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Electronic Appendix A. Phylogenetic Nomenclature

Given current variation in the meaning (content, definition) of several higher-level taxa used in this report, the phylogenetic definitions for key taxa are given below (for discussion see Wilson *et al.* 2003):

Neotheropoda, the least inclusive clade including *Coelophysis* and Neornithes (i.e., crown-group birds).

Coelophysoidea, the most inclusive clade including *Coelophysis bauri* but not Neornithes.

Ceratosauria, the most inclusive clade including *Ceratosaurus nasicornis* but not Neornithes.

Abelisauroidea, the least inclusive clade including *Carnotaurus sastrei* and *Noasaurus leali*.

Noosauridae, the most inclusive clade including *Noasaurus leali* but not *Carnotaurus sastrei*.

Abelisauridae, the most inclusive clade including *Carnotaurus sastrei* but not *Noasaurus leali*.

Carnosaurinae, the most inclusive clade including *Carnotaurus sastrei* but not *Abelisaurus comahuensis*.

Electronic Appendix B. Phylogenetic Analysis

The phylogenetic analysis shown in Fig. 4 is based on 169 characters (66 cranial, 5 dental, 36 axial, 62 appendicular) scored for 21 ingroups, using *Herrerasaurus ischigualastensis* and *Eoraptor lunensis* as successive outgroups. Maximum-parsimony analysis (Swofford 1999) yielded two minimum-length tree of 205 steps, with the poorly known genera *Genusaurus* and *Ilokelesia* removed (CI = 0.86; RI = 0.93). The temporally-calibrated phylogeny uses a recent time scale (Gradstein *et al.* 1999).

Character List

The codings for the 169 characters (66 cranial, 5 dental, 36 axial, 62 appendicular) used in the analysis are listed below. There are 6 multistate characters, 5 of which were ordered (47, 78, 83, 84, 91). The first cladistic use of each character appears in parentheses after the character. Characters with no citation are new to this analysis or are so modified from previous usage that attribution to a previous author may not constitute an accurate reference.

1. Skull length: less (0), or more (1), than 3 times posterior skull height. (Sereno 1999)
2. Skull, general external texture: smooth (0); sculptured (1). (Sampson *et al.* 1998)
3. Skull roof (frontal, nasal, lacrimal, postorbital), thickness: platelike (0); considerably thickened (1). (Novas 1997)
4. Premaxilla, shape ventral to external naris: longer than deep (0); deeper than long (1). (Holtz 1994)

5. Premaxilla, medial premaxillary foramen: absent (0); present (1).
6. Premaxilla posterolateral process, length: 2-3 times (0), or subequal to (1), transverse width at midlength. (modified from Carrano *et al.* 2002)
7. Premaxilla posterolateral process, form of articulation with maxilla: overlapping maxillary edge or anteromedial process (0); inserting into narrow slot between maxillary edge and anteromedial process (1). (modified from Carrano *et al.* 2002)
8. Premaxilla, palatal process: present (0); absent (1).
9. Premaxilla-maxilla arched diastema: absent (0); present (1). (Rowe 1989)
10. Premaxilla-maxilla alveolar suture (portion of contact below premaxillary posterolateral process): present (0); absent (1). (Sereno 1999)
11. Premaxilla-maxilla suture, form of upper portion (immediately ventral to the premaxillary posterolateral process): butt joint (0); separated by pneumatic spaces (1).
12. Premaxilla-nasal suture, form: V-shaped (0); W-shaped (1).
13. Maxilla, promaxillary fenestra and antrum: absent (0); present (1).
14. Maxilla, position of principal row of labial neurovascular foramina: displaced dorsal to (0), or immediately above (1), the alveolar margin.
15. Maxilla, position of articular facet for distal end of anteroventral process of nasal: anterior or slightly anterolateral (0); lateral (1).
16. Maxilla, form of articular surface for nasal anteroventral process, and form of nasal anteroventral process: shallow facet, tapered anteroventral process (0); trough with terminal pit, blunt-tipped anteroventral process (1).
17. Maxilla, contact with ventral process of lacrimal: present (0); absent (1). (modified from Coria & Salgado 2000)
18. Maxilla, form of articular surface for jugal posteroventral to antorbital fossa: partially (0), or entirely (1), laterally facing.
19. Maxilla, articular surface for jugal, width: 15% or less (0), or 25% or more (1), of the length of the suture. (modified from Sampson *et al.* 1998)
20. Lacrimal canal, position of anterior (internal) foramen: at midlength (0), or at proximal base (1), of ventral process.
21. Lacrimal canal, position of posterior (external) foramen: at midlength (0), or at proximal base (1), of ventral process.
22. Lacrimal antorbital pneumatic recess (into central body of lacrimal): absent (0); present (1). (Novas 1992)
23. Lacrimal antorbital pneumatic recess, orientation: laterally partially exposed (0); laterally covered (by rim of fossa) (1).
24. Lacrimal-postorbital contact: absent (0); present (1). (Novas 1992)
25. Lacrimal brow, form: horizontal shelf (0); ventrolaterally beveled surface (1).
26. Lacrimal-jugal articulation, form: jugal overlaps lacrimal (0); jugal overlaps lacrimal and inserts into a slot in lacrimal near orbital margin (1). (modified from Sereno *et al.* 1994)
27. Lacrimal ventral process, shape of distal end: flange-shaped, broadening distally (0); subtriangular, tapering distally (1). (modified from Sereno 1999)
28. Nasal, form of narial margin (lateral view): asymmetrical U-shape (0); symmetrical C-shape (1).
29. Nasal-nasal suture, form: open (0); fused anteriorly (1). (Forster 1999; Sereno 1999)
30. Nasal posterolateral process: absent (0); present (1). (Sereno 1999)

31. Nasal posterior process, position of distal end: offset lateral (0), or adjacent (1), to the midline.
32. Nasal posterior process, anteroposterior position of distal end: anterior (0), or dorsal (1), to the orbit.
33. Jugal, antorbital pneumatic recess (anterior ramus): present (0); absent (1).
34. Antorbital fossa, size (anteroposterior diameter): greater than anteroposterior diameter (0), or any diameter (1), of other skull openings. (modified from Rowe 1989)
35. Antorbital fossa, position of anterior end: posterior (0), or ventral (1), to posterior end of external naris. (Sereno 1999)
36. Antorbital fossa on ventral ramus of maxilla: present (0); absent (1). (modified from Lamanna *et al.* 2002)
37. Antorbital fossa, form of ventral margin on maxilla: rounded edge (0); raised, rounded rim (1). (modified from Rowe 1989)
38. Antorbital fossa, external rim on anterior process of lacrimal: present (0); absent (1).
39. Antorbital fossa on ventral ramus of lacrimal: present (0); absent (1).
40. Postorbital orbital process, shape and dorsoventral position: rounded, posterodorsal orbital margin (0); triangular flange, posterior orbital margin (1).
41. Postorbital orbital process, continuity: continuous with (0), or inset from (1), remainder of ventral ramus. (modified from Sampson *et al.* 1998)
42. Postorbital posterior process, shape: elongate (0), or equilateral (1), triangle.
43. Squamosal anterior process, form of postorbital articulation: tongue-and-groove (0); squamous (1).
44. Squamosal anterior process, orientation (lateral view): anterior (0); anterodorsal (1). (Sereno 1999)
45. Supratemporal fossa, postorbital participation: present (0); absent (1). (Sereno 1999)
46. Frontal-parietal suture, form: open (0); fused (1). (Forster 1999; Sereno 1999)
47. Frontal-parietal skull table, shape (dorsal view): hourglass (0); subtriangular (1); frontal triangle with parietal sagittal crest (2) (ordered).
48. Frontal horn(s): absent (0); present (1). (modified from Novas 1997)
49. Parietal posteromedian process (capping nuchal wedge): absent or rudimentary (0); present and thickened (1).
50. Parietal alae, orientation: posterolateral (0); lateral (1).
51. Quadrate lateral flange, maximum width: approximately 50 % of (0), or subequal to (1), transverse width of distal condyles. (modified from Forster 1999)
52. Quadrate foramen, position: mid height (opening anteriorly) (0), or closer to quadrate head (opening posterodorsally) (1). (modified from Holtz 2000)
53. Quadrate distal condyles, flattened or slightly concave anterior facet: absent (0); present (1).
54. Palatine anterior process, shape: tapered distally (0); expanded distally (1). (Sereno 1999)
55. Supraoccipital nuchal wedge, position: anterior (0), or posterior (1), to occipital condyle.
56. Supraoccipital nuchal wedge, length from foramen magnum to summit: subequal to (0), or more than twice (1), vertical diameter of the occipital condyle. (modified from Forster 1999)

57. Supraoccipital nuchal wedge and parietal alae, position of dorsal extremity: slightly (0), or considerably (1), above frontoparietal skull table. (modified from Sampson *et al.* 1998)
58. Exoccipital-opisthotic, participation in basal tubera: absent (0); present (1). (Sereno 1999)
59. Laterosphenoid head, location of articular socket: split between the frontal and postorbital (0); postorbital only (1). (Sereno 1999)
60. Basisphenoid fontanelle: absent (0); present (1). (Forster 1999; Sereno 1999)
61. External mandibular fenestra, position of anterior end: posterior (0), or ventral (1), to last dentary tooth. (Sereno 1999)
62. Dentary anterior end, shape: rounded (0); expanded dorsoventrally (1). (Forster 1999; Sereno 1999)
63. Dentary-surangular articulation, form: narrow V-shaped notch (0); broad U-shaped socket (1). (modified from Carrano *et al.* 2002)
64. Dentary, medial articular prong for surangular (separate from dorsal prong that is exposed laterally): absent (0); present (1).
65. Dentary posteroventral process, length: long (0); short (1), extending only as far posteriorly as the dentary posterodorsal process. (Sereno 1999)
66. Prearticular-angular foramen: absent (0); present (1). (Sereno 1999)
67. Premaxillary tooth row, position of posterior end: ventral (0), or anterior (1), to the external naris. (Sereno 1999)
68. Maxillary tooth row, position of posterior end: ventral (0), or anterior (1), to the ventral ramus of the lacrimal. (modified from Gauthier 1986)
69. Crown height (largest maxillary crowns): 20-30% (0), or 10-15% (1), of height of snout at midlength. (modified from Martinez *et al.* 1993)
70. Tooth rows, transverse curvature: minor (0); marked (1). (Sereno 1999)
71. Dentary tooth 3, size: subequal (0), or enlarged (1), relative to dentary tooth 2. (Sereno 1999)
72. Axial intercentrum length: 25-35% (0), or 40-70% (1), axial centrum length. (Sereno 1999)
73. Axial anterior pleurocoel: absent (0); present (1). (Rowe 1989)
74. Axial neural canal, vertical diameter: more (0), or less (1), than 30% vertical diameter of centrum. (Sereno 1999)
75. Axial spinopostzygapophyseal lamina, form: straight or gently concave (0); deeply notched (1). (modified from Gauthier 1986)
76. Axial prezygapophyses, form: raised facet (0); anteriorly-projecting shelf (1). (modified from Sereno 1999)
77. Axial transverse process, size: rounded prominence (0); cylindrical process (1). (modified from Sereno 1999)
78. Mid cervical (C3-C6) centrum length: less than 3 (0), 3 (1), or more than 4 (2), times centrum height (ordered). (Sereno 1999)
79. Postatlantal cervical centra, form of articular surfaces: amphicoelous (0); marked opisthocoely (1). (Sereno 1999)
80. Postaxial cervical centra, pleurocoel (anterior): absent (0); present (1). (Rowe 1989)
81. Postaxial presacral vertebrae, posterior pleurocoel: absent (0); present (1). (Sereno *et al.* 1994)

82. Postaxial presacral vertebrae, posterior pleurocoel, form: open fossa (0); partially sharp-rimmed and invaginated (1).
83. Cervical epiphyseal-prezygapophyseal ridge/lamina, form and distribution: absent (0); rounded ridge in mid cervicals C4-C6 (1); prominent crest or lamina in all postaxial cervicals (2) (ordered). (modified from Coria & Salgado 2000)
84. Cervical epiphyses, form: ridgelike or subconical if extended (0); mid cervical epiphyses anteroposteriorly extended with anterior corner (1); all anteroposteriorly extended (2) (ordered). (modified from Bonaparte *et al.* 1990)
85. Cervical epiphyses, height (dorsoventral distance from edge of postzygapophyseal facet): less (0), or more (1), than 50% of height of the posterior centrum face. (modified from Novas 1997)
86. Postatlantal cervical vertebrae, pneumatic fossa on neural arch ventral to postzygapophysis: absent (0); present (1).
87. Mid cervical (C4-6) neural spines, orientation: vertical (0); posterodorsally inclined (1).
88. Dorsal centrum length: subequal to (0), or more than 2.5 times (1), centrum height. (Sereno 1999)
89. Mid dorsal parapophyses, form: short process (0); process with cylindrical shaft (1).
90. Posterior dorsal parapophyses, position: anteroventral to diapophysis and ventral to prezygodiapophyseal lamina (0); anterior to diapophysis and joined with prezygodiapophyseal lamina (1).
91. Sacral number: 3 (primordial sacral pair, 1 dorsosacral) (0); 5 (primordial sacral pair, 1 dorsosacral, 2 caudosacrals) (1); 6 (primordial sacral pair, 2 dorsosacrals, 2 caudosacrals) (2) (ordered). (modified from Bonaparte 1991)
92. Sacrum shape, dorsal view: subrectangular (0); subtriangular (1). (Sereno 1999)
93. Mid sacral centra, ventral margin: horizontal (0); dorsally arched (1). (Sereno 1999)
94. Mid sacral centra, transverse dimensions: similar to adjacent sacrals (0); strongly constricted (1). (Sereno 1999)
95. Sacral transverse processes, relations: separate (0); fused (1). (Rowe 1989)
96. Sacral neural spines, relations: separate (0); fused (1). (Rowe 1989)
97. Sacral neural arches, development of paramedian fossae: poorly developed (0); divided by vertical septa (1).
98. Anterior caudal transverse processes, form: subrectangular or distally tapering (0); distally expanding (1). (Coria & Salgado 2000)
99. Anterior caudal neural spines, anterior flange for interspinous articulation: absent (0); present (1). (Sereno 1999)
100. Distal caudal centrum length: 3 to 4 (0), or approximately 7 (1), times centrum height. (Sereno 1999)
101. Distal caudal prezygapophyses, maximum length: at least 30% or less (0), or at least 40% (1), overlap of preceding centrum. (Sereno 1999)
102. Cervical ribs, pneumatic recesses near rib articular processes: absent (0); present (1). (Sampson *et al.* 1998)
103. Mid cervical (C4-8) ribs, lateral process for articulation with successive rib spine: absent (0); present (1).
104. Mid cervical (C4-8) ribs, form of lateral process for articulation with successive rib spine: ridge (0); flange (1).

105. Caudosacral ribs, attachment position: ventral margin (0), or angled toward posterodorsal corner (1), of postacetabular process. (Sereno 1999)
106. Chevron base, paired anterior and posterior processes: absent (0); present (1). (Sereno *et al.* 1994)
107. Anterior chevrons, midshaft shape: transversely flattened (0); rod-shaped (1).
108. Scapular glenoid, shape: approximately twice as long as (0), or subequal to (1), its transverse width.
109. Coracoid posterior process, shape: hook-shaped (0); rounded corner (1). (Sereno *et al.* 1996)
110. Humeral head, shape and size: subcylindrical, approximately 50% of maximum width of proximal end (0); subspherical, approximately 70% or more of maximum width of the proximal end (1). (modified from Coria *et al.* 2000)
111. Humeral lateral tuberosity, position: proximal (0), or distal (1), to medial tuberosity.
112. Humeral deltopectoral crest, size (measured from the anterior margin of midshaft): subequal to (0), or less than (1), anteroposterior shaft diameter at midshaft. (modified from Carrano *et al.* 2002)
113. Humeral shaft axis, form: sigmoid (0); straight (1). (Holtz 1994)
114. Humeral distal condyles, form: convex, rounded anteriorly (0); nearly flat (1). (Carrano *et al.* 2002)
115. Distal carpal 1, distal articulation: metacarpal I (0); metacarpals I and II (1). (Gauthier 1986)
116. Manual digits and metacarpals, longest: digit III, metacarpal III (0); digit II, metacarpal II (1). (Sereno 1999)
117. Metacarpal I length: longer (0), or shorter (1), than phalanx 1 or ungual of digit I. (Sereno 1999)
118. Metacarpal III, mid shaft transverse diameter, and III-ungual length: subequal to digit II (0); diameter 55% or less metacarpal II, ungual length less than 70% II-ungual (1). (modified from Sereno *et al.* 1994)
119. Manual digit V: present (0); absent (1). (Gauthier 1986)
120. Pelvic girdle sutures, form: open (0); fused (1). (Rowe 1989)
121. Iliac length: shorter (0), or longer (1), than femoral length. (modified from Novas 1991)
122. Iliac supracetabular crest, form: shelf-like with straight edge in lateral view (0); pendant with convex margin in lateral view (1). (Gauthier 1986)
123. Iliac preacetabular process, position of anteroventral corner: anteroventral extremity of process (0); proximal to the anterior margin of the process (1).
124. Iliac postacetabular process, form of posterior margin: convex (0); concave (1). (Sereno 1999)
125. Iliac postacetabular process, form of lateral attachment scar: subtle (0); pronounced scar (1). (Sereno 1999)
126. Iliac pubic peduncle, orientation of distal articular end: approximately 45° (0), or 60° (1), from the horizontal. (modified from Sereno 1999)
127. Iliac pubic peduncle, anterodorsal margin: present (0); rudimentary or absent (1).
128. Iliopubic contact, form: butt joint (0); peg-in-socket (1). (Sampson *et al.* 2001)
129. Ilioschial contact, form: butt joint (0); peg-in-socket (1).
130. Ilioschial articulation, width of distal end: subequal to (0), or smaller than (1), iliac-pubic articulation (1). (Sereno *et al.* 1994)

131. Pubic fenestra: absent (0); present (1). (Rowe 1989)
132. Pubic shaft axis, form: straight (0); bowed anteriorly (1). (Rowe 1989)
133. Pubic shaft, distal half, transverse width of blade-shaped medial portion: subequal to (0), or twice the width of (1), rod-shaped lateral portion. (Sereno 1999)
134. Pubic foot: present (0); absent (1). (Holtz 1994)
135. Pubic foot, symphyseal area: absent or restricted to distal margin (0); broad median contact (1). (Sereno 1999)
136. Pubic foot, anteroposterior length: longer (0), or shorter (1), than ischial foot. (Sereno 1999)
137. Ischial antitrochanter, form of nonarticular acetabular margin: concave (0); concave so as to undercut the antitrochanter (1).
138. Ischial antitrochanter, size: less (0), or subequal to or greater (1), than adjacent articular surface for ilium. (Sereno 1999)
139. Ischial obturator notch (or foramen): absent (0); present (1). (Sereno *et al.* 1994)
140. Ischial shaft, cross-sectional shape (paired): broad contact, rod-like (0); separated dorsally, V-shaped. (Sereno 1999)
141. Ischial foot: absent (0); present (1). (Bonaparte *et al.* 1990)
142. Femoral anterior trochanter, form: sigmoid (0); blade-shaped (1). (Sereno *et al.* 1994)
143. Femoral anterior trochanter, dimorphism: absent (0); present (1). (Rowe 1989)
144. Tibial cnemial crest, width (lateral view): tapers distally, or less than 50% of proximal end (0); expands distally, or more than 50% of proximal end (1), distally. (cnemial crest measured from anterior margin of shaft)
145. Tibial cnemial crest, lateral fossa: absent (0); present (1).
146. Tibial proximal end, tibiofibular crest: absent (0); present (1). (Forster 1999; Sereno 1999)
147. Tibial midshaft proportions, transverse versus anteroposterior: subequal (0); transverse width 135-150% of anteroposterior width (1). (Sereno 1999)
148. Tibiofibular shaft contact distal to tibiofibular crest: absent (0); present (1).
149. Tibial crest (distal to tibiofibular crest) with flattened articular edge for fibular shaft: absent (0); present (1). (Martinez *et al.* 1986)
150. Tibial distal end, lateral extension of posterolateral flange (= calcaneum, posterior articular facet for tibial posterolateral flange): partially (0), or nearly completely (1), backs the distal end of fibula and calcaneum. (modified from Sereno *et al.* 1994)
151. Fibular fossa: absent (0); present (1). (Rowe 1989)
152. Fibular fossa, form: oval, opens medially (0); crescentic, invaginated anteriorly, opens posteromedially (1).
153. Fibular shaft ventral to tibiofibular crest, position relative to tibial shaft: lateral (0); anterior (1).
154. Fibular midshaft, anteroposterior width: 40% (0), or 10-25% (1), of anteroposterior width of the proximal end. (Sereno 1999)
155. Astragalar ascending process, thickness: wedge-shaped, dorsal margin inserting into tibia (0); low plate, 3-4 times taller than thick anteroposteriorly at midpoint (1); tall plate, more than 5 times taller than thick at midpoint (2). (modified from Gauthier 1986)
156. Astragalar posterolateral crest (ascending process to posterolateral corner): absent (0); present (1). (Sereno 1999)

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