovascular foramen of the maxillary row that is of similar size to all others.
14. Reversal to the caudal neurovascular foramen of the maxillary row not opening caudally.
16. Loss of antorbital fossa.
17. Reversal to the absence of a dorsally open neurovascular canal on the floor of the antorbital fossa.
23. Reversal to a short caudal process of the prefrontal (length of the prefrontal is less than the orbit).
25. Reversal to a blunt rostral end of the jugal.
31. Reversal to a broad quadratojugal ramus of the squamosal (basal width greater than 25% of its length).
51. Reversal to absence of a fontanelle between the supraoccipital and the parietals.
54. Upper jaws broad and U-shaped in ventral view.
55. Reversal to the absence of a buccal emargination on the dentary.
59. Dorsoventral expansion of the dentary at its symphyseal end.
67. Tooth-tooth contact upon occlusion.
72. Longitudinal labial grooves on tooth crowns.
78. Number of cervical vertebrae increased to twelve or more.
85. Loss of free tip from all postaxial epipophyses (epipophyses are joined to postzygapophyses along their length).

114. Minimum width of scapular blade greater than 20% of its length.
137. Proximal width of metacarpal I is greater than 80% of its length.
139. Reversal to a metacarpal V that is longer than its proximal width and has a flat proximal articulating surface.
140. Metacarpal V greater than 75% of the length of metacarpal III.
143. Manual digit I longer than manual digit II.
144. Loss of manual ungual II.
145. Non-terminal manual phalanges wider than long.
172. Craniocaudal length of the distal pubic expansion is greater than 15% of the length of the pubis.
176. Crest-like lesser trochanter with the height exceeding the basal width.
203. Length of pedal ungual II less than 90% of the length of pedal ungual I.
204. Length of pedal ungual I greater than metatarsal I.
207. Pedal ungual III less than 85% of pedal ungual II in all linear dimensions.
208. Fewer than four phalanges in pedal digit IV.

Antetonitrus + (Isanosaurus + (Kotasaurus + (Vulcanodon + *Eusauropoda*)))

Unambiguous synapomorphies

97. Suprpostzygapophyseal laminae on caudal dorsal vertebrae.
121. Length of the humerus greater than 80% of the femur.
175. Strongly elliptical cross-section of the femoral shaft with a mediolaterally oriented long axis.
197. Length of metatarsal III less than 40% of the tibia.
198. Width of the midshaft of metatarsal I is greater than that of metatarsal II.

Synapomorphies with DELTRAN

127. Cranial condylar process of the proximal ulna much greater than the lateral condylar process.

Synapomorphies with ACCTRAN

82. Reversal to well-developed lamination of cervical neural arches 4 to 8, including diapophyseal-postzygapophyseal laminae.
148. Cranial end of the preacetabular process of the ilium projects further forward than the pubic peduncle.
158. Ischial peduncle of the ilium much shorter than the pubic peduncle.
159. Reversal to a bluntly rounded postacetabular process of the ilium.
190. Loss of ossified distal tarsals.
191. Medial end of the astragalus much shallower than lateral end, creating a wedge shaped astragalus.
192. Caudomedial margin of the astragalus rounded and not forming a corner.
194. Loss of fossa with vascular foramina at the base of the ascending process of the astragalus.

Isanosaurus + (Kotasaurus + (Vulcanodon + *Eusauropoda*))

Unambiguous synapomorphies

81. Reversal to the presence of ventral keels on the cervical vertebrae.
86. Opisthocoelous cervical centra.
90. Dorsal centra with deep fossae on their lateral surfaces that approach the midline.
98. Dorsal vertebrae with supradiapophyseal laminae.
174. Columnar femur (longitudinal axis is straight).
177. Fourth trochanter is a low rugose ridge.

Synapomorphies with DELTRAN

112. Longitudinal ridge on the dorsal surface of the sternal plate.

182. Reversal to a fourth trochanter with a symmetrical and rounded profile.

Synapomorphies with ACCTRAN

95. First two dorsal centra are opisthocoelous.
107. Caudal vertebrae with a hyposphenal ridge.
114. Reversal to a minimum width of scapular blade less than 20% of its length.
126. Loss of olecranon process of the ulna.
128. Length of the radius greater than 80% of the humerus.
129. Flat caudal margin of the distal radius.
133. Reversal to the proximal end of metacarpal I lying flush with the other metacarpals.
137. Reversal to a metacarpal I where the proximal width is less than 80% of the length.
142. Reversal to the absence of ventrolateral twisting between the proximal and distal ends of manual phalanx I.1.
171. Minimum transverse width across the pubic apron is less than 40% of the width across the iliac peduncles.
176. Reversal to a low, ridge-like lesser trochanter.
188. A triangular rugose area on the medial side of the fibula.
200. Reversal to a straight lateral margin of the proximal surface of metatarsal II.
210. Pedal digit V robust and weight bearing.

Kotasaurus + (Vulcanodon + *Eusauropoda*)

Unambiguous synapomorphies

94. Spinoprezygapophyseal laminae well-developed on most dorsal vertebrae.
212. Adult femur length greater than 1 m.

Synapomorphies with DELTRAN

71. Tooth crowns with lingual concavities.
72. Longitudinal labial grooves on tooth crowns.
82. Reversal to well-developed lamination of cervical neural arches 4 to 8, including diapophyseal-postzygapophyseal laminae.
95. First two dorsal centra are opisthocoelous.
107. Caudal vertebrae with a hyposphenal ridge.
148. Cranial end of the preacetabular process of the ilium projects further forward than the pubic peduncle.
158. Ischial peduncle of the ilium much shorter than the pubic peduncle.
159. Reversal to a bluntly rounded postacetabular process of the ilium.
162. Ischium longer than the pubis.
172. Craniocaudal length of the distal pubic expansion is greater than 15% of the length of the pubis.
188. A triangular rugose area on the medial side of the fibula.
192. Caudomedial margin of the astragalus rounded and not forming a corner.
194. Loss of fossa with vascular foramina at the base of the ascending process of the astragalus.
203. Length of pedal ungual II less than 90% of the length of pedal ungual I.
207. Pedal ungual III less than 85% of pedal ungual II in all linear dimensions.

Vulcanodon + *Eusauropoda*

Unambigupous synapomorphies

116. Caudal margin of the acromion process of the scapula rises from the blade at an angle greater than 65º.
120. Deltopectoral crest is a low rounded ridge.
184. Length of the tibia is less than 60% of the femur
206. Pedal ungual I with flattened sides and a narrow ventral surface.

Synapomorphies with DELTRAN
126. Loss of olecranon process on ulna.
129. Flat caudal margin of the distal radius.
165. Transverse width of the ischial shaft greater than its depth.
171. Minimum transverse width across the pubic apron is less than 40% of the width across the iliac peduncles.
190. Loss of ossified distal tarsals.
200. Reversal to a straight lateral margin of the proximal surface of metatarsal II.
202. Transverse width of the proximal end of metatarsal V is greater than half its length.
204. Length of pedal ungual I greater than metatarsal I.
209. Pedal digit V bears phalanges.
210. Pedal digit V robust and weight bearing.
Synapomorphies with ACCTRAN
76. Dorsal excavation of the cervical parapophyses.
92. Broad, triangular cross-sections of the dorsal neural spines.
96. Excavation of the cranial face of the dorsal neural arches.
147. Strongly convex dorsal margin of the ilium.
151. Postacetabular process of the ilium less than 30% of the total length of the ilium.
152. Depth of the preacetabular blade of the ilium subequal to the depth of the ilium above the acetabulum.
181. Fourth trochanter placed halfway along the length of the femur.

Eusauropoda
Unambiguous synapomorphies
168. Width of conjoined pubes greater than 75% of their length.
170. Pubic blades twisted caudomedially.
178. Loss of lesser trochanter.
189. Tubercle on the lateral side of the fibula shaft.
197. Length of metatarsal III less than 30% of tibia.
201. Reversal to a metatarsal IV where the transverse width of the proximal end is less than twice the craniocaudal depth of the proximal end.
Synapomorphies with DELTRAN
2. Length of pedal ungual I greater than metatarsal I.
4. Loss of caudolateral process of premaxilla.
6. Caudolateral process of premaxilla widely separated from the rostroventral process of the nasal by a broad exposure of the maxilla in the narial margin.
8. Naris retracted so that the dorsal margin is level with that of the orbit.
9. Profile of the premaxilla with an inflection at the base of the dorsal process.
12. Reversal to a rostral ramus of the maxilla is deeper than it is long.
16. Loss of antorbital fossa.
20. Loss of dorsal exposure of the lacrimal.
25. Reversal to a blunt rostral end of the jugal.
31. Reversal to a broad quadratojugal ramus of the squamosal (basal width greater than 25% of its length).
32. Loss of squamosal-quadratojugal contact.
34. Jugal ramus of the quadratojugal longer than the squamosal ramus.
35. Rostral end of the jugal ramus of the quadratojugal is dorsoventrally expanded.
36. Loss of caudoventral, heel-like process of the quadratojugal.
41. Maxillary articulating surface of the palatine at the end of a narrow anterolateral process.
42. Medial process of the pterygoid forming an upturned and pointed hook.

54. Upper jaws broad and U-shaped in ventral view.
59. Dorsoventral expansion of the dentary at its symphyseal end.
63. Procumbent dentary tooth crowns.
67. Tooth-tooth contact upon occlusion.
78. Number of cervical vertebrae increased to twelve or more.
85. Loss of free tip from all postaxial epipophyses (epipophyses are joined to postzygapophyses along their length).
92. Broad, triangular cross-sections of the dorsal neural spines.
97. Suprapostzygapophyseal laminae on all dorsal vertebrae.
117. Reversal to the absence of a flat caudoventrally-facing surface on the coracoid, in front of the glenoid.
118. Loss of the coracoid tubercle.
133. Reversal to the proximal end of metacarpal I lying flush with the other metacarpals.
140. Metacarpal V greater than 75% of the length of metacarpal III.
142. Reversal to the absence of ventrolateral twisting between the proximal and distal ends of manual phalanx I.1.
143. Manual digit I longer than manual digit II.
144. Loss of manual ungual II.
145. Non-terminal manual phalanges wider than long.
147. Strongly convex dorsal margin of the ilium.
151. Postacetabular process of the ilium less than 30% of the total length of the ilium.
152. Depth of the preacetabular blade of the ilium subequal to the depth of the ilium above the acetabulum.
208. Fewer than four phalanges in pedal digit IV.

Synapomorphies with ACCTRAN

108. Ventrally slit midcaudal chevrons.
128. Reversal to a radius that is less than 80% of the length of the humerus.
183. Reversal to a fourth trochanter that is placed away from the medial margin of the femoral shaft in caudal view.
191. Reversal to an astragalus with the depth of the lateral side roughly equal to that of the medial side (astragalus not wedge shaped).

Barapasaurus + (Omeisaurus + *Neosauropoda*)

Unambiguous synapomorphies

79. Length of the third cervical centrum is greater than 2.5 times the height of the cranial face
91. Reversal to the presence of diapo-prezygapophyseal laminae in all dorsal vertebrae.
93. Composite lateral spinal laminae on the dorsal neural spines.
211. Pedal unguals deflected laterally.

Synapomorphies with DELTRAN

96. Excavation of the cranial face of the dorsal neural arches.
181. Fourth trochanter placed halfway along the length of the femur.

Synapomorphies with ACCTRAN

15. Neurovasular foramina irregularly arranged on the lateral surface of the maxilla.
24. Jugal contribution to the margin of the antorbital fenestra.
30. Transverse long axis of the supratemporal fenestra.
136. Reversal to a metacarpal I with a proximal width that is less than that of metacarpal II.
137. Reversal to a metacarpal I with a proximal width that is less than 65% of its length.
205. Metatarsals III and IV with shaft diameters that are less than 60% of the shaft diameter of metatarsal II.

Omeisaurus + *Neosauropoda*

Unambiguous synapomorphies

90. Invasive, sharp-rimmed fossae (pleurocoels) on the lateral surface of the dorsal centra.
95. Cranial half of dorsal column with opisthocoelous vertebrae.
102. Two dorsosacral vertebrae in the sacrum.
113. Craniocaudal length of the acromion process of the scapula greater than 1.5 times the minimum width of the scapula blade.

Synapomorphies with DELTRAN

15. Neurovasular foramina irregularly arranged on the lateral surface of the maxilla.
17. Reversal to the absence of a dorsally open neurovascular canal on the floor of the antorbital fossa.
29. Loss of frontal contribution to the supratemporal fenestra.
30. Transverse long axis of the supratemporal fenestra.
65. Reversal to less than 18 dentary teeth in adults.
76. Dorsal excavation of the cervical parapophyses.
136. Reversal to a metacarpal I with a proximal width that is less than that of metacarpal II.
137. Reversal to a metacarpal I with a proximal width that is less than 65% of its length.
205. Metatarsals III and IV with shaft diameters that are less than 60% of the shaft diameter of metatarsal II.