SUPPLEMENTARY INFORMATION AND FIGURES FOR SMITH ET AL. 2008 "A *Megaraptor*-like theropod (Dinosauria: Tetanurae) in Australia; support for faunal exchange across eastern and western Gondwana in the mid-Cretaceous".

S1. INSTITUTIONAL ABBREVIATIONS

BMNH, British Museum of Natural History, London, UK; **FMNH**, The Field Museum of Natural History; **MB**, Museum für Naturkunde der Humboldt Universität, Berlin, Germany; **MCF-PVPH**, Museo Carmen Funes, Paleontología Vertebrados, Plaza Huincul, Argentina; **MNN**, Musée National du Niger, Niamey, Niger; **MUCPv**, Museo de la Universidad Nacional del Comahue, Neuquén, Argentina; **NMV**, Museum Victoria, Melbourne, Australia; **PVL**, Fundacíon Miguel Lillo, Tucumán, Argentina; **UCMP**, University of California Museum of Paleontology, Berkeley, USA; **UCRC**, University of Chicago Research Collection, Chicago, USA; **UNPSJB-PV**, Universidad Nacional de la Patagonia San Juan Bosco, Comodoro Rivadavia, Argentina; **YPM**, Yale Peabody Museum, New Haven, USA.

Figure *S2*. Location of Dinosaur Cove, and outcrop of the Late Jurassic–Early Cretaceous Otway Group (dark shaded area) in southeastern Australia.

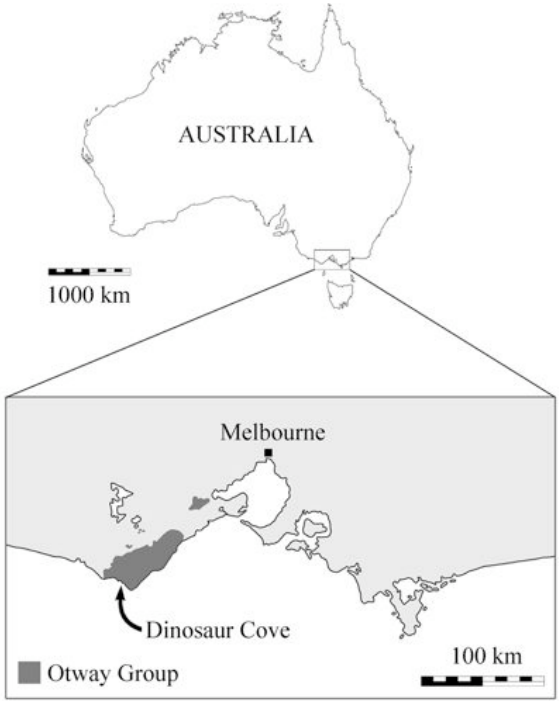


Figure *S3*. Left theropod ulnae in proximal aspect. (*a*) *Liliensternus liliensterni*, MB R. 2175); (*b*) *Poekilopleuron bucklandii*, YPM 4839, cast of holotype destroyed during World War II; (*c*) *Allosaurus fragilis*, YPM 4944; (*d*) *Suchomimus tenerensis*, MNN GAD 500; (*e*), cf. *Megaraptor*, NMV P186076; (*f*) *Megaraptor namunhuaiquii*, MCF-PVPH 79, right ulna reversed for comparison; (*g*) *Megaraptor namunhuaiquii*, MUCPv 341, right ulna reversed for comparison. Anatomical abbreviations: **proc ol**, olecranon process, **tub lat**, lateral tuberosity. Specimens shown are not to scale.

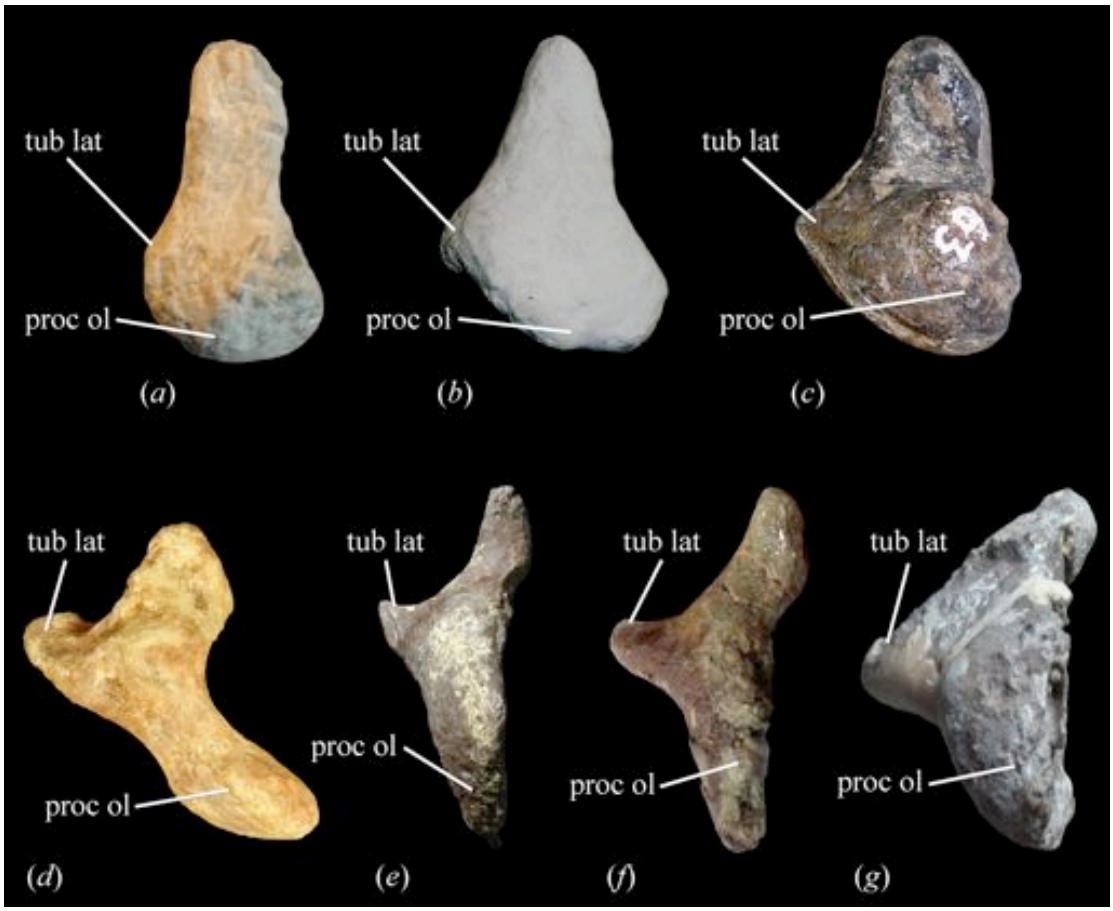


Figure *S4*. Right theropod ulnae in lateral aspect. (*a*) *Suchomimus tenerensis*, MNN GAD 500; (*b*) *Allosaurus fragilis*, YPM 4944, left ulna reversed for comparison; (*c*) *Megaraptor namunhuaiquii*, MUCPv 341; (*d*), cf. *Megaraptor*, NMV P186076, left ulna reversed for comparison; (*e*) *Megaraptor namunhuaiquii*, MCF-PVPH 79; (*f*) *Megaraptor namunhuaiquii*, interpretive drawing of MCF-PVPH 79. Anatomical abbreviations: **cr caud**, caudal crest; **cr lat**, lateral crest; **fac art hu**, humeral articular facet; **fac art rad dist**, distal radial articular surface; **proc corn**, coronoid process; **proc ol**, olecranon process, **tub lat**, lateral tuberosity. Scale bars equal 50 mm.

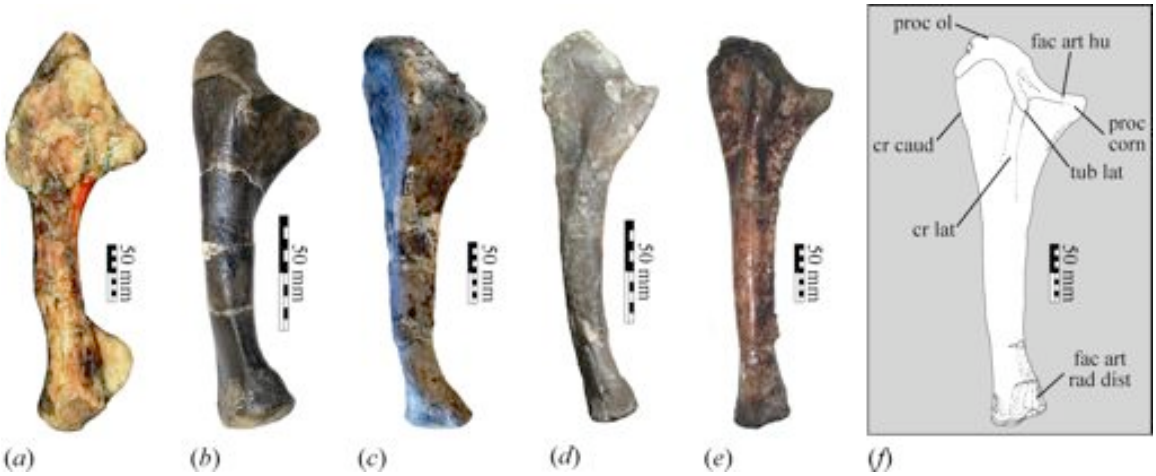
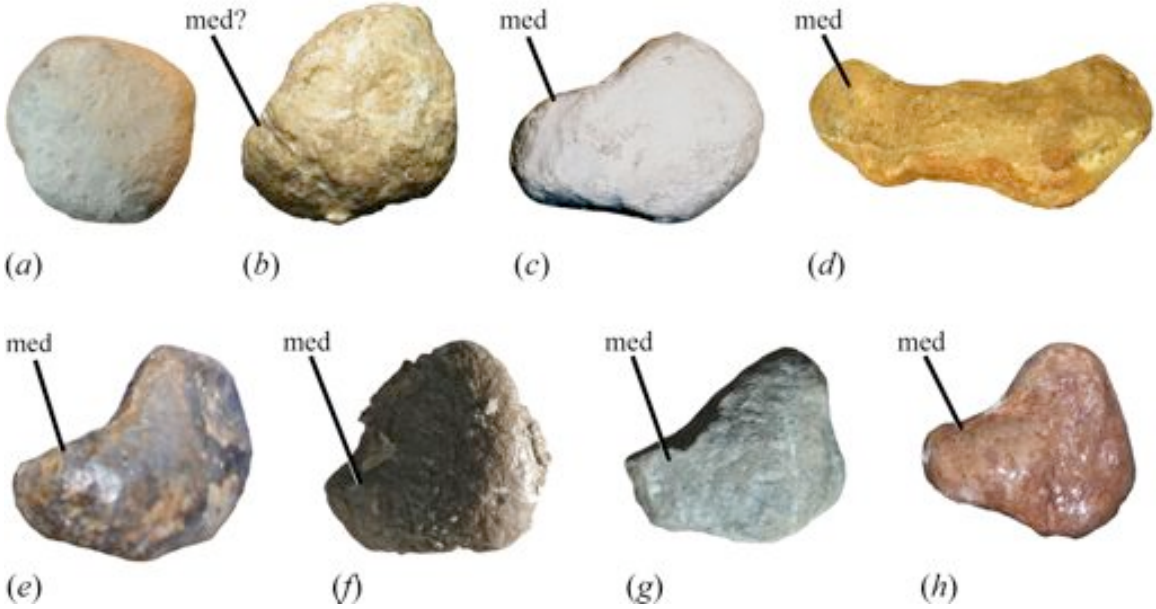


Figure *S5.* Left theropod ulnae in distal aspect. (*a*) *Liliensternus liliensterni*, MB R. 2175; (*b*), *Piatnitzkysaurus floresi*, PVL 4073; (*c*) *Poekilopleuron bucklandii*, YPM 4839, cast of holotype destroyed during World War II; (*d*) *Suchomimus tenerensis*, MNN GAD 500, right ulna reversed for comparison; (*e*) *Allosaurus fragilis*, YPM 4944; (*f*) cf. *Megaraptor*, NMV P186076; (*g*) *Megaraptor namunhuaiquii*, MUCPv 341; (*h*) *Megaraptor namunhuaiquii*, MCF-PVPH 79, right ulna reversed for comparison. Cranial is to the top of the page, medial is to the left. Anatomical abbreviations: **med**, medial expansion of distal ulna. Specimens shown are not to scale.



S6. EMENDED SYSTEMATIC PALAEONTOLOGY

(a) Systematic Palaeontology

Dinosauria (Owen 1842)

Theropoda (Marsh 1881)

Tetanurae (Gauthier 1986)

Megaraptor (Novas 1998)

(b) *Type Species and Holotype*

Megaraptor namunhuaiquii Novas 1998, MCF-PVPH 79, right ulna, left manual phalanx I-1, ungual phalanx of manual digit I, distal half of right metatarsal III (Novas 1998).

(c) *Referred Material*

Megaraptor namunhuaiquii–MUCPv 341, a fragmentary postcranial skeleton (Calvo *et al*. 2004). *Megaraptor namunhuaiquii*–MUCPv 412, the distal portion of a right ulna (Porfiri et al. 2007). *Megaraptor namunhuaiquii*–MUCPv 413, the proximal portion of a right manual phalanx I-1 (Porfiri et al. 2007). *Megaraptor* sp.–UNPSJB-PV 944, a fragmentary postcranial skeleton (Lamanna 2004). *Megaraptor* sp.–UNPSJB-PV 958, a fragmentary postcranial skeleton (Lamanna 2004). Cf. *Megaraptor*–NMV P186076, an isolated left ulna (this paper).

(d) *Locality and Horizon*

MCF-PVPH 79–Sierra del Portezuelo, Neuquén Province, Argentina, Portezuelo Formation (Late Turonian–Early Coniacian), of the Nequén Group (Albian–Campanian). MUCPv 341, 412, 413–Los Barreales lake, Neuquén Province, Argentina, Portezuelo Formation (fate Turonian–early Coniacian), of the Nequén Group (Albian–Campanian). UNPSJB-PV 944, 958–Estancia Viento Fuerte, south central Chubut Province, Argentina, Upper section of the Lower Member of the Bajo

Barreal Formation (middle Cenomanian–Turonian) (Lamanna 2004). NMV P186076–First Cross Tunnel at the 'Slippery Rock' site (see Rich & Vickers-Rich 2000: figure 44), Dinosaur Cove, near Cape Otway, Victoria, Australia (38º 46' 53±1" S, 143º 24' 14±1" E, World Geodetic Standard 1984; figure *S2*), Eumeralla Formation (late Aptian–early Albian; Wagstaff & McEwen-Mason 1989), of the Otway Group of Victoria (Rich & Vickers-Rich 2003).

(e) *Diagnosis*

Megaraptor namunhuaiquii Novas 1998 can be diagnosed by the following autapomorphies: **1)** the presence of a mediolaterally compressed, proximocaudally expanded, blade-like olecranon process on the proximal ulna that extends distally as a caudal olecranon crest; **2)** the presence of a hypertrophied lateral tuberosity that extends distally as a blade-like crest; **3)** a metacarpal II with a transversely expanded and fan-shaped ventral surface at its proximal end; **4)** a manual phalanx I-1 which is sub-quandrangular in proximal aspect, with the dorsal border transversely wider than ventral border; **5)** a metatarsal III with a deep and wide extensor ligament pit; and **6)** a metatarsal IV with a distal extremity that is transversely narrower than its shaft. Characters 1 and 2 may have a broader distribution, depending upon the exact phylogenetic affinities of NMV P186076.

S6. List of characters, character-states, and codings used in phylogenetic analysis. Original citations and/or modifications are provided in parantheses. The abbreviation 'TwiG' is used to denote characters derived or modified from the Theropod Working Group Matrix. Characters 348–353 represent new additions to the character list utilized in Smith et al. (2007).

1. Orbit round in lateral or dorsolateral view (0); or dorsoventrally elongate (1) (TWiG).

2. Skull length relative to femur length: > 0.5 (0); ≤ 0.5 (1) (Benton et al., 2000).

3. Tooth row: extends posteriorly to approximately half the length of the orbit (0); ends at the anterior rim of the orbit (1); completely antorbital, tooth row ends anterior to the vertical strut of the lacrimal (2) (Gauthier, 1986).

4. Infratemporal fenestra: smaller than or subequal in size to orbit (0); strongly enlarged, more than 1.5 times the size of the orbit (1) (Bonaparte, 1991).

5. Height:length ratio of premaxilla below external naris: 0.5-1.25 (0), < 0.5 (1), or > 1.25 (2) (modified from Carrano et al.,2002 and Rauhut, 2003)

6. Premaxillary body in front of external nares: shorter than body below the nares and angle between anterior margin and alveolar margin more than 75 degrees (0); longer than body below the nares and angle less than 70 degrees (1) (Rauhut, 2003).

7. Ventral process at the posterior end of premaxillary body: absent (0); present (1) (Rauhut, 2003).

8. Number of premaxillary teeth: three (0); four (1); five (2); more than five (3); premaxillary teeth absent (4) (Rauhut, 2003).

9. Premaxillary tooth row ends: ventral (0); anterior (1) to naris (Sereno, 1999).

10. Subnarial process of the premaxilla: wide; plate-like, broadly contacting the nasals and excluding the maxilla from the external nares (0); strongly reduced in width, but still contacting the nasals (1); strongly reduced process does not contact the nasals, and the maxilla forms part of the posteroventral border of the external nares (2) (modified from Gauthier, 1986; Rauhut, 2003).

11. Maxillary/palatal process of premaxilla: large flange (0); blunt triangle (1) (Sampson et al., 1998).

12. Foramen on the medial side of the premaxillary body, below the narial margin: absent (0); present (1) (modified from Sereno et al., 2004; Yates, 2005).

13. Slot-shaped foramen on the lateral face of the premaxilla, located at the base of the nasal process: absent (0); present (1) (Yates, 2005).

14. Length of the nasal process of the premaxilla: posterior tip level with the posterior tip of the posterolateral premaxillary process (0); posterior tip extends posterior to the posterior tip of the posterolateral premaxillary process (1) (Yates, 2005).

15. Premaxillary posterodorsal process contributes to a blade-like nasal crest: no (0); yes (1).

16. Premaxilla-nasal suture on internarial bar: V-shaped (0); W-shaped (1) (Sereno et al., 2004).

17. Serrations on premaxillary teeth: present (0); absent (1) (Rauhut, 2003).

18. Premaxillary teeth cross-sections: elliptical (0); subcircular (1); D-shaped in cross-section (modified from Carrano et al., 2002; TWiG; Tykoski & Rowe, 2004; Yates, 2005).

19. Labiolingual symmetery of premaxillary teeth: symmetrical (0); asymmetrical (1); (Bakker et al., 1988).

20. Rostroventral narial fossa: absent or shallow (0); expanded, well-developed fossa on the premaxilla in the rostroventral corner of the naris (1) (modified from Sereno, 1999; Langer & Benton, 2006).

21. Constriction between articulated premaxillae and maxillae: absent (0); present (1). (Rauhut, 2003).

22. Premaxilla and maxilla in contact at alveolar magins (0), or alveolar margins do not contact (1) (Tykoski, 2005).

23. Orientation of the maxillae towards each other in dorsal view: acutely angled (0); subparallel (1) (Harris, 1998).

24. Ascending process of the maxilla: confluent with anterior rim of maxillary body and gently sloping posterodorsally (0); offset from anterior rim of maxillary body, with anterior projection of maxillary body shorter than high (1); offset from anterior rim of maxillary body, with anterior projection of maxillary body as long as high or longer (2) (Sereno et al., 1996).

25. Maxillary antorbital fossa: deep, and with sharp margins (0); shallow, margins formed by low ridges, a sharp rim may be present only in front of the promaxillary foramen (1) (Sues, 1997).

26. Maxillary antorbital fossa in front of the internal antorbital fenestra: 25 percent or less of the length of the external antorbital fenestra (0); more than 40 percent of the length of the external antorbital fenestra (1) (Sereno et al., 1996).

27. Depth of the ventral antorbital fossa: less than or subequal to the depth of the maxilla below the ventral margin of the antorbital fossa (0); or much greater than the depth of the maxilla below the ventral margin of the antorbital fossa (1) (Yates, 2005).

28. Horizontal ridge on the maxilla: absent (0); present (1) (Rowe & Gauthier, 1990).

29. Maxillary fenestra: absent (0); present (1) (Gauthier, 1986).

30. Maxillary fenestra situated at rostral border of antorbital fossa (0); or situated posterior to rostral border of fossa (1) (TWiG).

31. Pneumatic excavation/antrum in maxillary anterior ramus: absent (0); present (1) (Sereno et al., 1994).

32. Promaxillary fenestra: absent (0); present (1) (Carpenter, 1992).

33. Palatal process of maxilla: ridged flange (0); reduced, simple process (1); long, and plate-shaped (2) (modified from Sereno et al., 1998; Carrano et al., 2002).

34. Secondary palate formed by premaxilla only (0); or by premaxilla, maxilla, and vomer (1) (TWiG).

35. Maxillary tooth count: 12-18 (0); $\geq$ 20 (1); < 12 (2) (modified from Carrano et al., 2002; Tykoski, 2005).

36. Maxillary and dentary teeth: serrated (0); some or all without serrations (1) (modified from Chiappe et al., 1996; Rauhut, 2003; TWiG).

37. Medial surface of paradental plates: smooth (0); striated (1) (Sampson et al., 1998).

38. Pneumatic foramen in the nasals: absent (0); present (1) (Rauhut, 2003).

39. Dorsal extent of antorbital fossa: dorsal rim of antorbital fossa below nasal suture, or formed by this suture (0); antorbital fossa extending onto the lateroventral side of the nasals (1) (Sereno et al., 1994).

40. Nasals: unfused (0); partially or fully fused (1) in adults (Sereno, 1999).

41. Lateral surface of anterior end of nasal along the posterior margin of the external naris: flat (0); concave fossa (1); laterall convex hood covering posterior part of external naris (2) (modified from Tykoski, 1998, 2005; Carrano et al., 2002).

42. Nasals: flat or gently convex, lacking crest (0); expanded into sagittal or parasagittal crests (1).

43. Nasal crest (when present): midline sagittal crest (0); parasagittal crests (1).

44. Construction of nasal crest: formed from the nasals only (0); lacrimal contributes to posterior margin of crest (1).

45. Caudolateral process on the nasal that envelops part of the rostral ramus of the lacrimal: no (0); yes (1) (modified from Yates, 2003b; Langer & Benton, 2006).

46. Sublacrimal part of the jugal: tapering (0); triradiate anterior end (1); strongly expanded anteriorly, overlapping most of the ventral portion of the lacrimal (2) (Rauhut, 2003).

47. Pneumatization of the jugal: absent (0); jugal pneumatized by a foramen in the posterior rim of the jugal antorbital fossa (1) (Sereno et al., 1996).

48. Medial jugal foramen present on medial surface ventral to postorbital bar: absent (0) or present (1) (TWiG).

49. Lateral ridge longitudinally traversing the rostral and caudal processes of the jugal: present (0), absent (1) (modified from Sereno & Novas 1993; Tykoski 1998).

50. Anterior end of jugal participates in internal antorbital fenestra: yes (0); no (1) (modified from Holtz, 1994; Rauhut, 2003).

51. Lacrimal fenestra: absent (0); present (1) (Molnar et al., 1990).

52. Lacrimal 'horn': absent (0); dorsal crest above orbit (1) (Russell & Dong, 1993).

53. Posterior dorsal process of lacrimal: absent (0); present, lacrimal 'T'-shaped in lateral view (1) (Currie, 1995).

54. Configuration of lacrimal and frontal: lacrimal separated from frontal by prefrontal (0); lacrimal contacts frontal (1) (Rauhut, 2003).

55. Contact between lacrimal and postorbital: absent (0); present (1) (Sampson et al., 1998).

56. Lacrimal anterior ramus length: > 65% ventral ramus length (0), ≤ 65% ventral ramus length (1); lacrimal anterior ramus stongly reduced and almost non-existent (2); (Sereno et al., 1998).

57. Suborbital process of lacrimal: absent (0); present (1) (Sampson et al., 1998).

58. Lateral blade (sensu Britt, 1991) of lacrimal overhangs antorbital fenestra: yes (0); no (1) (modified from Britt, 1991; Allain, 2002).

59. Ventral ramus of lacrimal: broadly triangular, articular end nearly twice as wide anteroposteriorly as lacrimal body at juncture between anterior and ventral ramus (0); bar- or strut-like, roughly same width anteroposteriorly throughout ventral ramus (1).

60. Orientation of the long axis of the lacrimal ventral process: strongly sloping anterodorsally (0); erect or nearly vertical (1); strongly sloping posterodorsally (2) (Yates, 2006).

61. Prefrontal: exposed dorsally on the anterior rim of the orbit in lateral view and with a slender ventral process along the medioposterior rim of the lacrimal (0); excluded from the anterior rim of the orbit in lateral view, being displaced posteriorly and/or medially; ventral process absent, but dorsal exposure similar to that of lacrimal (1); excluded from the anterior rim of the orbit in lateral view, being displaced posteriorly and/or medially; ventral process absent, and greatly reduced in size (2); absent (3) (modified from Rauhut, 2003; TWiG).

62. Anterior edge of associated frontals: rectangular anteriorly (0); triangular wedge-shaped anteriorly (1) (Holtz, 1994).

63. Relative length of associated frontals: longer than wide (0); as wide as long, or wider (1) (Allain, 2002).

64. Frontal contribution to midline nasal crest: no (0); yes (1).

65. Frontals and parietals: separate (0); fused (1) in adults (Forster, 1999).

66. Median fossa in saddle—shaped depression overlapping frontal-parietal contact: absent (0); present (1) (Sampson et al., 1998).

67. Supratemporal fossa: extends onto posterodorsal surface of frontal (0); restricted by overhanging frontoparietal shelf (1) (Coria & Currie, 2002).

68. Supratemporal fenestrae: face dorsally (0); face anterodorsally (1) (Coria & Currie, 2002).

69. Distinct anterior spur indicating the lower delimitation of the eyeball present on jugal process of the postorbital: no (0); yes (1) (Rauhut, 2003).

70. Postorbital in lateral view with straight anterior (frontal) process (0); or frontal process curves anterodorsally and dorsal border of temporal bar is dorsally concave (1) (TWiG).

71. Cross-section of the ventral process of the postorbital: triangular (0); U-shaped (1) (Sereno et al., 1994, 1996).

72. Ventral extent of postorbital substantially above ventral margin of orbit: yes (0); no (1); no and postorbital process of jugal reduced or absent (2) (Allain, 2002).

73. Long axis of postorbital: dorsal-ventral (0); anteroventral-posterodorsal (1) (Novas, 1989).

74. Stepped-down ventrolateral fossa on postorbital: absent (0); present (1) (Sampson et al., 1998).

75. Supratemporal fenestrae: separated by a horizontal plate formed by the parietals (0); contact each other posteriorly, but separated anteriorly by an anteriorly widening triangular plate formed by the parietals (1); confluent over the parietals; parietals form a sagittal crest (2) (Molnar et al., 1990).

76. Nuchal wedge and parietal alae: small (0); hypertrophied and elevated (1) (Forster, 1999).

77. Tounge-like process of parietals overlapping the supraoccipital knob: absent (0); present (1) (Coria & Currie, 2002).

78. Squamosal contribution to broad, arching nuchal crest: absent (0); present (1) (modified from Novas, 1989; Sampson et al., 1998).

79. Supratemporal fenestra bounded laterally and posteriorly by the squamosal (0); or supratemporal fenestra extended as a fossa on to the dorsal surface of the squamosal (1) (TWiG).

80. Posterolateral shelf on squamosal overhanging quadrate head: absent (0); present (1) (TWiG).

81. Quadratojugal process of the squamosal: tapering (0); broad, and somewhat expanded (1) (Rauhut, 2003).

82. Squamosal-quadratojugal contact: at tips (0); absent (1); broad (2) (modified from Carrano et al., 2002, 2005; Rauhut, 2003).

83. Anteroposterior breadth of quadratojugal dorsal process: narrow (0); broad (1).

84. Quadratojugal: hook-shaped, without posterior process (0); with broad, short posterior process that wraps around the lateroventral edge of the quadrate (1) (Rauhut, 2003).

85. Quadratojugal fused to quadrate in adults: no (0); yes (1) (Holtz, 1994, 2000).

86. Quadratojugal-Quadrate suture, exposed laterally and with a sharp lateral flange running anterodorsally on the quadratojugal: no (0); yes (1).

87. Pneumatization of the quadrate: absent (0); present (1) (Rauhut, 2003).

88. Lateral border of quadrate shaft straight (0); or with lateral tab that touches squamosal and quadratojugal above an enlarged quadrate foramen (1) (TWiG).

89. Quadrate foramen: developed as a distinct opening between the quadrate and quadratojugal (0); almost entirely enclosed in the quadrate (1); absent (2) (modified from Carrano et al., 2002; Rauhut, 2003; Tykoski, 2005).

90. Paroccipital processes: directed laterally, or slightly ventrolaterally (0); directed strongly ventrolaterally, with distal end entirely below the level of the foramen magnum (1); (modified from Rauhut, 1997; Rauhut, 2003; TWiG).

91. Ventral rim of the basis of the paroccipital processes: above or level with the dorsal border of the occipital condyle (0); situated at mid-height of occipital condyle or lower (1) (Rauhut, 2003).

92. Paroccipital process elongate and slender, with dorsal and ventral edges nearly parallel (0); or process short, deep with convex distal end (1) (TWiG).

93. Paroccipital process with straight dorsal edge (0); or with dorsal edge twisted rostrolaterally at distal end (1) (Currie 1995).

94. Caudal (posterior) tympanic recess: absent (0); present as opening on anterior surface of paroccipital process (1); or extends into opisthotic posterodorsal to fenestra ovalis, confluent with this fenestra (2) (TWiG).

95. Depth of median supraoccipital ridge: $<$ (0); $\geq$ (1) depth of occipital condyle (Carrano et al., 2002).

96. Participation of the supraoccipital in the dorsal margin of the foramen magnum: large (0); reduced or absent (1) (Allain, 2002).

97. Width of dorsal expansion of supraoccipital: less than twice the width (0); or more than twice the width (1) of the foramen magnum (Coria & Currie, 2002).

98. Neck of occipital condyle invaded by ventrolateral pair of pneumatic cavities that join medially: no (0); yes (1) (Coria & Currie, 2002).

99. Angle between occipital condyle and basal tubera: perpendicular or almost perpendicular (0); acute (1) (Coria & Currie, 2002).

100. Basal tubera: equally formed by basioccipital and basisphenoid and not subdivided (0); subdivided by a lateral longitudinal groove into a medial part entirely formed by the basioccipital, and a lateral part, entirely formed by the basisphenoid (1) (Rauhut, 2003).

101. Basioccipital participates in basal tubera: yes (0); no (1) (modified from Currie & Carpenter, 2000; Allain, 2002).

102. Basal tubera width: $\geq$ (0); $<$ (1) occipital condyle width (Holtz, 2000).

103. Basisphenoid between basal tubera and basipterygoid processes: approximately as wide as long, or wider (0); significantly elongated, at least 1.5 times longer than wide (1) (Rauhut, 2003).

104. Basisphenoid recess: absent or poorly developed (0); present between basispenoid and basioccipital (1); present entirely within basisphenoid (2) (modified from Rauhut, 2003; TWiG).

105. Posterior opening of basisphenoid recess single (0); or divided into two small, circular foramina by a thin bar of bone (1) (TWiG).

106. Pneumatic openings associated with internal carotid artery: no (0); yes (1) (modified from Allain, 2002; Coria & Currie, 2006).

107. Anterior tympanic recess in the braincase: absent (0); present (1) (Makovicky & Sues, 1998).

108. Cranial nerve V exit foramen: single (0); fully split (1) (Currie & Zhao, 1993).

109. Exit of trigeminal nerve (CN V): in front or below the level of nuchal crest (0); behind the level of nuchal crest (1) (Coria & Currie, 2002).

110. Foramen on prootic for exit of facial nerve (CN VII): round or slightly anteroposteriorly elongate (0); dorsoventrally elongate (1).

111. Interorbital region: unossified (0); ossified (1) (modified from Russell & Dong, 1993; Novas, 1997).

112. Middle ear region exposed in occipital view: no (0); yes (1) (Coria & Currie, 2002).

113. Median ridge separating exit of sixth cranial nerves: present (0); absent (1) (Coria & Currie, 2002).

114. Shape of palatine in ventral view: plate-like trapezoidal or subrectangular (0); tetraradiate (1); jugal process strongly reduced or absent (2) (Harris, 1998).

115. Jugal process of palatine: tapered (0); expanded (1) (Sereno et al., 1994).

116. Palatine and ectopterygoid separated by pterygoid (0); or contact (1) (Currie 1995).

117. Dorsal recess on ectopterygoid absent (0); or present (1) (TWiG).

118. Ectopteygoid: slender, without ventral fossa (0); expanded, with a deep ventral depression medially (1); as above, but with a deep groove excavated into the body of the ectopterygoid from the medial side (2); excavated by a foramen leading from the medial side laterally into the body of the ectopterygoid (3) (Gauthier, 1986).

119. Contact between pterygoid and palatine: continuous (0); discontinuous in the mid-region, resulting in a subsidiary palatal fenestra (1) (Ostrom, 1969).

120. Palatal teeth: present (0); absent (1) (Rauhut, 2003).

121. Surangular articulation for dentary: small notch (0); large socket (1) (Carrano et al., 2002).

122. Posterior end of dentary: strongly forked (0); straight or only slightly concave (1) (Barsbold et al., 1990).

123. Posteroventral dentary process: far posterior (0), ventral (1) to posterodorsal process (Sereno, 1999).

124. Anterior end of external mandibular fenestra: posterior (0); ventral (1) to last dentary tooth (Sereno, 1999).

125. Dentary rostral end: unexpanded (0), dorsally raised over the distance of the first three to four alveoli (1); square-shaped (2) (modified from Sereno 1999, Novas et al., 2005).

126. Jaws occlude for their full length (0); or diverge rostrally due to kink and downward defelction in dentary buccal margin (1) (modified from Perez-Moreno et al., 1994; TWiG).

127. Dentary teeth: large, less than 25 (0); moderate number of small teeth (25-30) (1); teeth relatively small and numerous (>30) (2) (modified from Russell & Dong, 1993; Carrano et al., 2002; TWiG).

128. Enlarged, fang-like teeth in the anterior part of the dentary: absent (0); present (1) (Gauthier, 1986).

129. Splenial: exposed as a broad triangle between dentary and angular on lateral surface of mandible (0); or not widely exposed on lateral surface of mandible (1) (TWiG).

130. Foramen in the ventral part of the splenial: absent (0); present (1) (Rauhut, 2003).

131. Posterior end of splenial: straight or slightly curved (0); distinctly forked (1) (Sereno et al., 1996).

132. Anterior portion of the surangular: less than half the height of the mandible above the manibular fenestra (0); more than half the height of the mandible at the level of the mandibular fenestra (1) (Gauthier, 1986).

133. Horizontal shelf on the lateral surface of the surangular rostroventral to the mandibular condyle: absent or only a faint ridge (0), prominent and extending laterally (1) (Holtz 1998).

134. Laterally inclined flange along dorsal edge of surangular for articulation with lateral process of lateral quadrate condyle absent (0); or present (1) (TWiG).

135. Lateral groove along posterior end of surangular, just dorsal to articulation with caudal splint of angular: no (0); yes (1).

136. Well-developed anterior wall to lateral glenoid on surangular, resulting in a lateral glenoid fossa that is at least weakly U-shaped in lateral aspect: no (0); yes (1).

137. Angular exposed almost to end of mandible in lateral view, reaches or almost reaches articular (0); or excluded from posterior end of articular, suture turns ventrally and meets ventral border of mandible rostral to glenoid (1) (TWiG).

138. Pendant medial process on the articular: no (0); yes (1) (Sereno et al., 1994).

139. Retroarticular process of the mandible: narrow and rod-like, anteroposterior length much greater than mediolateral breadth (0); broadened, as wide mediolaterally as long anteroposteriorly or wider, often with groove posteriorly for the attachment of the m. depressor mandibulae (1) (modified from Sereno et al., 1996; Harris, 1998).

140. Attachment for the m. depressor mandibulae on retroarticular process of mandible: facing dorsally (0); facing posterodorsally (1) (Sereno et al., 1996).

141. Erect, tab-like dorsal processes on the articular, one immediately posterior to the opening of the chorda tympanic foramen and the other on the anterolateral margin of the posterodorsal fossa of the retroarticular process: no (0); yes (1) (Yates, 2005).

142. Pleurocoel in axis: absent (0); present (1) (Rowe & Gauthier, 1990).

143. Axial parapophyses: moderate/prominent (0); reduced/absent (1) (Rowe, 1989).

144. Axial diapophyses: moderate (0); reduced/absent (1) (Rowe, 1989).

145. Axial neural spine: sheet-like (0); anteroposteriorly reduced and rod-like (1) (Molnar et al., 1990).

146. Large groove excavated into posterior base of axis: present (0); absent (1) (Makovicky, 1995).

147. Pleurocoels in cervical vertebrae: absent (0); present (1) (Holtz, 1994).

148. Number of pleurocoels in cervicals: two (0); one (1) (Gauthier, 1986).

149. Cervical pleurocoels developed as: deep depressions (0); foramina (1) (Rauhut, 2003).

150. Cervical pleurocoels arranged in an anteroventral-posterodorsal position: no (0); yes (1).

151. Cervical vertebral centra: amphi- to platycoelous (0); strongly opisthocoelous (1) (Gauthier, 1986).

152. Interior pneumatic spaces in cervicals: absent (0), present, structure camerate (1), present, structure camellate (2) (Britt, 1993).

153. Cervical centrum length: < (0); > (1) three times height (Russell & Dong, 1993).

154. Anterior articular facet of anterior cervical vertebrae: approximately as high as wide or higher (0); significantly wider than high (1) (Gauthier, 1986).

155. Anterior cervical centra level with or shorter than posterior extent of neural arch (0); or centra extending beyond posterior limit of neural arch (1) (TWiG).

156. Prezygapophyses in anterior cervicals: transverse distance between prezygapophyses less than width of neural canal (0); prezygapophyses situated lateral to the neural canal (1) (Makovicky, 1995).

157. Prezygapophyses in anterior postaxial cervicals: straight (0); anteroposteriorly convex, flexed ventrally anteriorly (1) (Gauthier, 1986).

158. Cervical prezygapophyseal-epipophyseal lamina: absent/weak (0); marked (1) (Coria & Salgado, 2000).

159. Epipophyses in anterior cervical vertebrae: absent or poorly developed (0); well-developed, rod-like structures extending posteriorly beyond the postzygapophyses (1); pronounced, strongly overhanging the postzygapophyses and expanded dorsally (2) (Gauthier, 1986).

160. Anterior prongs on cervical epipophyses: absent (0); present (1) (Novas, 1992).

161. Cervical prespinal fossa: narrow (0); broad (1) (Coria & Salgado, 2000).

162. Postzygadiapophyseal laminae: present in all cervicals (0); present in anteriormost cervicals but absent in cervicals 4-8 (1) (Yates, 2003b).

163. Cervical neural spine location: posterior (0); anterior (1) half of centrum (Carrano et al., 2002).

164. Cervical neural spines: anteroposteriorly long (0); anteroposteriorly short and centered on neural arch, giving arch an "X" shape in dorsal view (1); extremely short anteroposteriorly, less than 1/3 length of neural arch (2). (Novas, 1992).

165. Pneumatic excavations in cervical rib heads: absent (0); present (1) (Harris, 1998).

166. Posterior process of anterior cervical ribs: narrow (0); wide and flat (1) (Coria & Salgado, 2000).

167. Shaft of cervical ribs slender and longer than vertebra to which they articulate (0); or broad and shorter than vertebrae (1) (TWiG).

168. Pleurocoels in dorsal vertebrae: absent (0); present in anterior dorsals ('pectorals') (1); present in all dorsals (2) (Holtz, 1994).

169. Posterior dorsal vertebrae centrum length/height: 1.0-2.5 (0); < 1 (1); > 2.5 (2) (Carrano et al., 2005).

170. Ventral keel in anterior dorsals: absent or very poorly developed (0); pronounced (1) (Rauhut, 2003).

171. Number of hypapophyses in anterior dorsals: less than 2 (0); two (1) (Allain, 2001).

172. Large, anterior fossa at base of prezygapophyses (not peduncler fossa), located medial and anterior to infraprezygapophyseal fossa in anterior dorsals: absent (0); or present (1).

173. Hyposphene-hypantrum articulation in dorsal vertebrae: absent (0); hyposphene developed as a single sheet of bone or lamina (1); hyposphene wide, formed by the ventrally bowed medial parts of the postzygapophyses, and only connected by a thin horizontal lamina of bone, postzygapophyses placed lateral to neural canal and separated by groove for interspinuous ligaments, hyposphenes separated (2) (modified from Rauhut, 2003; and TWiG).

174. Distinct step-like ridge lateral to hyposphene, running posterodorsally from the dorsal border of the neural canal to the posterior edge of the postzygapophyses in the dorsal vertebrae: absent (0); present (1) (Rauhut, 2005a).

175. Height of neural spine of posterior dorsals: broadly rectangular and approximately as high as long (0); high rectangular, significantly higher than long (1) (Rauhut, 2003).

176. Neural spine in posterior dorsals: of subequal length throughout its height or tapering dorsally (0); significantly expanded anteroposteriorly at their dorsal ends and fan-shaped (1) (Chen et al., 1998).

177. Transverse width of distal ends of neural spines of dorsal vertebrae: distal ends not expanded transversely (0); or distal ends expanded transversely to form ‘spine table’ (1) (TWiG).

178. Scars for interspinous ligaments terminate at apex of neural spine in dorsal vertebrae (0); or terminate below apex of neural spine (1) (TWiG).

179. Parapophyses in posteriormost dorsals: on the same level as transverse process (0); distinctly below transverse process (1) (Makovicky, 1995).

180. Parapophyses of posterior trunk vertebrae flush with neural arch (0); or distinctly projected on pedicles (1) (modified from Carrano et al., 2002, 2005; and TWiG).

181. Paradiapophyseal laminae in dorsal vertebrae: absent, or weakly developed (0), pronounced, developed as ‘web’ (1) (Carrano et al., 2002).

182. Number of sacral vertebrae: two (0) three (1); more than three (2); more than five (3) (Gauthier, 1986).

183. Mid-sacral centra dimensions: normal (0); strongly constricted (1) (Sereno, 1999).

184. Low, robust ridge running across the base of the transverse process, from the posterolateral corner of the prezygapophysis to the anterolateral corner of the postzygapophysis on sacral vertebra 1: absent (0); present (1) (Rauhut, 2005a).

185. Caudosacral 1 (= 5th sacral vertebra), transverse process extends posteriorly past the level of the posterior articular facet in lateral aspect: yes (0); no (1).

186. Sacral neural spines: separate (0); fused into a distinct lamina (1) in adults (Rowe, 1989).

187. Sacral ribs: slender and well separated (0); forming a more or less continuous sheet in ventral or dorsal view (1); very massive and strongly expanded (2) (Rowe & Gauthier, 1990).

188. Pleurocoels in caudal vertebrae: no (0); yes (1) (Sereno et al., 1996).

189. Number of caudal vertebrae: 41 or more (0); fewer than 36 caudals (1) (modified from Chiappe et al., 1996, and Rauhut, 2003).

190. Shape of anterior caudal centra: oval (0); subrectangular and box-like (1) (Gauthier, 1986).

191. Number of caudal vertebrae bearing transverse processes: 16 or more (0); fewer than 16 (1) (Gauthier, 1986).

192. Transverse processes of caudal vertebrae: unexpanded (0); expanded (1) anteroposteriorly at ends (Coria & Salgado, 2000).

193. Number of caudal vertebrae with well-developed neural spines: 11 or more (0); fewer than 11 (1) (Rauhut, 2003).

194. Prezygapophyses of distal caudal vertebrae extremely elongated, (up to 10 vertebral segments in some taxa): no (0); yes (1) (Gauthier, 1986).

195. Anterior margin of neural spines of anterior mid-caudal vertebrae: straight (0); with distinct kink, dorsal part of anterior margin more strongly inclined posteriorly than ventral part (1) (Rauhut, 2003).

196. Anterior caudal neural spines: long (0); narrow (1) anteroposteriorly (Rauhut, 2000).

197. Neural spines of mid-caudals: rod-like and posteriorly inclined (0); subrectangular and sheet-like (1); rod-like and vertical (2) (Rauhut, 2003).

198. Anterior spur in front of neural spine in mid-caudals: absent (0); present (1) (Makovicky, 1995).

199. Anterior process of chevron base: absent/weak (0); large (1) (Molnar et al., 1990).

200. Proximal end of chevrons of anterior caudals short anteroposteriorly, shaft cylindrical (0); or proximal end elongate anteroposteriorly, flattened and plate-like (1) (TWiG).

201. Mid-caudal chevrons: rod-like or only slightly expanded ventrally (0); L-shaped (1) (Sereno et al., 1996).

202. Distal chevrons: rod-like or L-shaped (0); skid-like (1) (Rauhut, 2003).

203. Ossified uncinate processes absent (0); or present (1) (TWiG).

204. Ossified ventral rib segments absent (0); or present (1) (TWiG).

205. Lateral gastral segment shorter than medial one in each arch (0); or distal segment longer than proximal segment (1) (TWiG).

206. Contour feathers: absent (0); present (1) (Rauhut, 2003).

207. Vaned feathers on forelimb symmetric (0); or asymmetric (1) (TWiG).

208. Ossified sternal plates separate in adults (0); or fused (1) (TWiG).

209. Sternum without distinct lateral xiphoid process posterior to costal margin (0); or with lateral xiphoid process (1) (TWiG).

210. Articular facet of coracoid on sternum (conditions may be determined by the articular facet on coracoid in taxa without ossified sternum): anterolateral or more lateral than anterior (0); almost anterior (1) (Xu et al. 1999).

211. Scapula longer than humerus (0); or humerus longer than scapula (1) (TWiG).

212. Scapula: short and broad (ratio length/minimal height of shaft <9) (0); slender and elongate (ratio >10) (1) (Perez-Moreno et al., 1993).

213. Distal end of scapula: markedly expanded (0); not expanded (1), relative to proximal portion of scapula (Gauthier, 1986).

214. Acromion process of scapula: significantly and abruptly expanded dorsally (0); small dorsal rim of proximal scapula slopes gently downwards (1) (Molnar et al., 1990).

215. Glenoid facet on scapula: facing ventrally (0); facing ventrolaterally (1) (Novas and Puerta, 1997).

216. Scapula and coracoid form a continuous arc in posterior and anterior views (0); or coracoid inflected medially, scapulocoracoid 'L' shaped in lateral view (1) (TWiG).

217. Ventral part of coracoid anterior to the glenoid facet: approximately level with the rim of the facet (0); with tapering posteroventral process (1) (Gauthier, 1986).

218. Coracoid, anteroposterior length: less than (0); greater than (1), dorsoventral height (Rauhut, 2003).

219. Shape of coracoid: semicircular (0); subrectangular (1); shallow ventral blade with elongate posteroventral process (2) (Gauthier, 1986).

220. Humerus in lateral view: sigmoidal (0); straight (1) (Holtz, 1994).

221. Outline of proximal articular facet of humerus: broadly oval (more than twice as broad transversely than anteroposteriorly) (0); distinctly rounded (less than twice as broad transversely than anteroposteriorly) (1) (Rauhut, 2003).

222. Shape of internal tuberosity on humerus: triangular, often rounded (0); proximodistally expanded and rectangular in outline (1); extremely hypertrophied, extending posteromedially as a large triangular flange (2) (modified from Sereno et al., 1998; Rauhut, 2003).

223. Deltopectoral crest: extending over at least one-third of the length of humerus and well-developed (0); strongly reduced, only developed as a small, triangular emimence (1) (Gauthier, 1986).

224. Anterior surface of deltopectoral crest smooth (0); or with distinct groove or ridge near lateral edge along distal end of crest (1) (TWiG).

225. Distal humeral condyles: rounded (0); flattened (1) (Carrano et al., 2002).

226. Mediolateral width of distal humerus relative to total length: ≤ 0.3 (0); > 0.3 (Langer & Benton, 2006).

227. Olecranon process of ulna: well-developed (0); strongly reduced or absent (1) (modified from Novas, 1998; Rauhut, 2003).

228. Proximal surface of ulna a single continuous articular facet (0); or divided into two distinct fossae separated by a median ridge (1) (TWiG).

229. Radius: more than half the length of humerus (0); less than half the length of humerus (1) (Rauhut, 2003).

230. Radial external tuberosity and ulnar internal tuberosity: low and rounded (0), hypertrophied (1). (Sereno et al., 1998)

231. Lateral proximal carpal quadrangular (0); or triangular in proximal view (1) (TWiG).

232. Two distal carpals in contact with metacarpals, one covering the base of metacarpal I (and perhaps contacting metacarpal II) the other covering the base of metacarpal II (0); or a single distal carpal capping metacarpals I and II (1) (TWiG).

233. Semilunate distal carpal well developed, covering all of proximal ends of metacarpals I and II (0); or small, covers about half of base of metacarpals I and II (1) (TWiG).

234. Metacarpal I length: ≥ 50% metacarpal II length (0); < 50% of metacarpal II length (1) (Gauthier, 1986).

235. MC I: significantly longer than broad (0); very stout, approximately as broad as long (1) (Rauhut, 2003).

236. Contact between MC I and MC II: metacarpals contact each other at their bases only (0); MC I closely appressed to proximal half of MC II (1) (Gauthier, 1986).

237. Distal end of metacarpal I: condyles symmetrical, or only slightly asymmetrical (0); condyles strongly asymmetrical, with lateral condyle extending further distally than the medial condyle (1) (Langer & Benton, 2006)

238. Medial side of MC II: expanded proximally (0); not expanded (1) (Rauhut, 2003).

239. Shaft of MC III: subequal in width to MC II (0); considerably more slender than MC II (less than 70 percent of the width of MC II) (1) (Rauhut, 2003).

240. Proximal articular end of MC III: expanded and similar in width to MC I and II (0); not expanded, very slender when compared to MC I and II (1) (Gauthier, 1986).

241. Metacarpal IV: present (0); absent (1) (Gauthier, 1986).

242. Third finger of the manus: longer than second finger (0); shorter than second finger (1) (Gauthier, 1986).

243. Extensor pits on the dorsal surface of the distal end of metacarpals: deep, well-developed (0); absent or poorly developed (1) (Sereno et al., 1993).

244. Proximal outline of MC III: subrectangular (0); triangular, apex dorsal (1) (Rauhut, 2003).

245. Shaft of MC III: straight (0); bowed laterally (1) (Gauthier, 1986).

246. Shaft diameter of phalanx I-1 less (0); or greater (1), than shaft diameter of radius (TWiG).

247. Penultimate phalanx of the third finger longer than both proximal phalanges taken together: no (0); yes (1) (Gauthier, 1986).

248. Manual unguals strongly curved, with large flexor tubercles (0); or weakly curved with weak flexor tubercles displaced distally from articular end (1) (TWiG).

249. Manual ungual I: less than half the length of the radius (0); more than two-thirds of the length of the radius (1) (Sereno et al., 1998).

250. Dorsal lip at proximal articular end of manual unguals: absent (0); present (1) (Currie and Russell, 1988).

251. Flexor tubercle on manual unguals: less than half the height of the articular facet (0); more than half the height of the articular facet (1) (Rauhut, 2003).

252. Pubis: propubic (0); vertical to opisthopubic (1) (modified from Rauhut, 2003; TWiG).

253. Pronounced ventral 'hook' (= "ventral preacetabular hook" of Carrano & Hutchinson, 2002) on anterior expansion of ilium: absent (0); present (1) (Gauthier, 1986).

254. Preacetabular part of ilium: significantly shorter than postacetabular part (0); subequal in length to postacetabular part (1); significantly longer than postacetabular process, 2/3 or more of ilium length (2) (Currie & Russell, 1988).

255. Anterodorsal corner of ilium: convex or straight (0); distinctly concave dorsally (1) (Rauhut, 2003).

256. Anterior end of ilium: gently rounded or straight (0); anterior end strongly curved (1); pointed at anterodorsal corner (2) (TWiG).

257. Orientation of iliac blades to sacral neural spines in dorsal view: dorsal edges of iliac blades parallel to neural spines (0); dorsal edges of iliac blades bowed strongly medially, almost contacting each other or sacral neural spines at the midline (1); dorsal edges of iliac blades parallel to neural spines anteriorly, but diverge strongly laterally at posterior of sacrum (2) (Holtz, 1994; Rauhut, 2003).

258. Spacing between dorsal edge of iliac blades and sacral neural spines: wide (0); narrow (1).

259. Tuber along dorsal edge of ilium, dorsal or slightly posterior to acetabulum: absent (0); or present (1) (TWiG).

260. Posterior end of ilium: rectangular (0); sloping downwards (1) (Gauthier, 1986).

261. Iliac postacetabular length: < (0); > (1) acetabulum length (Forster, 1999).

262. Posterior margin of ilium notched or indented in lateral aspect: no (0); yes (1) (modified from Tykoski, 1998; Sereno, 1999; Tykoski, 2005).

263. M. iliofemoralis fossa on lateral surface of ilium: reaches posterior rim of bone (0); stops short of posterior margin, resulting in distinct rim on lateral surface of postacetabular process (1) (Tykoski, 2005).

264. Cuppedicus fossa ('preacetabular fossa' of Hutchinson, 2001a): absent (0); formed as antiliac shelf anterior to acetabulum, extends posteriorly to above anterior

end of acetabulum (1); or posterior end of fossa on anterior end of pubic peduncle, anterior to acetabulum (2) (modified from Hutchinson, 2001a; and TWiG).

265. Pubic peduncle of ilium: transversely broad and roughly triangular in outline (0); anteroposteriorly elongated and narrow (1) (Rauhut, 2003).

266. Pubic peduncle: subequal in length to ischial peduncle (0); significantly longer than ischial peduncle, ischial peduncle tapering ventrally and without clearly defined articular facet (1) (Sereno et al., 1994).

267. Articulation facet of pubic peduncle of ilium: flat distally, with uninterrupted surface (0); with pronounced kink and separate anterior and ventral facets (1); peg(ilium)-in-socket(pubis) articulation (2) (modified from Rauhut, 2003; Carrano et al., 2002).

268. Iliac supraacetabular crest: shelf-like and short, extending primarily laterally (0); hood-like and extensive, extending laterally and also curving ventrally, to cover the dorsal portion of the acetabulum in lateral view (1); absent (2) (Gauthier, 1986).

269. Antitrochanter posterior to acetabulum: prominent (0); or absent or poorly developed (1) (TWiG).

270. Brevis fossa: absent (0); narrow and with subparallel margins (1); very strongly expanded posteriorly (2) (Molnar et al., 1990).

271. Lateral wall of iliac brevis fossa: deeper (0); shallower (1) ventrally than medial wall (Carrano et al., 2002).

272. Brevis fossa: deeply concave with lateral overhang (0); or shelf-like (1) (Norell and Makovicky, 1997).

273. Lateral shelf of brevis fossa continuous with posteior portion of supraacetabular shelf: no (0); yes (1).

274. Iliac-ischial articulation formed by peg (iliac peduncle) and socket (ischium) joint: no (0); yes (1) (TWiG).

275. Pubic tubercle: rugosity on anterolateral portion of cranial end of pubic shaft (0); extended cranially as a crest or spine (=preacetabular tubercle of Aves) (1) (Hutchinson, 2001a).

276. Obturator foramen in pubis: completely enclosed (0); open ventrally (1); absent (2) (Holtz, 1994).

277. Pubic fenestra below obturator foramen: absent (0); present (1) (Gauthier, 1986).

278. Pubic apron about half of pubic shaft length (0); or less than 1/3 of shaft length (1) (TWiG).

279. Pubic apron: completely closed (0); with medial opening distally above the pubic boot (1) (Rauhut, 1995).

280. Strongly expanded pubic boot: absent (0); present (1) (Gauthier, 1986).

281. Pubic boot expanded posteriorly and posterior expansion more than half the length of the pubic shafts: no (0); yes (1) (Gauthier, 1986).

282. Distal expansion of pubis continuous with or expanded laterally beyond margin of shaft (0); or medially inset from lateral edge of pubic shaft (1) (Tykoski, 2005).

283. Ischium: straight (0); twisted at midshaft and with flexure of obturator process toward midline so that distal end is horizontal (1) (TWiG).

284. Ischium length: ischium at least three-quarters the length of pubis (0); ischium two-thirds or less the length of pubis (1) (Gauthier, 1986).

285. Tubercle on anterior edge of ischium absent (0); or present (1) (TWiG).

286. Posterior process on proximal part of ischium: absent or weakly developed (0); semicircular scar on posterior part of the proximal end of the ischium (1); or well-developed as a triangular posterior process (2) (modified from TWiG; Rauhut, 2003).

287. Obturator process on ischium: confluent with pubic peduncle (0); offset from pubic peduncle by a distinct notch (1) (Rauhut, 2003).

288. Obturator process: proximally placed (0); located distally, near middle or end of ischiadic shaft (1) (Gauthier, 1986).

289. Ventral notch between obturator-process or –flange on ischium: absent (0); present (1) (Sereno et al., 1996).

290. Distal end of ischium: slightly expanded (0); strongly expanded, anteroposterior length more than twice anteroposterior length of ischial shafts, forming ischial ‘boot’ (1); tapering (2) (Smith and Galton, 1990).

291. Distal ends of ischia form symphysis (0); or approach one another but do not form symphysis (1); or widely separated (2) (TWiG).

292. Femoral head: confluent with greater trochanter (0); separated from greater trochanter by a distinct cleft (1) (Holtz, 1994).

293. Femoral head orientation relative to the distal femoral condyles: directed anteromedially (0); directed strictly medially (1) (Holtz, 1994).

294. Femoral head directed: ventrally (0); horizontally (1); dorsally (2) (Molnar et al., 1990).

295. Femoral head without fovea capitalis (="fovea lig. capitis" of Baumel and Witmer, 1993:64) (for attachment of capital ligament) (0); or circular fovea present in center of medial surface of head (1) (TWiG).

296. Oblique ligament groove on posterior surface of femoral head: absent or very shallow (0); deep, bound medially by a well-developed posterior lip (1) (Rauhut, 2003).

297. Lesser trochanter: absent or poorly developed as small knob-like structure (0); spike-like or developed as trochanteric shelf (1); broadened ('wing-like') (2); separated from greater trochanter by small groove (3); completely fused (or absent) to form crista trochanteris (4) (modified from Rauhut, 2003; TWiG).

298. Placement of lesser trochanter: at distal end of femoral head or below greater trochanter (0); as high or higher than greater trochanter (1) (Gauthier, 1986).

299. Posterior M. iliofemoralis insertion on proximal femur: shelf (0); mound (1) lateral ridge (2) (Hutchinson, 2001b).

300. Dorsolateral trochanter on proximal femur: well-developed as a proximodistally elongate quandrangular raised ridge (0); reduced or absent (1).

301. Fourth trochanter on the femur: forming a stout, well-developed, high ridge (0); reduced to a feeble, low ridge or absent (1) (Gauthier, 1986).

302. Broad groove on cranial surface of distal femur: absent or poorly developed (0); well developed and bound medially by an expanded medial lamella (1) (modified from Forster, 1999, and Rauhut, 2003).

303. Well-developed extensor groove present on anterior side of distal femur: no (0); yes (1) (Molnar et al., 1990).

304. Infrapopliteal ridge present between medial femoral distal condyle and crista tibiofibularis: no (0); yes (1) (Tykoski, 1998, 2005).

305. Fibular condyle on proximal end of tibia: confluent with cnemial crest anteriorly in proximal view, or only slightly offset (0); strongly offset from cnemial crest (1) (Rauhut, 2003).

306. End of cnemial process: rounded (0); proximodistally expanded (1) (Forster, 1999).

307. Posterior cleft between medial part of the proximal end of the tibia and fibular condyle: absent (0); present (1) (Rauhut, 2003).

308. Ridge on lateral side of tibia for connection with fibula: absent (0); present, extending from the proximal articular surface distally (1); present, clearly separated from proximal articular surface (2) (Gauthier, 1986).

309. Tibial lateral malleolus: lobular (0); tabular (1) (Sereno, 1999).

310. Bracing for ascending process of astragalus on anterior side of distal tibia: distinct ‘step’ running obliquely from mediodistal to lateroproximal: present (0); absent (1) (Rauhut, 2003).

311. Distal articular surface of tibia: subrectangular in outline and only slightly wider transversely than anteroposteriorly (0); subrectangular with small lateral process (1); narrow triangular to elongate rectangular in outline and strongly mediolaterally expanded (2); (Rauhut, 2003).

312. Anteroposterior breadth of medial margin of distal tibia: subequal to the lateral margin (0); broader than the lateral margin (1) (Langer & Benton, 2006).

313. Deep caudomedial notch in distal tibia for articulation with caudal ascending process of astragalus: no (0); yes (1).

314. Ridge on medial side of proximal end of fibula, than runs anterodistally from the posterproximal end: absent (0); present (1) (Rowe & Gauthier, 1990).

315. Deep groove on medial side of proximal end of fibula: absent, medial proximal fibula flat or only slightly concave (0); present, medial side of fibula bearing distinct fossa (1) (Sereno et al., 1996).

316. Insertion of m. iliofibularis on fibular shaft: not especially marked (0); present as a well-developed anterolateral tubercle (1) (modified from Mader and Bradley, 1989; Holtz, 1994; Rauhut, 2003).

317. Fibular shaft: gradually narrowing from proximal end to mid-shaft (0); abruptly narrowing below the insertion of m. iliofibularis (1) (Rauhut, 2003).

318. Fibula fused to astragalar ascending process in adults: absent (0); present (1) (Carrrano et al., 2002).

319. Fibular facet on the astragalus: large and facing partially proximally (0); reduced and confined to anterior half of lateral side of astragalus (1); strongly reduced, facing laterally or absent (2) (modified from Hotlz, 1994; Carrano et al., 2002; Rauhut, 2003).

320. Basal width of ascending process of astragalus: arising out of the lateral part of the astragalar body (0); arising our of the complete breadth of the astragalar body (1) (Welles & Long, 1974).

321. Height of ascending process of astragalus: lower than astragalar body (0); higher than the astragalar body, typically covering only lateral half of anterior surface of distal tibia (1); more than twice the height of astragalar body (2) (Welles & Long, 1974).

322. Anterior base of ascending process of astragalus: confluent or only slightly offset from astragalar body (0); offset from astragalar body by pronounced groove (1) (Welles & Long, 1974).

323. Anteroposterior breadth of astragalar ascending process: wedge-shaped/blocky (0); plate-like/laminar (1) (Sereno et al., 1994).

324. Astragalar condyles: almost entirely below tibia and face distally (0); significantly expanded proximally on anterior side of tibia and face anterodistally (1) (Sereno et al., 1996).

325. Horizontal groove across astragalar condyles anteriorly: absent (0); present (1) (Welles & Long, 1974).

326. Posterior process of astragalus: extends straight posteriorly, or curves only slightly proximally, but not strongly covering the posterior side of the tibia (0); extends posterodorsally and caps the posterior side of the distal tibia (1) (Allain, 2001).

327. Astragalus and calcaneum: separate (0); fused (1) in adults (Welles & Long, 1974).

328. Calcaneum: without facet for tibia (0); with small tibial facet on posteromedial corner (1); or with well-developed tibial facet covering most of posterior surface (2) (modified from Sereno et al., 1996; Tykoski, 2005).

329. Distal tarsals separate, not fused to metatarsals (0); or form metatarsal cap with intercondylar prominence that fuses to metatarsal early in postnatal ontogeny (1) (TWiG).

330. Metatarsals not co-ossified (0); or metatarsals co-ossified proximally (1) (TWiG).

331. Metatarsal I contacts the ankle joint: yes (1); no (1) (Gauthier, 1986).

332. MT I length: $\geq$ (0); < (1) 50% MT II length (Gauthier, 1986).

333. Metatarsal midshaft widths: II = IV and both < III (0); II < both IV and III (1) (Carrano et al., 2002).

334. Distal end of metatarsal II smooth, not ginglymoid (0); or with developed ginglymus (1) (TWiG).

335. Outline of proximal articular surface of metatarsal III: rectangular (0); hourglass-shaped (1) (Paul, 1984).

336. Proximal end of metatarsal III backing ventral sides of metatarsals II and IV, resulting in a "T"-shaped proximal profile ("antarctometatarsus" of Carrano et al., 2002): no (0); yes (1) (Carrano et al., 2002).

337. Proximal end of metatarsal III: not ventrally enlarged (0); with ventral boss protruding beyond plane of metatarsal shafts (1) (Tykoski, 2005).

338. Distal end of metatarsal III smooth, not ginglymoid (0); or with developed ginglymus (1) (TWiG).

339. Well-developed posteromedial flange on proximal end of metatarsal IV for articulation with metatarsal III: absent (0); present (1).

340. Shaft of MT IV round or thicker dorsoventrally than wide in cross section (0); or shaft of MT IV mediolaterally widened and flat in cross section (1) (TWiG).

341. Distal articular surface of metatarsal IV: as broad or broader mediolaterally than tall dorsoplantarly (0); taller dorsoplantarlly than broad mediolaterally (1) (modified from Sereno et al., 1999; Carrano et al., 2005; Langer & Benton, 2006).

342. Metatarsal V length: > (0) or < (1) 50% length of metatarsals II-IV (Gauthier, 1986).

343. Metatarsal V: with rounded distal articular facet (0); strongly reduced and lacking distal articular facet (1); short, without articular surface, transversely flattened and bowed anteriorly distally (2) (Gauthier, 1986).

344. Vascular grooves on pedal unguals: single (0); double (1) (Sampson et al., 2001; Novas and Bandyopadhyay, 2001).

345. Pedal digit I phalanges 1 + 2 length: > (0); ≤ (1) length of III-1 (Sereno et al., 1994).

346. Pedal digit II ungual: symmetrical (0); asymmetrical (1) (Carrano et al., 2002).

347. Pedal digit II: not specialized if compared to other digits (0); highly specialized: shortened, hyperextensible, phalanx II-2 with pronounced ventral heel proximally, ungual enlarged, transversely flattened and strongly curved (1) (Ostrom, 1969).

348. Mediolateral compression of olecranon process of ulna: absent or weakly compressed (0); pronounced, olecranon compressed into 'blade-like' morphology (1).

349. Lateral tuberosity of ulna: absent or small mound (0); hypertrophied and robust (1).

350. Blade-like longitudinal ridge extending distally from lateral tuberosity of ulna: absent (0); present (1).

351. Ventral surface of manual phalanx I-1: relatively flat or weakly concave (0); strongly concave with deep ventral furrow (1).

352. Accessory vertebral laminae in the infradiapophyseal fossae of the dorsal vertebrae: absent (0); present (1) (Sereno et al., 1998).

353. Orientation of olecranon process of the ulna: in same plane as coronoid (= "anterior" or "sigmoid") process (0); significantly everted medially, angle between olecranon and coronoid processes close to 120º in proximal aspect (1).

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Sinornithomimus
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Velociraptor
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Archaeopteryx

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2?11??312?10??????????????1??{0,1}2?110?0211?100???0????1???0??????

Confuciusornis
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?100?11?30??10?1?1010?0??????11?11111111111-1-
?0100001100111011?1111??10100111020l2?1110021102?--?0?1201?0-0?102--
0211111?412?10???????????011021201l0?1?111100???1?????0??0??????

S7. PHYLOGENETIC ANALYSIS

(a) Methods

To assess the relationships of *Megaraptor* and NMV P186076 we performed a phylogenetic analysis using a dataset modified from that of Smith et al. (2007). Part of the reason for utilizing this dataset is that it includes multiple representatives of major clades of basal theropods (e.g., "Coelophysoidea", Abelisauroidea, Spinosauroidea, Allosauroidea, Coelurosauria), and thus provides a rigorous test of the relative relationships of *Megaraptor* and NMV P186076. In addition to *Megaraptor* and NMV P186076, the carcharodontosaurid *Mapusaurus* (Coria & Currie 2006) was added to the dataset. Several new characters were constructed, and codings for some taxa were revised. In total, the dataset consisted of 58 taxa scored for 353 characters. *Megaraptor* could be scored for 69 characters (= 19.55%), and NMV P186076 could be scored for 7 characters (= 1.98%). See (*S6*) for a complete character list and codings for all included taxa. Two analyses were performed, one containing all taxa, and one excluding NMV P186076.

Phylogenetic analyses were performed using PAUP* 4.0b10 (Swofford 2002). All characters were equally weighted and treated as unordered. A heuristic search was performed with 10,000 random addition sequence replicates to find the most parsimonious trees for the data matrix. Tree bisection and reconnection (TBR) was utilized as the branch-swapping algorithm for the heuristic search. Following 'rule 1' of Coddington & Scharff (1994), zero length branches were collapsed if they lacked support under any of the most parsimonious reconstructions. Bootstrap analyses (Felsenstein 1985) were performed on the dataset to quantify support. Heuristic searches were performed on 2,000 pseudoreplicate datasets, with 10 random addition sequence replicates for each search. The maximum number of trees saved for each

random addition sequence replicate was set to 100 to prevent the searches from becoming stuck on a large island of MPTs during any particular random addition sequence replicate. Though this search strategy reduces the amount of tree space explored for any given random addition sequence replicate, it does allow for a much larger number of bootstrap replicates to be performed. In addition to bootstrap analyses, Bremer support values were also calculated for each node in the strict consensus of all MPTs using TreeRot.v2c (Sorenson 1999).

(b) Results

The phylogenetic analysis excluding NMV P186076 resulted in the recovery of 144 MPTs, each of 853 steps, with a consistency index of 0.484, and a retention index of 0.771. *Megaraptor* is recovered as a derived spinosauroid, in a polytomy with *Eustreptospondylus*, *Streptospondylus*, *Baryonyx*, *Suchomimus*, and *Irritator*. *Torvosaurus* is recovered as the sister taxon to this clade, and a dyad of *Dubreuillosaurus* and *Afrovenator* constitutes the sister taxon to this larger clade. Other relationships within the MPTs are similar to those recovered by Smith et al. (2007), with the exception of resolution within Allosauroidea.

The phylogenetic analysis including NMV P186076 resulted in the recovery of 172 MPTs, each of 853 steps, with a consistency index of 0.484, and a retention index of 0.772. The strict consensus of these 172 MPTs is shown in figure *S8*. Similar to the first analysis, *Megaraptor* and NMV P186076 are recovered as derived spinosauroids, in a polytomy with *Eustreptospondylus*, *Streptospondylus*, *Baryonyx*, *Suchomimus*, and *Irritator*. All other relationships within the MPTs are identical to those recovered in the first analysis.

In text figure 2, we present a single representative of these 172 MPTs. This representative MPT was chosen based on: **1)** the presence of a monophyletic

Spinosauridae, which has been supported in numerous analyses (e.g., Sereno et al. 1998; Allain 2002; Smith et al. 2007); **2)** the presence of a monophyletic *Eustreptospondylus* + *Streptospondylus* clade, which has been supported previously (Allain 2001; Smith et al. 2007), and is not contradicted by any unambiguous character evidence; **3)** the presence of both a monophyletic Spinosauridae (*Baryonyx* + *Suchomimus* + *Irritator*) and a monophyletic (*Eustreptospondylus* + *Streptospondylus*) clade in more than 50% of the bootstrap trees; **4)** the fact that although some MPTs (72 out of 172) recover a (*Megaraptor* + NMV P186076 + Spinosauridae) clade, no MPTs recover a (*Eustreptospondylus* + *Streptospondylus* + Spinosauridae) clade; and **5)** the presence of a monophyletic *Megaraptor* + NMV P186076 clade, which we provide support for in the main text, and is also not contradicted by any unambiguous character evidence.

(c) Discussion

The recovery of *Megaraptor* as a spinosauroid differs from the analysis of Smith et al. (2007) where this taxon was recovered as a carcharodontosaurid. However, Smith et al. (2007) noted that only 2 additional steps were required to obtain trees that grouped *Megaraptor* within Spinosauroidea. The majority of character support for placing *Megaraptor* within Carcharodontosauridae comes from features (primarily associated with pneumaticity) in the vertebral column, while support for its placement within Spinosauroidea derives mainly from characteristics of the forelimb and manus. In the present analysis, three additional steps are required to recover *Megaraptor* and NMV P186076 as members of Carcharodontosauridae.

It is important to note that some of the lack of resolution represented by the strict consensus tree can be attributed to the interaction of missing data in various taxa. For example, though 29 of the 144 MPTs (in the analysis excluding NMV P186076)

recovered possess a (*Megaraptor* + *Eustreptospondylus* + *Streptospondylus*) clade, there is no unambiguous character evidence to support this grouping to the exclusion of other spinosauroids. No character optimized as a synapomorphy supporting this clade is present in both *Megaraptor* and *Eustreptospondylus* (or *Streptospondylus*, which is known from less material; Allain, 2001). The fact that both *Eustreptospondylus* and *Streptospondylus* lack preserved ulnae prevents the presence of a compressed, blade-like olecranon process (present in *Baryonyx*, *Suchomimus*, *Megaraptor* and NMV P186076) from being resolved as an unambiguous synapomorphy above the level of *Torvosaurus*, which lacks this feature. Similarly, the lack of forelimb material from *Irritator* makes it unclear as to whether the hypertrophied medial process of the distal ulna (see figure *S5*) is a synapomorphy of *Suchomimus* + *Baryonyx*, or a more inclusive clade (e.g., Spinosauridae). The absence of preserved forelimb material for *Irritator*, *Eustreptospondylus*, and *Streptospondylus* also renders the distribution of character 350 (blade-like longitudinal ridge extending distally from lateral tuberosity of ulna), here considered a synapomorphy of *Megaraptor* and NMV P186076 (this feature is absent in *Baryonyx*, *Suchomimus*, *Torvosaurus*, and all other theropods where ulnae are known), as ambiguous. Thus, not all of the MPTs contain a *Megaraptor* + NMV P1867076 clade. However, in the MPTs that recover taxa closer to *Megaraptor* and NMV P186076 than either is to each other, these clades are not supported by unambiguous synapomorphies (i.e., there is no positive evidence to support the non-monophyly of a *Megaraptor* + NMV P1867076 clade).

Figure *S8. Smith et al.* Strict consensus of these 172 MPTs from the phylogenetic analysis (see *S7*) including all taxa. MPTs are 853 steps, with a consistency index of 0.484, and a retention index of 0.772. Bold numbers above nodes indicate bootstrap values > 50%, numbers below nodes indicate Bremer decay values > 1.

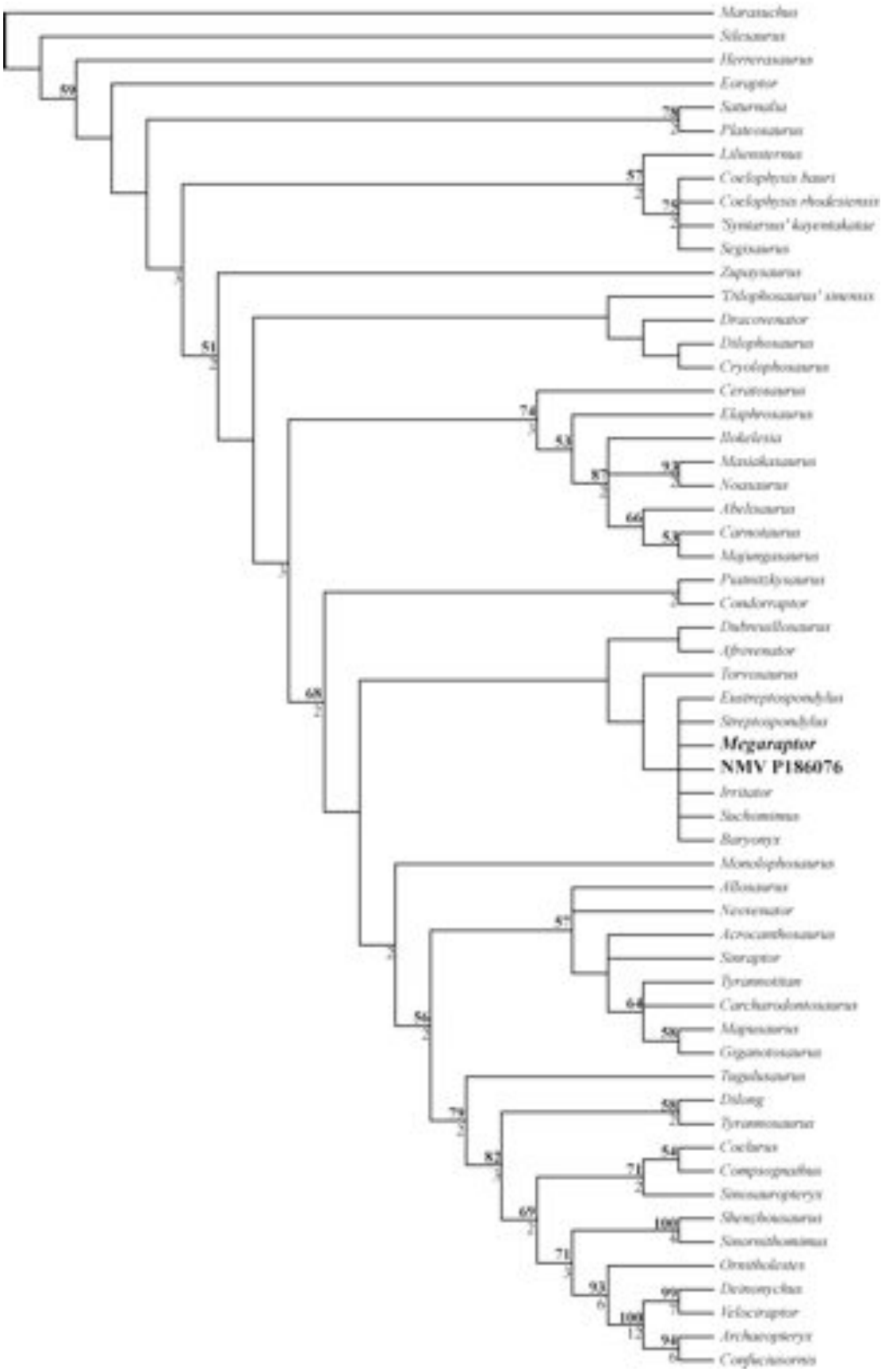
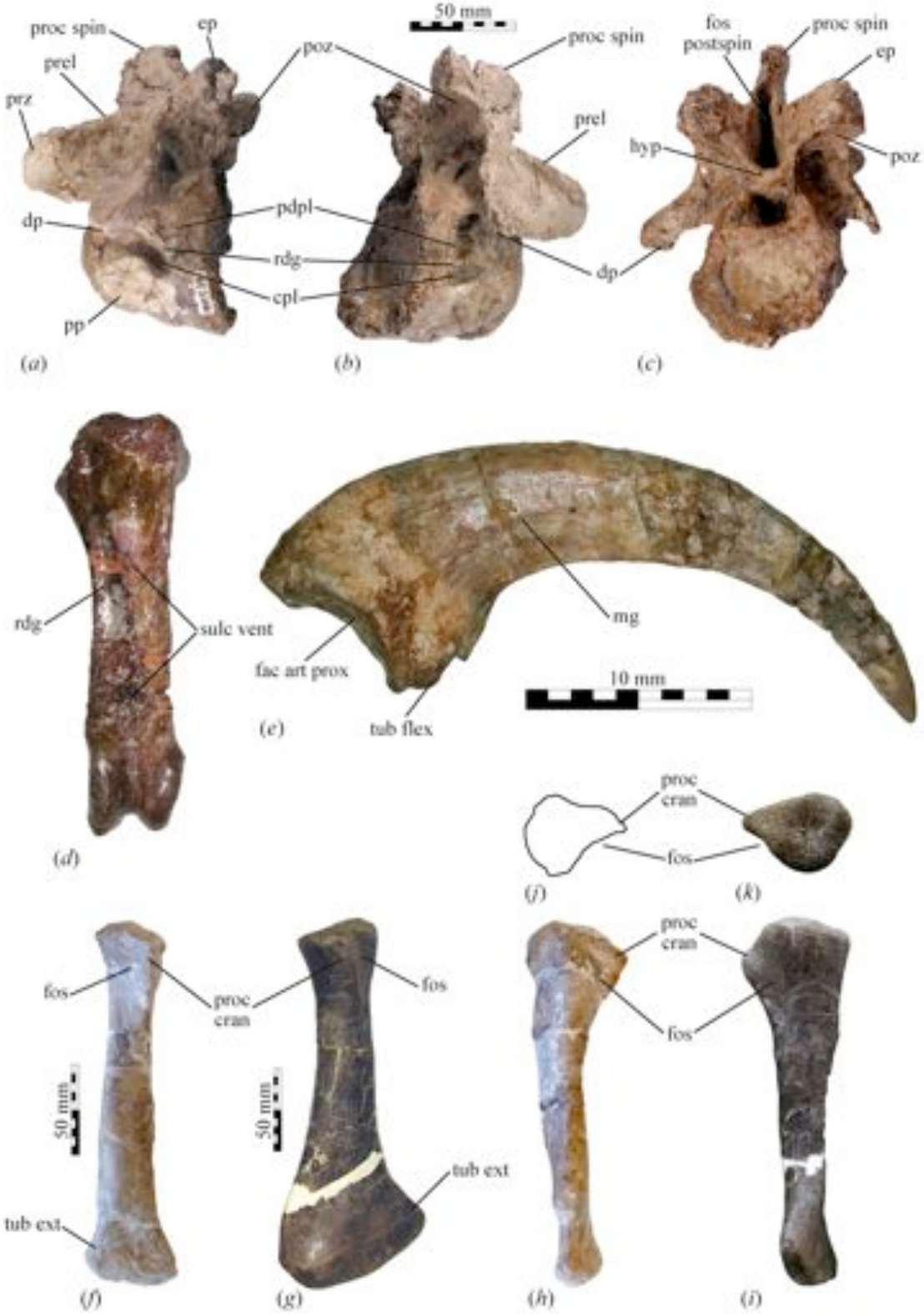

Marasuchus
Silesaurus
Herrerasaurus
Eoraptor
Saturnalia
Plateosaurus
Liliensternus
Coelophysis bauri
Coelophysis rhodesiensis
Syntarsus kayentakatae
Segisaurus
Zupaysaurus
Tawa
Dracovenator
Dilophosaurus
Cryolophosaurus
Ceratosaurus
Elaphrosaurus
Bekelesia
Masiakasaurus
Noasaurus
Abelisaurus
Carnotaurus
Majungasaurus
Piatnitzkysaurus
Condorraptor
Dubreuillosaurus
Aerosteon
Torvosaurus
Eustreptospondylus
Streptospondylus
Megaraptor
NMV P186076
Irritator
Suchomimus
Baryonyx
Monolophosaurus
Allosaurus
Neovenator
Acrocanthosaurus
Sinraptor
Tyrannotitan
Carcharodontosaurus
Mapusaurus
Giganotosaurus
Tagalosaurus
Dilong
Tyrannosaurus
Coelurus
Compsognathus
Sinosauropteryx
Shenzhousaurus
Sinornithomimus
Ornitholestes
Deinonychus
Velociraptor
Archaeopteryx
Confuciusornis

Figure *S9.* Additional, potentially phylogenetically informative characters of *Megaraptor namunhuaiquii*. Cervical vertebra of *Megaraptor namunhuaiquii* (MUCPv 341) in (*a*) left lateral, (*b*) right caudolateral, and (*c*) caudal aspects. Note the presence of: a prezygoepipophyseal lamina; two pleurocoels in a staggered position; and a hypsosphene/hypantrum-like accessory articulation. Left manual phalanx I-1 (*d*), and left manual ungual I-2 (*e*), of *Megaraptor namunhuaiquii* (MCF-PVPH 79) in ventral (*d*), and medial (*e*) aspects. Note the presence of a deep, well-defined ventral groove on I-1, and the hypertrophied manual ungual. Right radius (*f*, *h*, *j*) of *Megaraptor namunhuaiquii* (MUCPv 341) in cranial (*f*), lateral (*h*), and proximal (*j*) aspects. Left radius (*g*, *i*, *k*) of *Baryonyx walkeri* (BMNH R9951) in cranial (*g*), lateral (*i*), and proximal (*k*) aspects. Photographs in (*i*) and (*k*) are by Rud Sadleir (FMNH). Note the similarity in the development of a large triangular cranial process, with associated lateral fossa, of the proximal radius. Also note that *Megaraptor* lacks the hypertrophied external tuberosity of the distal radius present in *Baryonyx*, and also *Suchomimus* (MNN GAD 500). Anatomical abbreviations: **cpl**, cranial pleurocoel; **dp**, diapophysis; **ep**, epipophysis; **fac art prox**, proximal articular surface; **fos**, fossa; **fos postspin**, postspinal fossa; **hyp**, hyposphene; **mg**, medial blood groove; **pdpl**, posterodorsal pleurocoel; **poz**, postzygapophysis; **pp**, parapophysis; **prel**, prezygoepipophyseal lamina; **proc cran**, cranial process; **proc spin**, neural spine; **prz**, prezygapophysis; **rdg**, ridge; **sulc vent**, ventral groove; **tub ext**, external tuberosity; **tub flex**, flexor tubercle.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50 mm
tub ext
(f)
fos
50 mm
tub ext
(g)
proc
cran
fos
(h)
(i)

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