1. Differential diagnosis for *Asilisaurus kongwe*

Asilisaurus differs from *Eucoelophysis* in having a Meckelian groove in the dorsoventral middle of the dentary, teeth that have no expansion above the root, and a femur that possesses a distinct facies articularis antitrochanterica. *Asilisaurus* differs from *Silesaurus* in possessing a calcaneal tuber, a Meckelian groove in the dorsoventral middle of the dentary, teeth that have no expansion above the root, and a femur that possesses a distinct facies articularis antitrochanterica. *Asilisaurus* differs from *Sacisiaurus* in having a calcaneal tuber, a Meckelian groove in the dorsoventral middle of the dentary, teeth that have no expansion above the root, and a femur that possesses a distinct facies articularis antitrochanterica. *Asilisaurus* differs from *Lewisuchus* in having peg-like teeth and a dentary that tapers anteriorly to a point. *Asilisaurus* differs from *Pseudolagosuchus* in the poor development of the anterior trochanter of the femur.

2. Paratype and referred material of *Asilisaurus kongwe*

The holotype and paratype specimens of *Asilisaurus* were found at a single locality in the Lifua Member of the Manda Beds. Rare remains of cynodonts, amphibians, and archosauriform teeth were also found at the type locality. Known skeletal material of *Asilisaurus* includes articulated, disarticulated but closely associated (bones on top of each other, bones from different body regions adjacent), and isolated finds. Most of the bones had weathered as isolated elements or small accumulations whereas a few specimens were found *in situ.* The articulated specimens and associated clumps of elements support our contention that all of the *Silesaurus*-like material belongs to *Asilisaurus*. Furthermore, elements such as the ilium, femur, and dentary can be independently assigned using unambiguous synapomorphies to a close relative of *Silesaurus* - a similar approach was taken to assign the dinosauromorph remains from the Hayden Quarry of *Dromomeron romeri* (Irmis et al. 2007; Nesbitt et al. 2009).

3. Synonymy of *Lewisuchus admixtus* and *Pseudolagosuchus major*

Lewisuchus admixtus was described by Romer (1972) on the basis of a single specimen consisting of the skull, lower jaws, and anterior postcranial skeleton. Romer identified *Lewisuchus* as a thecodont, but did not hypothesize specific interrelationships among basal archosaurs. The taxon has received little subsequent attention in the literature, although some authors have utilized it as a dinosaur outgroup without further discussion (e.g., Hutchinson, 2001a,b; Langer and Benton, 2006; Carrano, 2006). In contrast, *Pseudolagosuchus major* was described by Arcucci (1987) from several specimens of partial pelvic and hindlimb material and was immediately recognized as a basal dinosauromorph. Subsequent studies (e.g., Novas, 1989, 1992, 1996) recognized *Pseudolagosuchus* as the closest sister taxon to Dinosauria, and recently suggested a close relationship with *Silesaurus* (e.g., Nesbitt et al., 2007).

Our first-hand examination and re-analysis of these two taxa (Irmis, 2008; Nesbitt, 2009) indicate that both *Lewisuchus* and *Pseudolagosuchus* share apomorphies with *Silesaurus* and related taxa. *Lewisuchus* and *Silesaurus* share two characters in the

braincase: the exits of the hypoglossal nerve (XII) are aligned in a near anteroposterior plane; and the presence of a rugose ridge on the anterolateral edges of the supraoccipital. These characters cannot be evaluated in *Asilisaurus*, *Eucoelophysis*, and *Sacisaurus* because the braincase is not preserved in known specimens of these taxa. *Lewisuchus*, *Asilisaurus*, and *Silesaurus* share the presence of cervical vertebrae 3-5 that are longer than the mid-dorsal vertebrae (cervical vertebrae are unknown in *Eucoelophysis* and *Sacisaurus*). *Pseudolagosuchus* shares the presence of a notch ventral to the proximal head of the femur with *Asilisaurus*, *Eucoelophysis*, *Sacisaurus*, and *Silesaurus*. An additional ambiguous synapomorphy uniting these taxa is the presence of a straight transverse groove on the proximal articular surface of the femoral head.

Given that both *Lewisuchus* and *Pseudolagosuchus* share apomorphies with other silesaurids, are approximately the same size, and are from the same stratum and locality (Romer, 1972; Arcucci, 1987; Bonaparte, 1997), it is reasonable to suspect that these specimens belong to the same taxon. This hypothesis has been proposed before (Arcucci, 1997, 1998, 2005), but has never been described in detail. When *Lewisuchus* and *Pseudolagosuchus* are placed in a phylogeny as separate taxa, all most parsimonious trees recover both taxa at the base of Silesauridae (Fig. S2). The two taxa form a basal polytomy within Silesauridae in the strict consensus tree, but the most parsimonious trees only vary in whether *Lewisuchus* or *Pseudolagosuchus* is the most basal taxon within Silesauridae. This is probably a result of the fact that the taxa do not preserve informative overlapping regions of the skeleton; the silesaurid synapomorphies in *Lewisuchus* are preserved in the cranium and anterior axial skeleton, whereas the silesaurid synapomorphies for *Pseudolagosuchus* are preserved in the femur. Unfortunately, this lack of overlapping material also means that the two taxa cannot be formally synonymized. The only overlapping element they share is the tibia, which does not preserve any autapomorphies or a unique combination of character states that could be used to diagnose either taxon and differentiate it from other silesaurids. Therefore, although we strongly suspect that *Lewisuchus* and *Pseudolagosuchus* are the same taxon, and score them accordingly in our main phylogenetic analysis (Fig. S1), we cannot formalize their synonymy. If future discoveries of material allow this synonymy, *Lewisuchus admixtus* Romer, 1972 would be the senior synonym to *Pseudolagosuchus major* Arcucci, 1987.

4. Details of the phylogenetic analysis

The phylogenetic analysis comprises 34 taxa and 290 characters. At least one of the authors personally observed nearly all of the taxa. *Erythrosuchus* was constrained as the outgroup, and ingroup taxa included a variety of pseudosuchians, pterosaurs, basal dinosauromorphs, and dinosaurs. Specimen numbers or literature sources for each taxon are reported in Table S1. Characters are mainly derived from Gauthier (1986), Benton and Clark (1988), Sereno (1991), Sereno and Arcucci (1994), Novas (1996), Benton (1999), Rauhut (2003), Yates (2003), Butler (2005), Langer and Benton (2006), Smith et al. (2007), Irmis et al. (2007a), Butler et al. (2008), and new and revised characters from Irmis (2008) and Nesbitt (2009).

The character-taxon matrix was assembled in Mesquite v.2.6 (Maddison and Maddison, 2004). We analyzed our dataset using PAUP* 4.0b10 for Macintosh PPC (Swofford, 2002). Trees were searched for using the parsimony criterion implemented

under the heuristic search option using tree bisection and reconnection (TBR) with 10,000 random addition sequence replicates. Zero length branches were collapsed if they lack support under any of the most parsimonious reconstructions. All characters were equally weighted and the following characters were ordered: 21, 78, 89, 98, 116, 142, 159, 169, 175, 177, 195, 200, 227, 250, 281. Three most-parsimonious trees were found when the scores of *Pseudolagosuchus* and *Lewisuchus* were combined, whereas six most-parsimonious trees were found when *Pseudolagosuchus* and *Lewisuchus* were treated as separate taxa. The strict consensus trees of both analyses are presented in Figures S1 and S2. Tree statistics were calculated using TNT v. 1.0 (Goloboff et al., 2003; Goloboff et al., 2008). Bremer support decay indices were calculated in TNT.

Constraining silesaurids to be within Dinosauria required 6 more steps than the original MPTs; constraining them to be ornithischians required 8 additional steps.

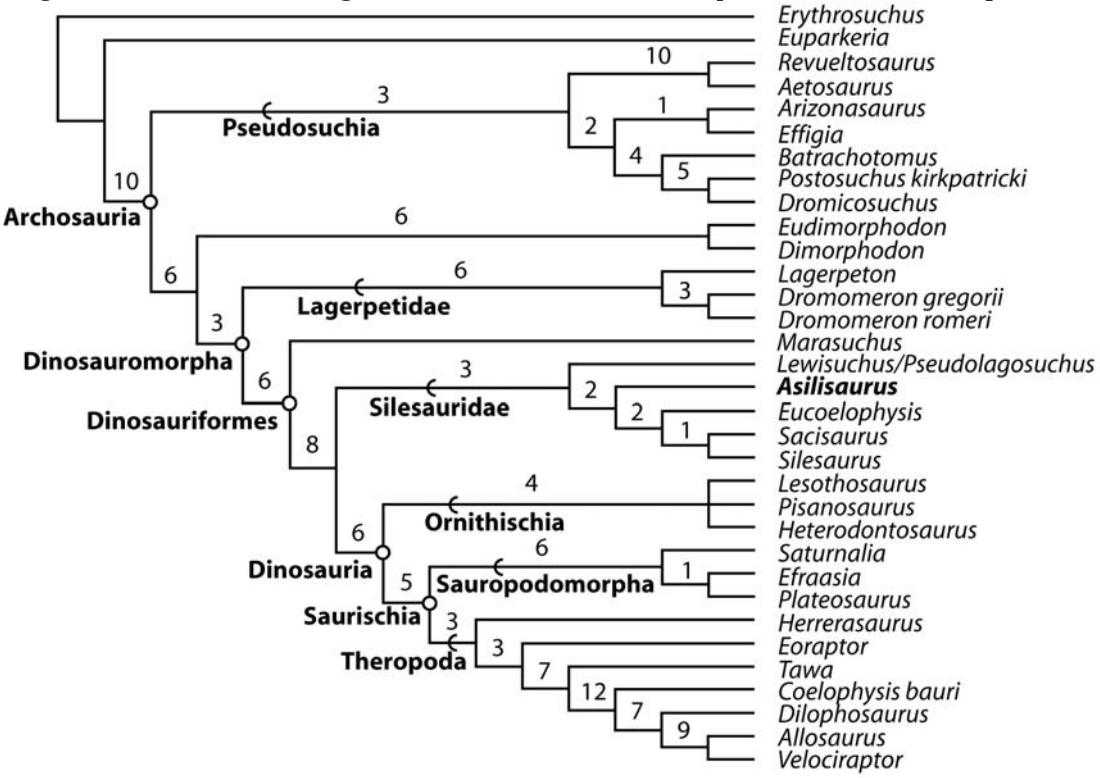

Figure S1. The relationships of early avian-line archosaurs with the inclusion of *Asilisaurus*. Strict consensus of 3 most parsimonious trees (TL = 745; CI = 0.472; RI = 0.705) when *Lewisuchus* scores are combined with those of *Pseudolagosuchus*. Bremer support is listed for each clade.

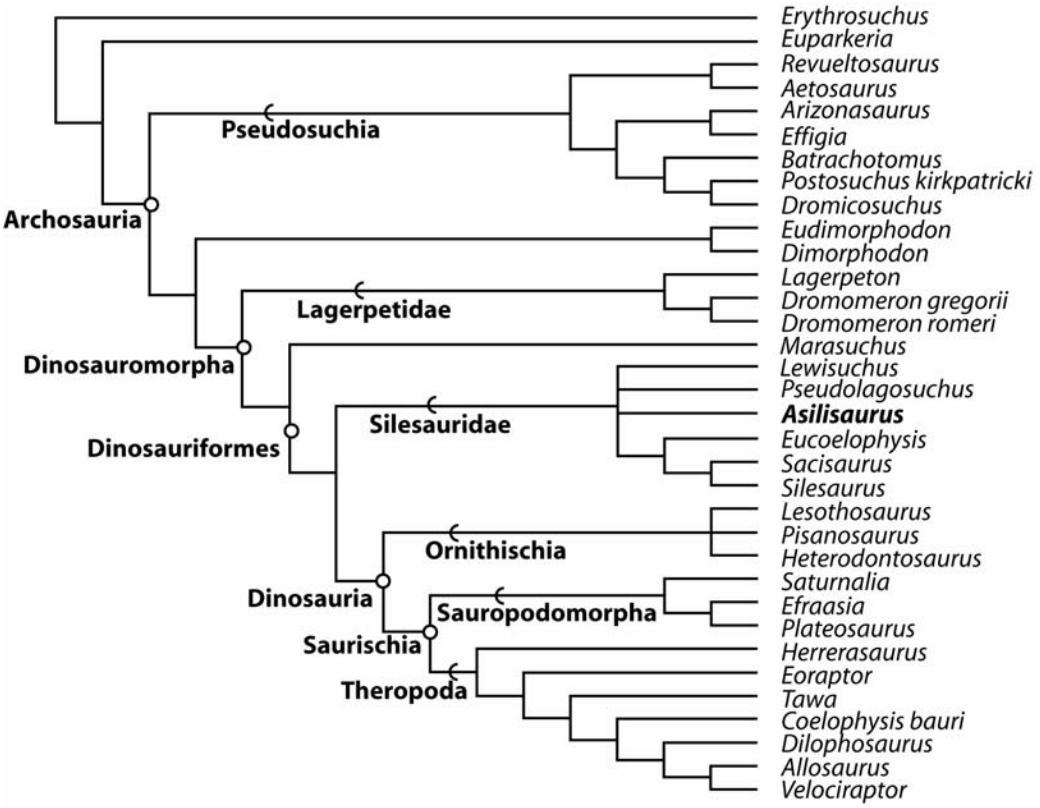

Figure S2. The relationships of early avian-line archosaurs with the inclusion of *Asilisaurus*. Strict consensus of six most parsimonious trees (TL = 745; CI = 0.472; RI = 0.705) when *Lewisuchus* and *Pseudolagosuchus* are treated as separate taxa.

Specimen list and sources

Table S1: Specimens and literature used for scoring taxa in the phylogenetic analysis. AMNH, American Museum of Natural History, New York; BNMH, The Natural History Museum, London; BP, Bernard Price Institute for Palaeontological Research, Johannesburg, South Africa; CM, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania; CMNH, Cleveland Museum of Natural History, Cleveland, Ohio; GPIT, Institut und Museum für Geologie und Paläontologie, Tübingen, Germany; GR, Ghost Ranch Ruth Hall Museum of Paleontology, Ghost Ranch, New Mexico; IGM, Mongolian Institute of Geology, Ulanbaatar, Mongolia; LACM, Los Angeles County Museum of Natural History, Los Angeles, California; MCN, Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Brazil; MCP, Museu de Ciências e Tecnologia, Pontificia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil; MNA, Museum of Northern Arizona, Flagstaff, Arizona; MSM, Arizona Museum of Natural History, Mesa, Arizona; NMT, National Museum of Tanzania, Dar es Salaam, Tanzania; NMMNH, New Mexico Museum of Natural History and Science, Albuquerque, New Mexico; PEFO, Petrified Forest National Park, Arizona; PVL, Instituto Miguel Lillo, Tucumán, Argentina; PVSJ, Museo de Ciencias Naturales, San Juan, Argentina; SAM, Iziko South African Museum, Capetown, South Africa; SMNS, Staatliches Museum für Naturkunde, Stuttgart, Germany; TMM, Vertebrate Paleontology Laboratory, Texas Natural Science Center, Austin, Texas; TTUP, Texas Tech University, Lubbock, Texas; UCMP, University of California Museum of Paleontology, Berkeley, California; UMCZ, Museum of Zoology, Cambridge University, Cambridge, England; UNC, Department of Geological Sciences, University of North Carolina at Chapel Hill, North Carolina; UNLR, Universidad Nacional de La Rioja, La Rioja, Argentina; YPM, Yale Peabody Museum, Yale University, New Haven, Connecticut; ZPAL, Instytut Paleobiologii PAN, Warsaw, Poland.

Taxon	Source
Erythrosuchus africanus	BMNH R3592, R8667; BP/1/ 5207
Euparkeria capensis	SAM 5867; SAM 6050; SAM 6047B; SAM 6049; SAM 6047A; UMCZ T692
Revueltosaurus callenderi	PEFO 33788, 34274, 34561, various other PEFO specimens
Aetosaurus ferratus	SMNS 5770 (block of at least 22 specimens), SMNS 5771, SMNS 18554
Arizonasaurus babbitti	MSM P4590, UCMP 36232
Effigia okeeffeae	AMNH FR 30587, AMNH FR 308588, AMNH FR 30859
Batrachotomus kupferzellensis	SMNS 52970, SMNS 80260-80339
Postosuchus kirkpatricki	TTUP 9000, TTUP 9002, UCMP various (from loc. A269)
Dromicosuchus grallator	UNC 15574
Eudimorphodon spp.	Wild 1978, Dalla Vecchia, 2003, Wellnhofer, 2003
Dimorphodon macronyx	BMNH R 1034, BMNH R 1035, BMNH 41212, YPM 350, YPM 9182
Lagerpeton chanarensis	UNLR 06, PVL 4619, PVL 4625
Dromomeron gregorii	TMM 31100-1306 (holotype), 31100-278, 31100-464, 31100-764, 31100-1234, 31100-1308, 31100-1314
Dromomeron romeri	GR 218-223, 234, 238-239
Marasuchus lilloensis	PVL 3870, PVL 3871
Eucoelophysis baldwini	NMNNH P-22298
Sacisaurus agudoensis	MCN PV10041, PV10009-10011, PV10013-10016, PV10018-10020, PV10023-10025, PV10033, PV10042-10044, PV10061, PV10063, PV10075
Silesaurus opelensis	ZPAL Ab III 361, ZPAL Ab III 363, ZPAL Ab III 364, ZPAL various referred material from type locality
Asilisaurus kongwe	NMT RB9-NMT RB21
Lewisuchus admixtus	UNLR 01
Pseudolagosuchus major	PVL 4629, 3454, UNLR 53
Lesothosaurus diagnosticus	BMNH RU B17, RU B23, R11956, R8501
Pisanosaurus mertii	PVL 2577
Heterodontosaurus tucki	SAM PK-K337, PK-K1332
Saturnalia tupiniquim	MCP 3844-PV, MCP 3845-PV, MCP 3846-PV
Efraasia minor	SMNS 11838, SMNS 12354, SMNS 12667, SMNS 12668, SMNS 12684, SMNS 14881, SMNS 17928
Plateosaurus engelhardti	SMNS 13200, GPIT mounted skeletons
Herrerasaurus ischigualastensis	PVL 2566, PVSJ 373, PVSJ 407
Eoraptor lunensis	PVSJ 512
Tawa hallae	GR 155, GR 241, GR 242, GR 243, GR 244
Coelophysis bauri	AMNH FR 7223, 7224, 7239, 7241, 7242; MNA V3315, MNA block; various LACM, CMNH, and CM specimens
Dilophosaurus wetherilli	UCMP 37302, 37303, 77270; Tykoski 2005
Allosaurus fragilis	UCMP 147068 (cast of MOR 693); UMNH Cleveland- Lloyd material; Gilmore, 1920; Madsen, 1976
Velociraptor mongoliensis	IGM 100/24, IGM 100/25, IGM 100/976, IGM 100/982, IGM 100/985, PIN 3143/8, ZPAL MgD-8/97, AMNH FR 6515

Character list

1. Premaxilla, anterodorsal process (=nasal process), length: less than the anteroposterior length of the premaxilla (0); greater than the anteroposterior length of the premaxilla (1). (Nesbitt and Norell, 2006; Nesbitt, 2009: 1)

2. Premaxilla, posterodorsal process (=maxillary process, = subnarial process), length: less than or about the same as the anteroposterior length of the premaxilla (0); greater than the anteroposterior length of the premaxilla (1). (Nesbitt, 2009: 2)

3. Premaxilla, posterodorsal process (=maxillary process, = subnarial process): wide, plate-like (0); thin (1). (modified from Parrish, 1993; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 3)

4. Premaxilla, posterodorsal process (=maxillary process, = subnarial process): extends posteriorly to the external naris (0); restricted to the ventral border of the external naris (1). (modified from Gauthier, 1986; Rauhut, 2003; Langer and Benton, 2006; Smith et al., 2007; Nesbitt, 2009: 4)

5. Premaxillary teeth, number: 3(0); 4 (1); 5 (2); 6+ (3); 0 (4). (Nesbitt and Norell, 2006; Nesbitt, 2009: 6)

6. Premaxilla, narial fossa: absent or shallow (0); expanded in the anteroventral corner of the naris (1). (modified from Sereno, 1999; Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 9)

7. Premaxilla-maxilla, subnarial gap between the elements in lateral view: absent (0); present (1). (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 11)

8. Premaxilla-maxilla, subnarial foramen between the elements: absent (0); present and the border of the foramen is present on both the maxilla and the premaxilla (1); present and the border of the foramen is present on the maxilla but not on the premaxilla (2); present and the border of the foramen is present on the premaxilla but not on the maxilla (3). (modified from Benton and Clark, 1988; Parrish, 1993; Juul, 1994; Benton, 1999; Nesbitt, 2009: 12)

9. Maxilla, facial portion anterior to anterior edge of antorbital fenestra: shorter than posterior portion (0); equal in length or longer than portion posterior to anterior edge of fenestra (1). (character states reversed from Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Clark et al., 2004; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 14)

10. Maxillary teeth, posterior edge of posterior maxillary teeth: concave or straight (0); convex (1). (modified from Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 15)

11. Maxilla, posterior process: articulates ventral to the jugal (0); articulates into a slot on the lateral side of the jugal (1). (Nesbitt, 2009: 16)

12. Maxilla, interdental plates: separate (0); fused (1). (Nesbitt, 2009: 22)

13. Maxilla, buccal emargination separated from the ventral margin of the antorbital fossa: absent (0); present (1). (Butler, 2005, 2007; Irmis et al., 2007a; Irmis et al., 2007b, Nesbitt, 2009: 23)

14. Maxilla, anterodorsal margin: separated from the external naris by the premaxilla (0); borders the external naris (1). (modified from Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 24)

15. Maxilla, anterodorsal margin at the base of the dorsal process: convex or straight (0);

concave (1). (modified from Langer and Benton, 2006; Nesbitt, 2009: 25)

16. Lateral surface of the maxilla: smooth (0); sharp longitudinal ridge present (1); bulbous longitudinal ridge present (2). (Gower, 1999; Weinbaum and Hungerbühler, 2007; Nesbitt, 2009: 26)

17. Maxilla, posterior portion ventral to the antorbital fenestra: tapers posteriorly (0); has a similar dorsoventral depth as the anterior portion ventral to the antorbital fenestra (1); expands dorsoventrally at the posterior margin of the maxilla (2). (Nesbitt, 2009: 27)

18. Maxilla, promaxillary foramen: absent (0); present (1). (Carpenter, 1992; Rauhut, 2003; Tykoski, 2005; Smith et al., 2007; Nesbitt, 2009: 28)

19. Maxilla, dorsal (=ascending) process: tapers posterodorsally (0); remains the same width (1). (Nesbitt, 2009: 29)

20. Antorbital fenestra, anterior margin: gently rounded (0); nearly pointed (1). (modified from Benton and Clark, 1988; Alcober, 2000; Benton and Walker, 2002; Weinbaum and Hungerbühler, 2007; Nesbitt, 2009: 30)

21. Maxilla, palatal processes: do not meet at the midline (0); meet at the midline (1); meet at the midline and expand anteriorly and posteriorly (2). ORDERED (modified from Parrish, 1993; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 32)

22. Nasals, posterior portion at the midline: convex or flat (0); concave (1). (Nesbitt, 2009: 34)

23. Nasal, dorsolateral margin of the anterior portion (just posterodorsal to the external naris): smoothly rounded (0); distinct anteroposteriorly ridge on the lateral edge (1). (Nesbitt, 2009: 35)

24. Nasal: does not possess a posterolateral process that envelops part of the anterior ramus of the lacrimal (0); possesses a posterolateral process that envelops part of the anterior ramus of the lacrimal (1). (Yates, 2003; Langer and Benton, 2006; Nesbitt, 2009: 36)

25. Nasal: does not form part of the dorsal border of the antorbital fossa (0); forms part of the dorsal border of the antorbital fossa (1). (modified from Sereno et al., 1994; Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 37)

26. Lacrimal: does not fold over the posterior/posterodorsal part of the antorbital fenestra (0); folds over the posterior/posterodorsal part of the antorbital fenestra (1). (modified from Sereno et al., 1994; Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 37)

27. Lacrimal, height: significantly less than the height of the orbit, and usually fails to reach the ventral margin of the orbit (0); as high as the orbit, and contacts the jugal at the level of the ventral margin of the orbit (1). (Rauhut, 2003; Nesbitt, 2009: 39)

28. Prefrontal: does not contact the palate (0); contacts the palate (1). (Wu and Chatterjee, 1993; Nesbitt, 2009: 41)

29. Frontal, dorsal surface: flat (0); with longitudinal ridge along midline (1). (Wu and Chatterjee, 1993; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 42)

30. Frontal, anterior portion: about as wide as the orbital margin or has a transversely aligned suture with the nasal (0); tapers anteriorly along the midline (1). (Nesbitt, 2009: 43)

31. Postfrontal: present (0); absent (1). (Gauthier, 1986; Benton and Clark, 1988; Juul, 1994; Bennett, 1996; Novas, 1996; Benton, 1999; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Langer and Benton, 2006; Nesbitt, 2007; Irmis et al., 2007a; Nesbitt, 2009: 44)

32. Quadratojugal: forms less than 80% of the posterior border of the lower temporal fenestra (0); more than 80% of the posterior border of the lower temporal fenestra (1). (modified from Benton and Clark, 1988; Parrish, 1993; Nesbitt, 2009: 45).

33. Squamosal, posterior end: does not extend posterior to the head of the quadrate (0); extends posterior to the head of the quadrate (1). (Nesbitt, 2009: 48)

34. Squamosal: without distinct ridge on dorsal surface along edge of supratemporal fossa (0); with distinct ridge on dorsal surface along edge of supratemporal fossa (1). (modified Bonaparte, 1982; Benton and Clark, 1988; Parrish, 1993; Juul, 1994; Benton, 1999; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 49)

35. Squamosal, facet for the paroccipital process on the medial side of the posterior process: mediolaterally thin (0); rounded and thick (1). (Nesbitt, 2009: 54)

36. Squamosal, ventral process: wider than one quarter of its length (0); narrower than one quarter of its length (1). (Yates, 2003; Langer and Benton, 2006; Nesbitt, 2009: 56)

37. Parietals, upper temporal fenestrae separated by: broad, flat area (0); supratemporal fossa separated by a mediolaterally thin strip of flat bone (1); has supratemporal fossa separated by a "sagittal crest" (which may be divided by interparietal suture)

(2). (modified from Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 59)

38. Postorbital, ventral termination of the ventral process: tapered (0); blunt (1). (modified from Benton and Clark, 1988; Juul, 1994; Benton, 1999; Alcober, 2000; Benton and Walker, 2002; Nesbitt, 2009: 65)

39. Postorbital-squamosal, contact: restricted to the dorsal margin of the elements (0); continues ventrally for much or most of the ventral length of the squamosal (1). (Nesbitt, 2009: 66)

40. Postorbital bar: composed both of the jugal and postorbital in nearly equal proportions (0); composed by mostly the postorbital (1). (Nesbitt, 2009: 67)

41. Jugal, anterior extent of the slot for the quadratojugal: well posterior of the posterior edge of the dorsal process of the jugal (0) or at or anterior to the posterior edge of the dorsal process of the jugal (1). (Nesbitt, 2009: 68)

42. Jugal, anterior process: participates in posterior edge of antorbital fenestra (0); excluded from the antorbital fenestra by lacrimal or maxilla (1). (Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Rauhut, 2003; Langer and Benton, 2006; Nesbitt, 2009: 69).

43. Jugal, posterior process: lies dorsal to the anterior process of the quadratojugal (0); ventral to the anterior process of the quadratojugal (1); splits the anterior process of the quadratojugal (2); is split by the anterior process of the quadratojugal (3). (New formulation, Nesbitt, 2009: 71)

44. Jugal, posterior termination: anterior to or at the posterior extent of the lower temporal fenestra (0); posterior to the lower temporal fenestra (1). (Nesbitt, 2009: 72)

45. Jugal, long axis of the body: nearly horizontal (0); anterodorsally inclined (1). (modified from Heckert and Lucas, 1999; Parker, 2007; Nesbitt, 2009: 74)

46. Jugal, longitudinal ridge on the body: absent (0); present and sharp (1); rounded and broad (2); rounded and restricted to a bulbous ridge (3). (Nesbitt, 2009: 75)

47. Quadrate, head: partially exposed laterally (0); completely covered by the squamosal (1). (Sereno and Novas, 1994; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt, 2009: 78)

48. Quadratojugal and quadrate, suture between the elements, foramen: present (0); absent (1). (modified from Parrish, 1991; Benton and Walker, 2002; Nesbitt, 2009: 79)

49. Quadrate, angled: posteroventrally or vertical (0); anteroventrally (1). (Nesbitt, 2007; Nesbitt, 2009: 82)

50. Pterygoid-ectopterygoid, articulation: ectopterygoid ventral to pterygoid (0); ectopterygoid dorsal to pterygoid (1). (Sereno and Novas, 1994; Novas, 1996; Benton, 1999; Irmis et al., 2007a; Nesbitt, 2009: 84)

51. Ectopterygoid, ventral recess: absent (0); present (1). (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 86)

52. Ectopterygoid, body: simply arcs anteriorly (0); arcs anterodorsally (1). (Nesbitt, 2009: 87)

53. Ectopterygoid: single-headed (0); double-headed (1). (Weinbaum and Hungerbühler, 2007: 89)

54. Basipterygoid, processes directed: anteriorly or ventrally at their distal tips (0); posteriorly at their distal tips (1). (Nesbitt, 2009: 93)

55. Parabasisphenoid, foramina for entrance of cerebral branches of internal carotid artery into the braincase positioned on the surface: ventral (0); posterolateral (1); anterolateral (2). (modified from Parrish, 1993; Gower and Sennikov, 1996; Gower, 2002; Nesbitt, 2009: 95)

56. Parabasisphenoid, plate: present and straight (0); present and arched anteriorly (1); absent (2). (modified from Gower and Sennikov, 1996; Nesbitt, 2009: 96)

57. Parabasisphenoid, semilunar depression on the lateral surface of the basal tubera: present (0); absent (1). (Gower and Sennikov, 1996; Nesbitt, 2009: 98)

58. Parabasisphenoid, recess (=median pharyngeal recess of some authors = hemispherical sulcus = hemispherical fontanelle): absent (0); present (1). (modified from Nesbitt and Norell, 2006; Nesbitt, 2009: 100)

59. Parabasisphenoid, anterior tympanic recess on the lateral side of the braincase: absent (0); present (1). (Makovicky and Sues, 1998; Rauhut, 2003; Nesbitt, 2009: 101)

60. Parabasisphenoid, 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; Nesbitt, 2007; Nesbitt, 2009: 103)

61. Basioccipital, portion of the basal tubera: rounded and anteroposteriorly elongated (0); blade-like and anteroposteriorly shortened (1). (Nesbitt, 2009: 106)

62. Opisthotic, paroccipital processes: no or slight dorsal and ventral expansion distally (0); markedly expanded dorsally at the distal ends (1). (character states reversed from Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004: Nesbitt, 2009: 108)

63. Opisthotic, paroccipital processes: directed laterally or dorsolaterally (0); directed ventrolaterally (1). (Rauhut, 1997; Rauhut, 2003; Hwang et al., 2004; Smith et al., 2007; Nesbitt, 2009: 110)

64. Opisthotic, ventral ramus (= crista interfenestralis): extends further laterally or about the same as lateralmost edge of exoccipital in posterior view (0); covered by the lateralmost edge of exoccipital in posterior view (1). (Gower, 2002; Nesbitt, 2009: 111)

65. Exoccipital, relative positions of the exits of the hypoglossal nerve (XII): aligned in a near anteroposteriorly plane (0); aligned sub vertically (1). (Nesbitt, 2009: 113)

66. Exoccipital, lateral surface: without subvertical crest (= metotic strut) (0); with clear crest (= metotic strut) lying anterior to both external foramina for hypoglossal nerve (XII)(1); with clear crest (= metotic strut) present anterior to the more posterior external foramina for hypoglossal nerve (XII) (2). (modified from Gower, 2002; Nesbitt, 2009: 114)

67. Exocciptials: meet along the midline on the floor of the endocranial cavity (0); do not meet along the midline on the floor of the endocranial cavity (1). (modified from Gower and Sennikov, 1996; Gower, 2002; Nesbitt, 2009: 115)

69. Vestibule, medial wall: incompletely ossified (0); almost completely ossified (1). (Gower, 2002; Nesbitt, 2009: 117)

70. Lagena/cochlea recess: absent or short and strongly tapered (0); present and elongated and tubular (1). (Gower, 2002; Nesbitt, 2009: 118)

71. Supraoccipital: excluded from dorsal border of foramen magnum by mediodorsal midline contact between opposite exoccipitals (0); contributes to border of foramen magnum (1). (Gower, 2002; Nesbitt, 2009: 126)

72. Supraoccipital, rugose ridge on the anterolateral edges: absent (0); present (1). (Nesbitt, 2009: 127)

73. Foramen for trigeminal nerve and middle cerebral vein: combined and undivided (0); at least partially subdivided by prootic (1); fully divided (2). (modified from Gower and Sennikov, 1996; Gower, 2002; Nesbitt, 2009: 131)

74. Foramen or groove passing above and into the dorsal end of the metotic foramen: absent (0); present (1). (modified from Gower and Sennikov, 1996; Gower, 2002;

Nesbitt, 2009: 131)

75. Auricular recess: largely restricted to prootic (0); extends onto internal surface of epiotic/supraoccipital (1). (Gower, 2002; Nesbitt, 2009: 133)

76. Skull length: less than 50% of length of the presacral vertebral column (0); more than 50% of length of the presacral vertebral column (1). (Sereno, 1991; Benton, 1999; Nesbitt, 2009: 134)

77. Skull length: longer than two-thirds of the femoral length (0); shorter than two-thirds of the femoral length (1). (Gauthier, 1986; Nesbitt, 2009: 135)

78. Antorbital fossa: restricted to the lacrimal (0); restricted to the lacrimal and dorsal process of the maxilla (1); present on the lacrimal, dorsal process of the maxilla and the dorsolateral margin of the posterior process of the maxilla (the ventral border of the antorbital fenestra) (2). ORDERED (Nesbitt, 2009: 137)

79. Post-temporal opening, size: equal or greater than half the diameter of the foramen magnum (0); less than half the diameter of the foramen magnum or absent (1). (modified from Sereno and Novas, 1994; Novas, 1996; Benton, 1999; Nesbitt, 2009: 141)

80. Orbit, shape: circular or elliptical (0); tall and narrow (the "'keyhole-shaped orbit'"; maximum width is less than half the maximum height)(1); with distinct ventral point surrounded by V-shaped dorsal processes of jugal (2). (Benton and Clark, 1988; Parrish, 1993; Gower, 2000; Benton and Walker, 2002; Nesbitt, 2009: 142)

81. Supratemporal fossa: absent anterior to the supratemporal fenestra (0); present anterior to the supratemporal fenestra (1). (Long and Murry, 1995; Heckert and Lucas, 1999; Parker, 2007; Nesbitt, 2009: 143)

82. Postparietal(s): present (0); absent (1). (modified from Juul, 1994; Bennett, 1996; Dilkes, 1998; Nesbitt, 2009: 146)

83. Palpebral(s): absent (0); present (1). (Nesbitt, 2009: 147)

84. Predentary: absent (0); present (1). (Sereno, 1986; Butler et al., 2007, 2008b; Nesbitt, 2009: 151)

85. Anterior half of the dentary, position of the Meckelian groove: dorsoventral center of the dentary (0); restricted to the ventral border (1). (Nesbitt, 2009: 152)

86. Dentary, anterior extent of the Meckelian groove: ends well short of the dentary symphysis (0); present through the dentary symphysis (1). (Nesbitt, 2009: 152)

87. Dentary, dorsal margin of the anterior portion compared to the dorsal margin of the posterior portion of the dentary: horizontal (about in the same plane)(0); ventrally deflected (1); dorsally expanded (2). (Nesbitt, 2009: 154)

88. Dentary, anterior extremity: rounded (0); tapers to a sharp point (1). (Nesbitt, 2009: 155)

89. Articular: without dorsomedial projection posterior to the glenoid fossa (0); with dorsomedial projection separated from glenoid fossa by a clear concave surface (1); with dorsomedial projection continuous with the glenoid fossa (2). ORDERED (Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 156)

90. Articular, ventromedially directed process: absent (0); present (1). (Nesbitt, 2009: 157)

91. Articular, glenoid of the mandible located: level with dorsal margin of the dentary (0); well ventral of the dorsal margin of the dentary (1). (modified from Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 158)

92. Articular, foramen on the medial side: absent (0); present and medial to the glenoid (1). (Nesbitt, 2009: 159)

93. Coronoid process, dorsally expanded: absent (0); present (1). (Sereno, 1986; Sereno, 1999; Butler, 2005; Butler et al., 2008; Irmis et al., 2007a; Nesbitt, 2009: 161)

94. Mandibular fenestra: anteroposterior length more than maximum depth of dentary ramus but less than half the length of the mandible (0); greater than half the length of the mandible (1); reduced, anteroposterior length less than maximum depth of dentary ramus (2). (Butler, 2005; Nesbitt and Norell, 2006; Nesbitt, 2009: 162)

95. Splenial, foramen in the ventral part: absent (0); present (1). (modified from Rauhut, 2003; Langer and Benton, 2006; Smith et al., 2007; Nesbitt, 2009: 165)

96. Dentary teeth: present along entire length of the dentary (0); absent in the anterior portion (1); completely absent (2). (modified from Parrish, 1994; Parker, 2007; Nesbitt, 2009: 166)

97. Dentition: generally homodont (0); markedly heterodont (1). (Parrish, 1993; Nesbitt, 2009: 167)

98. Tooth, serrations: absent (0); present as small fine knife-like serrations (1); present and enlarged and coarser (lower density) = denticles (2). ORDERED (modified from Gauthier et al., 1988; Juul, 1994; Dilkes, 1998; Irmis et al., 2007a; Nesbitt, 2009: 168)

99. Extensive planar wear facets across multiple maxillary/dentary teeth: absent (0); present (1). (Weishampel and Witmer, 1990; Nesbitt, 2009: 169)

100. Medial or lateral overlap of adjacent crowns in maxillary and dentary teeth: absent (0); present (1). (Sereno, 1986; Butler et al., 2008; Nesbitt, 2009: 170)

101. Tooth, crown: not mesiodistally expanded (0); mesiodistally expanded above root in cheek teeth (1). (Sereno, 1986; Butler et al., 2008; Nesbitt, 2009: 171)

102. Moderately developed lingual expansion of crown (=cingulum) on maxillary/dentary teeth: absent (0); present (1). (Sereno, 1986; Butler et al., 2008; Nesbitt, 2009: 172)

103. Maxillary and dentary crowns, shape: apicobasally tall and blade-like (0); apicobasally short and subtriangular (1). (Sereno, 1986; Butler et al., 2008; Nesbitt, 2009: 173)

104. Tooth, implantation: teeth fused to the bone of attachment at the base (0); free at the base of the tooth (1). (modified from Gauthier, 1984; Benton and Clark, 1988; Benton, 1990; Bennett, 1996; Nesbitt, 2009: 174)

105. Pterygoid, teeth, on palatal process of the pterygoid: present (0); absent (1). (Juul, 1994; Gower and Sennikov, 1997; Nesbitt, 2009: 175)

106. Postaxial intercentra: present (0); absent (1). (Gauthier, 1984; Benton and Clark, 1988; Sereno, 1991; Parrish, 1993; Juul, 1994; Bennett, 1996; Nesbitt, 2009: 177)

107. Atlantal articulation facet in axial intercentrum, shape: saddle-shaped (0); concave with upturned lateral borders (1). (modified from Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 178)

108. Axis, dorsal margin of the neural spine: expanded posterodorsally (0); arcs dorsally, where the anterior portion height is equivalent to the posterior height (1). (Nesbitt, 2009: 180)

109. Cervical vertebrae, 3-5 centrum length: shorter or the same length as the mid-dorsal (0); longer than mid-dorsal (1). (Sereno, 1991; Nesbitt, 2009: 181)

110. Cervical vertebrae, deep recesses on the anterior face of the neural arch, lateral to the neural canal (=prechonos of Welles 1984): absent (0); present (1). (Nesbitt, 2009: 182)

111. Third cervical vertebra, centrum length: subequal to the axis centrum (0); longer than the axis centrum (1). (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 183)

112. Anterior to middle cervical vertebrae, diapophysis and parapophysis: well separated (0); nearly touching (1). (Nesbitt, 2009: 184)

113. Anterior cervical vertebrae, neural arch, posterior portion ventral to the postzygapophysis: smooth posteriorly or has a shallow fossa (0); with a deep excavation with a thin bone lamina covering the anterior extent on the posterolateral surface (1). (modified from Langer and Benton, 2006; Nesbitt, 2009: 185)

114. Epipophyses: absent in post-axial anterior cervical vertebrae (0); present in post-axial anterior cervical vertebrae (1). (Gauthier, 1986; Novas, 1996; Langer and Benton, 2006; Nesbitt, 2009: 186)

115. Epipophyses: absent in posterior cervical vertebrae (cervicals 6-9) (0); present in posterior cervical vertebrae (cervicals 6-9) (1). (Sereno et al., 1993; Langer and Benton, 2006; Nesbitt, 2009: 187)

116. Cervical vertebrae, pneumatic features (=pleurocoels) in the anterior portion of the centrum: absent (0); present as deep fossae (1); present as foramina (2). ORDERED (modified from Holtz, 1994; Rauhut, 2003; Smith et al., 2007; Nesbitt, 2009: 188)

117. Cervical vertebrae, rimmed depression on the posterior part of the centrum: absent (0); present (1). (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2009: 189).

118. Cervical vertebrae, middle portion of the ventral keel: dorsal to the ventralmost extent of the centrum rim (0); ventral to the centrum rims (1). (Nesbitt, 2009: 190)

119. Cervical vertebrae, distal end of neural spines: expansion absent (0); present and laterally expanded in the middle of the anteroposterior length (1); present and expanded anteriorly so that the spine table is triangular or heart-shaped in dorsal view (2). (modified from Gauthier, 1984; Juul, 1994; Nesbitt, 2009: 191)

120. Posterior cervical and/or dorsal vertebrae, hyposphene-hypantrum accessory intervertebral articulations: absent (0); present (1). (modified from Weinbaum and Hungerbühler, 2007: Nesbitt, 2009: 193)

121. Cervical ribs: slender and elongated (0); short and stout (1). (Gauthier, 1986; Benton and Clark, 1988; Juul, 1994; Benton, 1999; Nesbitt, 2009: 196)

122. Dorsal vertebrae, neural spine distal expansion: absent (0); present with a flat dorsal margin (1); present with a rounded dorsal margin (2). (Nesbitt, 2009: 197)

123. Middle dorsal vertebrae, diapophyses and parapophyses: close to the midline (0); expand on stalks (1). (Nesbitt, 2009: 199)

124. Sacral centra: separate (0); co-ossified at the ventral edge (1). (Nesbitt, 2009: 200)

125. Sacral vertebrae, prezygapophyses and complimentary postzygapophyses: separate (0); co-ossified (1). (Nesbitt, 2009: 201)

126. Primordial sacral one, sacral rib: doesn't or weakly articulates with anteriorly directed process (=preacetabular process) of the ilium (0); articulates with the anteriorly directed process of the ilium (1). (Nesbitt, 2005, 2007, 2009: 202)

127. Sacral vertebrae, centra articular rims: present in sacrum (0); nearly obliterated (1). (Nesbitt, 2007, 2009: 204)

128. Trunk vertebrae: free from the sacrum (0); incorporated into the sacrum, with their ribs/transverse processes articulating with the pelvis (1). (Sereno et al., 1993; Langer and Benton, 2006; Nesbitt, 2009: 205)

129. Caudal vertebrae: free from the sacrum (0); incorporated into the sacrum, with their ribs/transverse processes articulating with the pelvis (1). (Galton, 1976; Langer and Benton, 2006; Nesbitt, 2009: 206)

130. Insertion of a sacral vertebra between the first and second primordial sacral vertebrae: absent (0); present (1). (Nesbitt, 2009: 207)

131. Sacral ribs: almost entirely restricted to a single sacral vertebra (0); shared between two sacral vertebrae (1). (Nesbitt, 2009: 208)

132. First primordial sacral, articular surface of sacral rib: circular (0); C- shaped in lateral view (1). (modified from Langer and Benton, 2006; Nesbitt, 2009: 209)

133. Middle caudal vertebrae, accessory laminar process on anterior face of neural spine: absent (0); present (1). (Benton and Clark, 1988; Juul, 1994; Benton, 1999; Benton and Walker, 2002; Rauhut, 2003; Irmis et al., 2007a; Nesbitt, 2009: 210)

134. Distal caudal vertebrae, prezygapophyses: not elongated (0); elongated more than a quarter of the adjacent centrum (1). (Gauthier, 1986; Rauhut, 2003; Nesbitt, 2007; Nesbitt, 2009: 211)

135. Forelimb-hindlimb length ratio: more than 0.55(0); less than 0.55(1). (Gauthier, 1984; Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 212)

136. Clavicles: present and unfused (0); fused into a furcula (1); clavicles absent (2). (modified from Gauthier, 1986; Sereno, 1991; Benton, 1999; Benton and Walker, 2002; Nesbitt, 2009: 213)

137. Interclavicle: present (0); absent (1). (Gauthier, 1986; Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 214)

138. Scapula, entire anterior margin: straight/convex or partially concave (0); markedly concave (1). (modified from Gower and Sennikov, 1997; Nesbitt, 2009: 217)

139. Scapula, blade height versus distal width: less than 3 times distal width (0); more than 3 times distal width (1). (Sereno, 1999; Nesbitt, 2009: 218)

140. Scapulocoracoid, anterior margin: distinct notch between the two elements (0); uninterrupted edge between the two elements (1). (Parrish, 1993; Benton, 1999; Nesbitt, 2009: 221)

141. Coracoid: subcircular in lateral view (0); with post-glenoid process (notch ventral to glenoid) (1). (Nesbitt, 2009: 222)

142. Coracoid, post-glenoid process: short (0); elongate and expanded posteriorly only (1); elongate and expanded posteriorly and anteriorly (2). ORDERED (modified from Clark et al., 2004; Nesbitt, 2009: 223)

143. Coracoid, posteroventral portion: smooth (0); possesses a "swollen" tuber (=biceps tuber) (1). (Nesbitt, 2009: 225)

144. Glenoid, orientation: posterolaterally (0); directed posteroventrally (1). (Fraser et al., 2002; Nesbitt, 2009: 227)

145. Humerus, apex of deltopectoral crest situated at a point corresponding to: less than 30% down the length of the humerus (0); more than 30% down the length of the humerus (1). (modified from Bakker and Galton, 1974; Benton, 1990; Juul, 1994; Novas, 1996; Benton, 1999; Nesbitt, 2009: 230)

146. Humerus, length: longer than or subequal to 0.6 of the length of the femur (0); shorter than 0.6 of the length of the femur (1). (modified from Novas, 1994; Langer and Benton, 2006; Nesbitt, 2009: 231)

147. Humerus, proximal head: confined to the proximal surface (0); posteriorly expanded and hooked (1). (Nesbitt, 2009: 232)

148. Humerus, proximal articular surface: continuous with the deltopectoral crest (0); separated by a gap from the deltopectoral crest (1). (Nesbitt, 2009: 232)

149. Humerus, ectepicondylar flange: present (0); absent (1). (Benton and Clark, 1988; Gauthier et al., 1988; Nesbitt, 2009: 234)

150. Humerus, distal end width: narrower or equal to 30% of humerus length (0); greater than 30% of humerus length (1). (Langer and Benton, 2006; Nesbitt, 2009: 235)

151. Ulna, lateral tuber (=radius tuber) on the proximal portion: absent (0); present (1). (Nesbitt, 2009: 238)

152. Ulna, distal end in posterolateral view: rounded and convex (0); squared off where the distal surface is nearly flat (1). (Nesbitt, 2009: 238)

153. Ulna, distal end: anteroposteriorly compressed or oval-shaped (0); with anterior expansion (1). (Nesbitt, 2009: 239)

154. Radius, distal end: convex (0); shallow longitudinal groove on the posterior side (1). (Nesbitt, 2009: 240)

155. Radius, length: longer than 80% of humerus length (0); shorter than 80% of humerus length (1). (Langer and Benton, 2006; Nesbitt, 2009: 241

156. Pteroid bone: absent (0); present (1). (Bennett, 1996; Nesbitt, 2009: 244)

157. Longest metacarpal: longest metatarsal >.5(0); <.5 (1). (Nesbitt, 2009: 245)

158. Metacarpals, proximal ends: overlap (0); abut one another without overlapping (1). (Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 246)

159. Manual length (measured as the average length of digits I" accounts for less than 0.3 of the total length of humerus plus radius (0); more than 0.3 but less than 0.4 of the total length of humerus plus radius (1); more than 0.4 of the total length of humerus plus radius (2). ORDERED (modified from Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 247)

160. Medialmost distal carpal: subequal other distal carpals (0); significantly larger than other distal carpals (1). (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 248)

161. Distal carpal V: present (0); absent (1). (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2009: 249)

162. Extensor pits on the proximodorsal portion of metacarpals I-III: absent or shallow and symmetrical (0); deep and asymmetrical (1). (modified from Sereno et al., 1993; Langer and Benton, 2006; Nesbitt, 2009: 250)

163. Metacarpal I, width at the middle of the shaft accounts for: less than 0.35 of the total length of the bone (0); more than 0.35 of the total length of the bone (1). (modified from Bakker and Galton, 1974; Langer and Benton, 2006; Nesbitt, 2009: 251)

164. Digit I with metacarpal: longer than the ungual (0); subequal or shorter than the ungual (1). (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2009: 252)

165. Manual digit I, first phalanx: is not the longest non-ungual phalanx of the manus (0); is the longest non-ungual phalanx of the manus (1). (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2009: 253)

166. Metacarpal I, distal condyles: approximately aligned or slightly offset (0); lateral condyle strongly distally expanded relative to medial condyle (1). (modified from Bakker and Galton, 1974, Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 254)

167. Metacarpal II: shorter than metacarpal III (0); equal to or longer than metacarpal III (1). (Gauthier, 1986; Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 256)

168. Manual digits I-III: blunt unguals on at least digits II and III (0); trenchant unguals on digits I-III (1). (Gauthier, 1986; Juul, 1994; Benton, 1999; Irmis et al., 2007a)

169. Manual digit IV: five phalanges (0); four phalanges (1); three or two phalanges (2); one phalanx (3). ORDERED (Gauthier, 1986; Benton and Clark, 1988; Sereno, 1993; Novas, 1996; Benton, 1999; Irmis et al., 2007a; Nesbitt, 2009: 258)

170. Metacarpal IV: present (0); reduced to a nubin or absent (1). (Gauthier, 1986; Nesbitt, 2009: 259)

171. Metacarpal IV, shaft width: about the same width than that of metacarpals I-III (0); significantly narrower than that of metacarpals I-III (1). (modified from Sereno et al., 1993; Langer and Benton, 2006; Nesbitt, 2009: 261)

172. Manual digit IV length: less than or equal to 50% of total forelimb length (0); more than 50% of total forelimb length (1). (Bennett, 1996; Irmis et al., 2007a; Nesbitt, 2009: 262)

173. Ilium, supra-acetabular crest (=supra-acetabular rim): projects laterally or ventrolaterally (0); projects ventrally (1). (Gauthier, 1986; Nesbitt, 2009: 264)

174. Ilium, crest dorsal to the supra-acetabular crest: absent (0); present and divides the anterior (=preacetabular) process from the posterior (=postacetabular) process (1); confluent with anterior extent of the anterior (=preacetabular) process of the ilium (2). (New formulation, Nesbitt, 2009: 265)

175. Ilium, anterior (=preacetabular, =cranial) process: short and does not extend anterior of the acetabulum (0); long and extends anterior of the acetabulum (1); sub-equal or longer than the posterior process of the ilium (2). ORDERED (modified from Galton, 1976; Benton, 1985; Sereno, 1986; Juul, 1994; Gower, 2000; Hutchinson,

2001b; Langer and Benton, 2006; Nesbitt and Norell, 2006; Butler et al., 2008; Nesbitt, 2009: 269)

176. Ilium, orientation: mainly vertically orientated (0-20^{o}) (0); ventrolaterally deflected about 45^{o}(1). (modified from Benton and Clark, 1988; Juul, 1994; Benton and Walker, 2002; Nesbitt, 2009: 270)

177. Ilium, distinct fossa present for the attachment of the m caudifemoralis brevis: absent (0); present as an embankment on the lateral side of the posterior portion of the ilium (1); present as a deep fossa on the ventral surface of postacetabular part of the ilium (2). ORDERED (modified from Gauthier and Padian, 1985; Gauthier, 1986: Juul, 1994; Novas, 1996; Benton, 1999; Hutchinson, 2001b; Nesbitt, 2009: 271)

178. Ilium, ridge connecting the posterior portion of the supra-acetabular rim to the posterior portion of the ilium: absent (0); present (1). (modified from Langer and Benton, 2006; Nesbitt, 2009: 272)

179. Ilium, ventral margin of the acetabulum: convex (0); straight (1); concave (2). (Bakker and Galton, 1974; Gauthier and Padian, 1985; Gauthier, 1986; Juul, 1994; Novas, 1996; Benton, 1999; Benton et al., 2000; Fraser et al., 2002; Langer and Benton, 2006; Nesbitt, 2009: 273)

180. Ilium, acetabular antitrochanter: absent (0); present (1). (Sereno and Arcucci, 1994a; Novas, 1996; Benton, 1999; Fraser et al., 2002; Irmis et al., 2007a; Nesbitt, 2009: 274)

181. Ilium, dorsal margin dorsal to the supra-acetabular rim: rounded, or blade-like (0); flat (1). (Nesbitt, 2009: 275)

182. Ilium, dorsal portion: height about the same or shorter than the dorsal portion of the supra-acetabular rim to the pubis-ischium contact (0); expanded dorsally, height markedly taller than the dorsal portion of the supra-acetabular rim to the pubis-ischium contact (1). (Nesbitt, 2009: 276)

183. Ilium, ischiadic peduncle orientation: mainly vertical in lateral aspect (0); well expanded posteriorly to the anterior margin of the postacetabular embayment (1). (Langer and Benton, 2006; Nesbitt, 2009: 277)

184. Pubis, length: less than 70% of femoral length (0); more than 70% or more of femoral length (1). (Novas, 1996; Nesbitt, 2009: 278)

185. Pubis, orientation: anteroventral (0); rotated posteroventrally to lie alongside the ischium (opisthopubic) (1). (Sereno, 1986; Butler et al., 2008; Nesbitt, 2009: 279)

186. Pubis, prepubic process: absent, anterior margin unexpanded (0); present, anterior margin expanded into a process (1). (Sereno, 1986; Butler et al., 2008; Nesbitt, 2009: 280)

187. Pubis, length: shorter or subequal to the ischium (0); longer than ischium (1). (modified from Benton and Clark, 1988; Juul, 1994; Novas, 1996; Benton, 1999; Benton and Walker, 2002; Nesbitt, 2009: 282)

188. Pubis, distal end: unexpanded (0); expanded relative to the shaft (=pubis boot) (1). (Gauthier, 1986; Sereno and Novas, 1992; Juul, 1994; Benton, 1999; Rauhut, 2003; Langer and Benton, 2006; Nesbitt, 2007, 2009: 283)

189. Pubis, expanded distal margin: mediolaterally thick and rounded (0); mediolaterally thin (1). (Gauthier, 1986; Juul, 1994; Benton, 1999; Nesbitt, 2009: 284)

190. Pubis, expanded distal margin: shorter than 33% of the length of the shaft of the pubis (0); greater than 33% of the length of the shaft of the pubis (1). (Nesbitt and Norell, 2006; Nesbitt, 2007, 2009: 285)

191. Pubis, proximal portion: articular surfaces with the ilium and the ischium continuous (0); articular surfaces with the ilium and the ischium separated by a groove or gap (1). (Nesbitt, 2009: 286)

192. Ischio-pubis contact: present and extended ventrally (0); present and reduced to a thin proximal contact (1); absent (2). (modified from Benton and Clark, 1988; Novas, 1996; Nesbitt, 2009: 287)

193. Pubis, pubic apron, proximal portion: similar anteroposterior thickness as the rest of the pubic apron (0); thickened process (1). (Nesbitt, 2005, 2007, 2009: 288)

194. Pubis, mediolateral width of distal portion: nearly as broad as proximal width (0); significantly narrower than proximal width (1); mediolaterally compressed and not broader than anteroposteriorly deep (2). (Galton, 1976; Novas, 1996; Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2009: 289)

195. Ischium, medial contact with antimere: restricted to the medial edge (0); extensive contact but the dorsal margins are separated (1); extensive contact and the dorsal margins contact each other (2). ORDERED (Nesbitt, 2009: 291)

196. Ischium, cross-section of the distal portion: thin, plate-like (0); rounded or elliptical (1); sub-triangular (2). (modified from Sereno, 1999; Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 293)

197. Ischium, distal portion: unexpanded (0); expanded relative to the ischial shaft (=ischial boot) (1). (Smith and Galton, 1990; Holtz, 1994; Hutchinson, 2001b; Rauhut, 2003; Langer and Benton, 2006; Nesbitt, 2009: 294)

198. Ischium, obturator process: confluent with the pubic peduncle (0); offset from the pubic peduncle by a notch (1). (Gauthier, 1986; Novas, 1993; Rauhut, 2003; Nesbitt, 2009: 295)

199. Ischium, ventral margin: continuous ventral margin (0); notch present (1); abrupt change in angle between the proximal end and the shaft (2). (modified from Sereno et al., 1996; Rauhut, 2003; Nesbitt, 2009: 296)

200. Ischium, proximal articular surfaces: articular surfaces with the ilium and the pubis continuous (0); articular surfaces with the ilium and the pubis continuous but separated by a fossa (1); articular surfaces with the ilium and the pubis separated by a large concave surface (2). ORDERED (modified from Irmis et al., 2007a; Nesbitt, 2009: 297)

201. Ischium length: about the same length or shorter than the dorsal margin of the iliac blade (minus the anterior process) (0); markedly longer than the dorsal margin of iliac blade (minus the anterior process) (1). (Juul, 1994; Nesbitt, 2009: 298)

202. Tibia (or fibula)-femur length: femur longer or about the same length as the tibia/fibula (0); tibia longer (1). (modified from Gauthier, 1986; Sereno, 1991; Juul, 1994; Benton, 1999; Irmis et al., 2007a; Nesbitt, 2009: 299)

203. Femur, proximal portion, anteromedial tuber: absent (0); small and rounded (1); offset medially (or posteriorly) relative to the posteromedial tuber (2); large and "hooked" posteriorly (3). (modified from Gauthier, 1986; Benton, 1999; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 300).

204. Femur, proximal portion, posteromedial tuber: present and small (0); present and largest of the proximal tubera (1); absent (2). (modified from Novas, 1996; Nesbitt, 2005; Irmis et al., 2007a; Nesbitt, 2009: 301)

205. Femur, proximal portion, anterolateral tuber: present as an expansion (0); absent, the anterolateral face is flat (1). (modified from Sereno and Arcucci, 1994a; Irmis et al., 2007a; Nesbitt, 2009: 302)

206. Femur, medial articular surface of the head in dorsal view: rounded (0); flat/straight (1). (Nesbitt, 2009: 303)

207. Femur, ventral to the proximal head: smooth transition from the femoral shaft to the head (0); notch (1); concave emargination (2). (Sereno and Arcucci, 1994a; Novas, 1996; Nesbitt, 2009: 304)

208. Femur, femoral head orientation (angle with respect to the transverse axis through the femoral condyles Parrish 1986): anterior (60 - 90^{o}) (0); anteromedial (20 -

60°) (1); medial (0 - 20°) (2). (modified from Benton and Clark, 1988; Hutchinson, 2001a; Nesbitt, 2009: 305)

209. Femur, femoral head in medial and lateral views: rounded (0); hook-shaped (1). (Sereno and Arcucci, 1994a; Irmis et al., 2007a; Nesbitt, 2009: 306)

210. Femur, dorsolateral margin of the proximal portion: smooth (0); sharp ridge (=dorsolateral trochanter of some) (1); rounded ridge (=dorsolateral trochanter of some) (2). (Nesbitt, 2009: 307)

211. Femur, anterior trochanter (=M. iliofemoralis cranialis insertion): absent (0); present and forms a steep margin with the shaft but is completely connected to the shaft (1); present and forms a steep margin with the shaft and separated from the shaft by a marked cleft (2). (Bakker and Galton, 1974; Gauthier, 1986; Novas, 1992; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt, 2009: 308)

212. Femur, medial articular facet of the proximal portion: rounded (0); straight (1). (Nesbitt, 2009: 309)

213. Femur, anterolateral side of the femoral head: smooth, featureless (0); ventral emargination present (1). (Sereno and Arcucci, 1994a; Irmis et al., 2007a; Nesbitt, 2009: 310)

214. Femur, anterior trochanter shelf proximal to the fourth trochanter (insertion site for the M. iliofemoralis externus): absent (0); present (1). (modified from Gauthier, 1986; Rowe and Gauthier, 1990; Novas, 1992, 1996; Langer and Benton, 2006; Nesbitt, 2009: 311)

215. Femur, posterolateral portion (= fossa trochanterica, = posterolateral depression, = facies antitrochanterica articularis) of the head: level with the greater trochanter (0); ventrally descended (1). (modified from Novas, 1996; Nesbitt, 2009: 313)

216. Femur, proximal surface: rounded and smooth (0); transverse groove that is straight (1); transverse groove that is curved (2). (modified from Novas, 1996; Nesbitt, 2009: 313)

217. Femur, fourth trochanter shape: mound-like and rounded (0); a sharp flange (1); absent, no distinct ridge for the attachment of the M. caudifemoralis (2). (Gauthier, 1986; Benton and Clark, 1988; Sereno, 1991; Juul, 1994; Bennett, 1996; Benton, 1999; Nesbitt, 2009: 316)

218. Femur, fourth trochanter: symmetrical, with distal and proximal margins forming similar low-angle slopes to the shaft (0); asymmetrical, with distal margin forming a steeper angle to the shaft (1). (Langer and Benton, 2006; Nesbitt, 2009: 317)

219. Femur, angle between the lateral condyle and the crista tibiofibularis in distal view: obtuse (0); about a right angle (1). (Parker and Irmis, 2005; Nesbitt, 2009: 319)

220. Femur, medial condyle of the distal portion: tapers to a point on the medial portion in distal view (0); smoothly rounded in distal view (1). (Nesbitt, 2009: 320)

221. Femur, surface between the lateral condyle and crista tibiofibularis on the distal surface: smooth (0); deep groove (1). (Nesbitt, 2009: 322)

222. Femur, bone wall thickness at or near midshaft: thickness/diameter >0.3 (0); thin; thickness/diameter >0.2, <0.3 (1); very thin; thickness/diameter <0.2 (2). (Nesbitt, 2009: 323)

223. Femur, distal condyles of the femur divided posteriorly: less than 1/4 the length of the shaft (0); between 1/4 and 1/3 the length of the shaft (1). (Nesbitt, 2009: 324)

224. Femur, anterior surface of the distal portion: smooth (0); distinct scar orientated mediolaterally (1). (Nesbitt et al., 2009: 325)

225. Femur, crista tibiofibularis (fibular condyle of Sereno and Arcucci 1994a): smaller or equal in size to the medial condyle (0); larger than the medial condyle (1). (modified from Sereno and Arcucci, 1994a; Irmis et al., 2007a; Nesbitt, 2009: 326)

226. Femur, anteromedial corner of the distal end: rounded (0); squared off near 90^{o} or acute $>90^{o}$ (1). (Nesbitt et al., 2009; Nesbitt, 2009: 327)

227. Tibia, proximal portion, cnemial crest: absent or just a slight bump (0); present and straight (1); present arcs anterolaterally (2). (Benton and Clark, 1988; Juul, 1994; Novas, 1996; Benton, 1999; Irmis et al., 2007a; Nesbitt, 2009: 328)

228. Tibia, proximal surface: flat or convex (0); concave, the posterior condyles of the tibia are separated from the cnemial crest by a concave surface (the cnemial process is proximally expanded)(1). (Nesbitt, 2009: 329)

229. Tibia, proximal surface of the lateral condyle: convex or flat (0); depressed (1). (Nesbitt, 2009: 330)

230. Tibia, lateral (fibular) condyle of the proximal portion: offset anteriorly from the medial condyle (0); level with the medial condyle at its posterior border (1). (Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 331)

231. Tibia, lateral margin of the lateral condyle of the proximal portion: rounded (0); squared-off (1). (Nesbitt, 2009: 332)

232. Tibia, lateral side of the proximal portion: smooth (0); dorsoventrally oriented crest present (=fibular crest) (1). (Gauthier, 1986; Rauhut, 2003; Nesbitt, 2009: 333)

233. Tibia, posterolateral flange of the distal portion: absent (0); present and nearly contacts or contacts fibula (1); present and extends well posterior to the fibula (2). (modified from Novas, 1992; Juul, 1994; Benton, 1999; Langer and Benton, 2006; Irmis et al., 2007a; Nesbitt, 2009: 334)

234. Tibia, posterolateral margin of the distal end: straight or convex (0); concave (1). (Irmis et al., 2007a; Nesbitt, 2009: 335)

235. Tibia, posterior face of the distal end: rounded surface (0); distinct proximodistally oriented ridge present (1). (Nesbitt, 2009: 336)

236. Tibia, posterior side of the distal portion: smooth and featureless (0); dorsoventrally oriented groove or gap (1). (Nesbitt, 2009: 337)

237. Tibia, lateral side of the distal portion: smooth/rounded (0); proximodistally oriented groove (1). (Novas, 1996; Nesbitt, 2009: 338)

238. Fibula, attachment site for the M. iliofibularis, location: near the proximal portion (0); near the mid point between the proximal and distal ends (1). (modified from Sereno, 1991; Nesbitt, 2009: 340)

239. Fibula, proximal end in proximal view: rounded or slightly elliptical (0); mediolaterally compressed (1). (Nesbitt, 2009: 341)

240. Fibula, anterior edge of the proximal portion: rounded (0); tapers to a point and arched anteromedially (1). (Nesbitt, 2009: 342)

241. Fibula, proximal portion in lateral view: symmetrical or nearly symmetrical (0); posterior part expanded posteriorly (1). (Nesbitt, 2009: 342)

242. Fibula, medial face of the distal portion: smooth (0); banked with an articular facet that articulates with the astragalus (1). (Nesbitt, 2009: 344)

243. Fibula, distal end in lateral view: angled anterodorsally (asymmetrical) (0); rounded or flat (symmetrical) (1). (Nesbitt, 2009)

244. Distal tarsal 4, transverse width: broader than distal tarsal 3 (0); subequal to distal tarsal 3(1). (Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 347)

245. Distal tarsal 4, size of articular facet for metatarsal V: more than half of lateral surface of distal tarsal 4 (0); less than half of lateral surface of distal tarsal 4 (1). (Sereno, 1991; Novas, 1996; Benton, 1999; Nesbitt, 2009: 348)

246. Distal tarsal 4, posterior prong: blunt (0); pointed (1). (Langer and Benton, 2006; Nesbitt, 2009: 350)

247. Distal tarsal 4, medial side: without a distinct medial process present in the anteroposterior middle of the element (0); with a distinct medial process present in the anteroposterior middle of the element (1). (Nesbitt, 2009: 351)

248. Distal tarsal 4, proximal surface: flat (0); distinct, proximally raised region on the posterior portion (=heel of Sereno and Arcucci, 1994a; b) (1). (Nesbitt, 2009: 353)

249. Astragalus, dorsally expanded process on the posterolateral portion of the tibial facet: absent or poorly expanded (0); expanded into a distinct, raised process (=posterior ascending process of Sereno and Arcucci, 1994a) (1). (modified from Sereno and Arcucci, 1994a; Nesbitt, 2009: 355)

250. Astragalus, anterior ascending flange (anterior process): absent (0); present and less than the height of the dorsoventral height of the posterior side of the astragalus (1); present and greater than the height of the dorsoventral height of the posterior side astragalus (2). ORDERED (modified from Gauthier, 1986; Novas, 1992, 1996; Benton, 1999; Rauhut, 2003; Nesbitt, 2009: 356)

251. Astragalus, anterior hollow: shallow depression (0); reduced to a foramen or absent (1). (Nesbitt, 2009: 357)

252. Articular facet for the astragalus of the calcaneum lies: completely medial to the fibular facet (0); partially ventral to the fibular facet (1). (modified from Parrish, 1993; Nesbitt, 2009: 358)

253. Astragalus, proximal surface: lacks a marked rimmed and elliptical fossa posterior to the anterior ascending process (0); possesses a marked rimmed and elliptical fossa posterior to the anterior ascending process (1). (Langer and Benton, 2006; Nesbitt, 2009: 359)

254. Astragalus, anteromedial corner shape: obtuse (0); acute (1). (Bonaparte, 1976; Novas, 1989; Sereno, 1991; Juul, 1994; Novas, 1996; Benton, 1999; Nesbitt, 2009: 361)

255. Astragalus, proximal articular facet for fibula occupies: more than 0.3 of the transverse width (0); less than 0.3 of the transverse width (1). (Langer and Benton, 2006; Nesbitt, 2009: 362)

256. Astragalus, posterior groove: present (0); absent (1). (Sereno, 1991; Nesbitt, 2009: 363)

257. Astragalus, tibial facet: concave or flat (0); divided into posteromedial and anterolateral basins (1). (Nesbitt, 2009: 364)

258. Astragalus-calcaneum, ventral articular surface: flat or slightly convex (0); concavoconvex with concavity on calcaneum (1); concavoconvex with concavity on astragalus (2). (Sereno, 1991; Nesbitt, 2009: 368)

259. Astragalus-calcaneum, articulation: free (0); co-ossified (1). (Sereno and Arcucci, 1994a; Irmis et al., 2007a; Nesbitt, 2009: 370)

260. Calcaneum, ventral articular surface for distal tarsal 4 and the distal end of the tuber: continuous (0); separated by a clear gap (1); separated by a gap with a ventral fossa (2). (Nesbitt, 2009: 371)

261. Calcaneum, articular facets for the fibula and astragalus: connected by a continuous surface (0); separated (1). (Nesbitt, 2009: 372)

262. Calcaneum, calcaneal tuber: present (0); absent (1). (Gauthier, 1986; Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 373)

263. Calcaneum, calcaneal tuber, distal end: rounded and unexpanded (0); flared, dorsally and ventrally (1). (Sereno, 1991; Nesbitt, 2009: 374)

264. Calcaneum, calcaneal tuber, distal end: without dorsoventrally aligned median depression (0); with dorsoventrally aligned median depression (1). (Parrish, 1993; Benton, 1999; Nesbitt, 2009: 375)

265. Calcaneum, calcaneal tuber, shaft proportions at the midshaft of the tuber: taller than broad (0); about the same or broader than tall (1); just short of twice the mediolateral width of the fibular facet (2). (modified from Sereno, 1991; Parrish, 1993; Juul, 1994; Benton, 1999; Nesbitt, 2009: 376)

266. Calcaneum, articular surface for the fibula: convex (0); convex and hemicylindrical shaped (1); concave (2). (modified from Sereno, 1991; Parrish, 1993; Juul, 1994; Novas, 1996; Gower, 1996; Benton, 1999; Nesbitt, 2009: 378).

267. Calcaneum, shape: proximodistally compressed with a short posterior projection and medial process (0); transversely compressed, with the reduction of these projections (1). (modified from Langer and Benton, 2006; Nesbitt, 2009: 379)

268. Calcaneum, articular surfaces for fibula and distal tarsal IV: separated by a non-articular surface (0); continuous (1). (Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 380)

269. Metatarsus, configuration: metatarsals diverging from ankle (0); compact metatarsus, with metatarsals II-IV tightly bunched (at least half of the length) (1).

(Gauthier, 1986; Benton and Clark, 1988; Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 382)

270. Longest metatarsal: shorter than 50% of tibial length (0); longer than 50% of tibial length (1). (modified from Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 383)

271. Metatarsals, midshaft diameters: I and V subequal or greater than II-IV (0); I and V less than II-IV (1). (Sereno, 1991; Juul, 1994; Novas, 1996; Benton, 1999; Nesbitt, 2009: 384)

272. Metatarsal I: reaches the proximal surface of metatarsal II (0); does not reach the proximal surface of metatarsal II and attaches onto the medial side of metatarsal II (1). (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2009: 385)

273. Metatarsal I, length, relative to length of metatarsal III: 0-84% (0); 85% or more (1). (Sereno, 1991; Benton, 1999; Nesbitt, 2009: 387)

274. Metatarsal III, proximal end: does not back to the ventral side of metatarsals II and IV (0); backs metatarsals II and IV posteroventrally, resulting in a T-shaped proximal profile (1). (Carrano et al., 2002; Tykoski, 2005; Nesbitt, 2009: 389)

275. Metatarsal III: longer than metatarsal II (0); subequal to metatarsal II (1). (Nesbitt, 2009: 390)

276. Metatarsal IV, distal articulation surface: broader than deep to as broad as deep (0); deeper than broad (1). (modified from Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2009: 391)

277. Metatarsal IV, proximal portion, possesses an elongated lateral expansion that overlaps the anterior surface of metatarsal V absent (0); present (1). (Sereno, 1999; Langer and Benton, 2006: Nesbitt, 2009: 392)

278. Metatarsal IV length: longer than metatarsal II (0); subequal or shorter than to metatarsal II (1). (modified from Gauthier, 1986; Nesbitt, 2009: 395)

279. Metatarsal V, dorsal prominence separated from the proximal surface by a concave gap: absent (0); present (1). (Nesbitt, 2009: 397)

280. Metatarsal V, 'hooked' proximal end: present (0); absent, and articular face for distal tarsal 4 subparallel to shaft axis (1). (Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2009: 398)

281. Metatarsal V, phalanges: present and has "fully" developed first phalanx (0); present and has a "poorly" developed first phalanx (1); without phalangies and tapers to a

point (2). ORDERED (modified from Gauthier, 1984; Parrish, 1993; Nesbitt, 2009: 399)

282. Pedal unguals: weakly mediolaterally compressed, rounded or triangular in cross-section (0); dorsolaterally compressed (1); strongly mediolaterally compressed, with a sharp dorsal keel (2). (modified from Sereno, 1991; Nesbitt, 2009: 400)

283. Osteoderms, dorsal to the vertebral column: absent (0); present (1). (Gauthier, 1984; Benton and Clark, 1988; Sereno, 1991; Juul, 1994; Bennett, 1996; Dilkes, 1998; Benton, 1999; Nesbitt, 2009: 401).

284. Osteoderms, presacral, dorsal, anterior edge: straight or rounded (0); with distinct anterior process (1). (Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 403)

285. Osteoderms, presacral, paramedian: flat (0); with distinct longitudinal bend near lateral edge (1). (Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Nesbitt, 2009: 404)

286. Osteoderms, covering the appendages (=appendicular osteoderms), at least in part: absent (0); present (1). (Heckert and Lucas, 1999; Nesbitt, 2009: 405)

287. Presacral osteoderms, dimensions: square shaped, about equal dimensions (0); longer than wide (1); wider than long (2). (Nesbitt, 2009: 407)

288. Anterior bar located on the anterior edge of an osteoderm: absent (0); present (1). (Heckert and Lucas, 1999; Parker, 2007; Nesbitt, 2009: 408)

289. Ventral carapace in the dorsal area: absent (0); present (1). (Heckert and Lucas, 1999; Nesbitt, 2009: 409)

290. Gastralia: form extensive ventral basket with closely packed elements (0); well separated (1); absent (2). (Nesbitt, 2009: 412)

Taxon scores

A = (0/1), B = (1/2), C = (0/2)

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Heterodontosaurus tucki
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00??002101111?0C00010120C12100111111000000100000?211?001110000 1?111?0?
111001101000101100010000112000?2100021000111 10??01??10000211?0??????20?
01011010?000020000110 1??0110?111000?110?1?1??1?01????111100?0101?1200?
?????2

Lesothosaurus diagnosticus
010003000011001000000010000000110100000000030000101010022101000 0?0?1??1
00??002101111100000101200020110111 1??000010000000?01??0?111?0??1??110??
?1100?1000?01010???000?00??000021010210001111 0??01??1000021110002101200
01011?100000020000020101?111?????001100111??0?01???2111110000101???00?
??????

Herrerasaurus ischigualastensis
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?111011010000011201100110130100200002100010011101101120002101010210 2100

11011011?0000200100101010111011111001101111??0?01???2011110000111011 00?
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Eoraptor lunensis
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Saturnalia tupiniquim
??????????????????????????11???????1?????????????????????????????????? ?????1?????????0????????00200100 1?1?????0??10000 1?000000000010010001000? 11100011 1??010?????????????????020010110001001100110012100210100021021 00 11111011?0000200001111010111011111001101111??0?01???2011110000111012 00? ??????

Plateosaurus engelhardti
10101201010100001010001001111001010010000003010000101002210100000011 01? 020?0121?1100101000110010020110011111001001100001000000001001000011000? 11100111100010101010111111200002000021000100110011001210021010002102100 01111011000002000001110101110111111001101111??0?01???2011010000111011 00? ??????

Efraasia minor
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Tawa hallae
10000001 1?00010?000000100??1100101000000 1?30000?01?1002211?000000?11?1 0001002?0110000000000?00?00100000 1?111111111110101000000?000?011?111??? ?11101101000001 1200?00110120100200112000110 0?110?101?1????2120002201100 01210011100002001101000101110111111001101111??0?01???2111110000101012 00? ?????1

Coelophysis bauri
10101101 1?000?01010000 1?0101100101001000011300 10?0101002211110001011??? 000?00210110 00?00000?00?00100000111111111111111001000100011101011111?0? 11110110100010112111001111301012102121111100111011?111110211200021021 00 11210011100002101111110101110111010011001 11??1?01???2111111010101012?0? ???0??

Dilophosaurus wetherelli
1010110?1?0001??0001001?0??11??101000??00113000000????0221110001101 10?? 02??002111?000000010 0?0100100000111100111111200010000000011101??1?111?10 11110010100010112??100111120101210212101110 0?110?10111111210200021?1200 01210011 10?00210111211010111011101001100111??0?01???2111111010101012 00? ?????1

Allosaurus fragilis
10101201011 0?10010210010111110010100000000130000001110022111000110 11??0 02??002111100000001000010010000011110101011120001000000011111111110101 0 11110110100010112111101111?1??02102021011100110111021111121020002200200

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0101001110000210111211010111011101002100111??0?01???2111011000101012007
?????1
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Velociraptor mongoliensis

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1010110100101?000001001001111001010010000003100000111002217?10011101117?
0???00210110000000007001001000001117?????????????107?0100111111?11101?11
1110011010000001211100001171??02102021011110111011?2001002102010220?200
0101001110000210171211?01?00?11???0210?111??1?01????11011000101012007
?????1
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Apomorphy List for Silesauridae

Parentheses next to character number indicate whether the apomorphy in question has an unambiguous (U) optimization, or is optimized as an apomorphy under ACCTRAN (A), or DELTRAN (D), optimization.

Silesauridae (=*Pseudolagosuchus*/*Lewisuchus* + *Silesaurus*)
6 (A) 1→ 2 CI = 0.333
37 (A) 0→1 CI = 0.200
47 (A) 0→2 CI = 0.333
66 (U) 0→1 CI = 1.000
72 (U) 0→1 CI = 1.000
96 (A) 0→1 CI = 0.750
104 (A) 1→0 CI = 1.000
109 (U) 0→1 CI = 0.167
139 (D) 0→1 CI = 0.333
141 (D) 0→1 CI = 0.333
148 (A) 1→0 CI = 0.200
179 (D) 0→1 CI = 0.500
180 (A) 1→0 CI = 0.200
194 (D) 0→1 CI = 0.333
207 (D) 0→1 CI = 1.000
216 (U) 0→1 CI = 0.286
257 (D) 1→0 CI =0.500
282 (A) 0→1 CI = 0.500

Asilisaurus + *Silesaurus*
56 (A) 2→0 CI = 0.333
88 (U) 0→1 CI = 0.333
96 (D) 0→1 CI = 0.750
101 (D) 0→1 CI = 0.200
103 (U) 0→1 CI = 0.500
104 (D) 1→0 CI = 1.000
131 (U) 0→1 CI = 0.333
202 (A) 1→0 CI = 0.200
212 (U) 0→1 CI = 1.000
222 (D) 0→1 CI = 0.400
223 (U) 0→1 CI = 1.000
282 (D) 0→1 CI = 0.500

Eucoelophysis + *Silesaurus*
86 (A) 0→1 CI = 1.000
111 (A) 1→0 CI = 0.250
130 (A) 0→1 CI = 0.200
177 (A) 0→1 CI = 0.400
204 (A) 0→2 CI = 0.400
214 (A) 1→0 CI = 0.250
215 (U) 1→0 CI = 0.333
230 (U) 0→1 CI = 0.500
256 (A) 0→1 CI = 0.250
262 (A) 0→1 CI = 0.250

Sacisaurus + *Silesaurus*
86 (D) 0→1 CI = 1.000
177 (D) 0→1 CI = 0.400
206 (U) 0→1 CI = 1.000
232 (U) 0→1 CI = 0.200

5. Geology and taphonomy of the type locality

The holotype and paratypes of *Asilisaurus* were collected from the Lifua Member of the Manda Beds near the village of Litumba Ndyosi in the western portion of the Ruhuhu Basin, southwestern Tanzania. Correlation of the locality to an exact stratigraphic horizon in the Lifua Member remains difficult given the extensive vegetation cover, numerous en-echelon faults from rifting, and no defined upper boundary of the Manda Beds. However it is clear that the type locality lies above the base of the Lifua Member, probably near middle of the member. All of the specimens were found in a small 6 meter-wide channel fill over a distance of some 10 m. Most of the bones had weathered out of light greenish-grey mudstone with purple mottles. Only a few specimens were found *in situ* and they demonstrated that the skeletons were mainly disarticulated but associated. Most specimens are encased in a thin layer of dark brown weathering calcareous nodular material which is abundant in a 30 cm-thick bed of intraformational clay pebble conglomerate lining the base of the channel form. *Asilisaurus* elements occur as either isolated, single elements, as disarticulated elements in close association within the carbonate lenses, or a small sections of articulated elements. The bed also contains rare remains of cynodonts, amphibians, and archosauriform teeth. Clumps of articulated unionid bivalves occur among the remains of *Asilisaurus*. The interpreted environment of accumulation of these skeletons is within an abandoned tributary channel on a semi-arid floodplain in the axial regions of the Ruhuhu half graben. Specimens of *Asilisaurus* were collected throughout the immediate area and also in eastern portion of the Ruhuhu Basin.

6. Age of the Manda Beds

The age of the Lifua Member is correlated with Subzone C of the *Cynognathus* Assemblage Zone of South Africa (Gay and Cruickshank 1999; Catuneanu 2005; Rubidge 2005). This correlation was based on the shared occurrences of the dicynodont *Angonisaurus* (Cox and Li 1983; King 1988; Hancox 2000) and the cynodonts

Diademodon and *Cricodon* (Crompton 1954). Subzone C of the *Cynognathus* Assemblage Zone is suggested to be late Anisian (Rubidge 2005). The Rio Mendoza Formation of Argentina correlates with Subzone C of the *Cynognathus* Assemblage Zone (Rubidge 2005), and thus the Lifua Member of the Manda Beds. The top of the Rio Mendoza Formation has been dated at 243 ± 5 Ma (Avila et al. 2006), which is consistent with the Anisian age as predicted by biostratigraphy.

7. Additional occurrences of the Silesauridae

Petrified Forest specimen, Parker et al. (2006) and Nesbitt et al. (2007)
Specimen: PEFO 34347, proximal portion of a femur
Locality: "Dying Grounds," Blue Mesa Member, Chinle Formation, Petrified Forest National Park, Arizona, USA.
Remarks: Parker et al. (2006) reported the proximal end of a *Silesaurus*-like femur from the Blue Mesa Member. The femoral head preserves a flat medial articular surface similar to the condition in *Silesaurus* and *Sacisaurus*, and a straight groove on the proximal surface and a notch at the base of the femoral head, features present in all silesaurids. However, the posteromedial tuber in PEFO 34347 is more well-developed than in *Silesaurus*, *Sacisaurus*, and *Eucoelophysis*. Additionally, PEFO 34347 has a well developed facies articularis antitrochanterica whereas this feature is absent in the Otis Chalk taxon, *Silesaurus*, *Sacisaurus*, and *Eucoelophysis*. Therefore, PEFO 34347 could represent a distinct taxon.

Hayden Quarry material, Irmis et al. 2007a
Specimens: GR 224, dentary; GR 225, ilium; and GR 195, proximal portion of a femur
Locality: Hayden Quarry, Petrified Forest Member, Chinle Formation, Ghost Ranch, New Mexico, USA.
Remarks: Irmis et al. (2007a) described isolated silesaurid material from the Hayden Quarry, roughly at the same stratigraphic horizon as the type locality of *Eucoelophysis*. Unfortunately, the nature of the material means it cannot be officially referred to *Eucoelophysis* even though it might belong to that taxon (Irmis et al. 2007a: SOM). The dentary shares two characters with *Silesaurus*: tooth roots fused to bone of attachment and a Meckelian groove restricted to the ventral border. The teeth of this specimen share with *Sacisaurus* + *Silesaurus* the presence of mesiodistally expanded subtriangular tooth crowns, and share with *Sacisaurus* the presence of enlarged denticles. The ilium shares with *Silesaurus* the presence of an enlarged brevis fossa that opens laterally. The femur possesses a straight groove on the proximal surface and a notch at the base of the femoral head, characters present in all silesaurids.

Technosaurus smalli Chatterjee 1984
Specimen: TTU-P 9021
Locality: Post (=Kirkpatrick) Quarry, Cooper Canyon Formation, Dockum Group, Texas, USA.
Remarks: *Technosaurus* consists of a premaxilla and much of the dentary. The other elements originally assigned to the taxon are either not diagnostic (e.g., the unguals), unidentifiable fragments (e.g., the "astragalus"), or belong to another taxon (the posterior portion of the mandible) (Irmis et al. 2007b; Nesbitt et al. 2007). The dentary shares the

following character states with *Silesaurus*: five premaxillary teeth; tooth roots fused to bone of attachment; tooth crowns mesiodistally expanded, apicobasally short and subtriangular; and Meckelian groove restricted to the ventral border. For these reasons, Nesbitt et al. (2007) hypothesized that *Technosaurus* represents a silesaurid.

Technosaurus represents a unique taxon because the presence of small accessory cusps on both sides of the apex of the tooth crown distinguishes the taxon from all other silesaurids, including the silesaurid material from the Hayden Quarry (Petrified Forest Member of the Chinle Formation, New Mexico; Irmis et al. 2007a: fig. 2).

Otis Chalk taxon
Specimens: TMM 31100-185, femur; TMM 31100-1309, femur; TMM 31100-1304, femur; TMM 31100-1303, femur; TMM 31100-172, tibia; TMM 31100-1330, tibia; TMM 31100-1311, tibia; TMM 31100-1319, humerus; and TMM 31100-1278, humerus.
Locality: Otis Chalk Quarry 3, Colorado City Formation (Lucas et al. 1993), Dockum Group, Texas, USA.
Remarks: The Otis Chalk taxon is represented by disarticulated but complete femora, tibiae, and humeri. Characters present on the femora include a straight groove on the proximal surface, a straight medial articular facet on the femoral head, a notch at the base of the femoral head, and a popliteal fossa on the distal end of the femur that extends proximally for at least one third the length of the shaft. The tibiae have a straight cnemial crest, and share the presence of a fibular crest and a distinct lateral process of the distal end with *Silesaurus* and *Sacisaurus*. The humeri have poorly expanded proximal and distal ends and the deltopectoral crest extends distally. These two character states are present in *Silesaurus* but are absent in *Asilisaurus*. One possible autapomorphy of the taxon is a mediolaterally compressed, straight cnemial crest. Therefore, these specimens possibly represent a distinct taxon.

Eagle Basin specimen
Specimens: Teeth, femora, and pelvic material (Small, 2009).
Locality: Chinle Formation, Eagle Basin, Colorado (Small, 2009).
Remarks: Recently, Small (2009) identified isolated *Silesaurus*-like remains consisting of isolated elements from the Chinle Formation in the Eagle Basin of Colorado. These specimens have yet to be formally described.

8. Details of Comparative Phylogenetic Tests

One goal of the present paper is to test whether a recurring suite of morphological characters evolved repeatedly in concert with the adoption of an omnivorous or herbivorous diet near the base of the dinosaurian radiation. Zanno et al. (2009) recently reported such a correlation among several theropod clades that evolved herbivorous diets, but their analysis focused on relatively derived members of the group and did not include any taxa outside of Theropoda.

Testing this hypothesis involves two steps: 1) reconstructing the evolutionary history of the characters in question by optimizing them on a phylogeny, and 2) testing whether gains of certain character states are significantly correlated with the adoption of a herbivorous or omnivorous diet. To accomplish these goals, we scored seven binary characters of the feeding system that potentially represent adaptations for omnivory or

herbivory (e.g., Barrett, 2000) for 34 taxa (see below for scorings). We also scored an eighth character representing likely dietary preference. Diet included two states, carnivore (0) and omnivore/herbivore (1), and our intention in using this scoring was to capture the distinction between animals whose diets consist completely or nearly completely of animal flesh and those whose diet includes some proportion of plant material. Our scoring on this character is based on Barrett (2000), Irmis et al. (2007), and Zanno et al. (2009). In particular, it is difficult to distinguish between omnivorous and herbivorous teeth in diapsids (Barrett, 2000). We then optimized these characters on three phylogenies based on the most parsimonious trees of the phylogenetic analysis. A strict consensus of the trees is shown below (Fig. S3); the trees used in the optimizations were fully resolved and differed only in the interrelationships of *Pisanosaurus*, *Heterodontosaurus*, and *Lesothosaurus*. Because missing data and the distribution of character states among OTUs resulted in multiple equally parsimonious optimizations, our subsequent analyses are based on ACCTRAN and DELTRAN (Swofford and Maddison 1987) optimizations of the characters.

We used Maddison's (1990) concentrated changes test to examine the correlation between the seven morphological characters and dietary preference. The test determines whether evolutionary changes to a dependent character state occur more frequently than expected by chance in taxa possessing a second, independent character state. The concentrated changes test is generally conservative (Lorch and Eadie 1999), although the relatively small size of our phylogeny (34 operational taxonomic units) and the shape of our tree [$I = 0.3561$ (Colless 1982; Heard 1992; Rogers 1994)] may mean that it is slightly less conservative than in a case involving a large, highly pectinate phylogeny. We ran the tests in MacClade 4.06 (Maddison and Maddison 2003), using ACCTRAN and DELTRAN optimizations of the characters and the three fully resolved trees described above. In most cases the ratio of character state changes to taxa was small enough to allow the use of the exact test described by Maddison (1990), but in a few cases simulations were required to determine whether the observed pattern of character state changes was likely to have occurred by chance. Herbivorous/omnivorous diet served as the independent character state in all analyses.

Results of the two sets of tests are summarized in Table S2. Each of the characters potentially associated with the adoption of an omnivorous or herbivorous diet were reconstructed as evolving multiple times on our phylogeny in nearly all cases (range = 1 to 5 gains), although the exact number of changes depended on the details of the character/topology/optimization algorithm combination. Two or more of these gains occurred in taxa hypothesized to have omnivorous or herbivorous diets in most cases (range = 0 to 5). Three characters states (large, coarse tooth serrations; medial or lateral overlap of adjacent crowns in maxillary and dentary teeth; tooth crown mesiodistally expanded above root in cheek teeth) were found to be significantly correlated with omnivorous/herbivorous diet for almost all combinations of reconstruction method and topology, which we interpret as strong evidence for the repeated evolution of these states in concert with the adoption of a herbivorous or omnivorous diet. Two additional character states [moderately developed lingual expansion of crown (=cingulum) on maxillary/dentary teeth; maxillary and dentary tooth crowns subtriangular] were significantly correlated with diet for most or all topologies under a DELTRAN optimization, but not under an ACCTRAN optimization. Because significant results for

these states are dependent on optimization method, we consider the evidence in favor of their repeatedly evolving in concert with the adoption of an omnivorous or herbivorous diet somewhat weaker than for the previous three character states. Finally, two character states (buccal emargination of maxilla separated from the ventral margin of the antorbital fossa; anterior extremity of the lower jaw tapers to a sharp point) were not significantly corrected with omnivorous/herbivorous diet in any of the cases we examined.

Taken together, we interpret these results as demonstrating that: 1) an omnivorous/herbivorous diet evolved multiple times near the base of the dinosaurian radiation; 2) suites of (primarily dental) character states evolved more frequently than expected by chance in the clades that adopted an omnivorous or herbivorous diet; 3) not all clades that adopted an omnivorous or herbivorous diet evolved exactly the same suites of feeding system characters, suggesting some flexibility in how basal avian-line archosaurs responded to the selective pressures imposed by such dietary changes.

Characters:

A (13). Maxilla, buccal emargination separated from the ventral margin of the antorbital fossa: absent (0); present (1).

B (88 modified). Anterior extremity of the lower jaw: rounded (0); tapers to a sharp point (1).

C (98 modified). Tooth, serrations: absent or present as small fine knife-like serrations (0); present and enlarged and coarser (lower density) = denticles (1).

D (100). Medial or lateral overlap of adjacent crowns in maxillary and dentary teeth: absent (0); present (1).

E (101). Tooth, crown: not mesiodistally expanded (0); mesiodistally expanded above root in cheek teeth (1).

F (102). Moderately developed lingual expansion of crown (=cingulum) on maxillary/dentary teeth: absent (0); present (1).

G (103 modified). Maxillary and dentary crowns, shape: recurved (0); subtriangular (1).

Taxon scores

	A G
Erythrosuchus africanus	00000000
Euparkeria capensis	00000000
Revueltosaurus callenderi	10100011
Aetosaurus ferratus	11001011
Arizonasaurus babbitti	00000000
Effigia okeeffeae	01-----?
Batrachotomus kuperferzellensis	10000000
Postosuchus kirkpatricki	00000000

Dromicosuchus grallator	00000000
Eudimorphodon ranzii	00?00010
Dimorphodon macronyx	?0?00000
Lagerpeton chanarensis	????????
Dromomeron gregorii	????????
Dromomeron romeri	????????
Marasuchus lilloensis	???????0
Asilisaurus kongwe	?10?1?11
Eucoelophysis baldwini	????????
Sacisaurus agudoensis	01101111
Lewisuchus/Pseudolagosuchus	00000000
Silesaurus opolensis	01001011
Pisanosaurus mertii	?0111111
Heterodontosaurus tucki	10100111
Lesothosaurus dianosticus	10111011
Herrerasaurus ischigualastensis	00000000
Eoraptor lunensis	00000?00
Panphagia protos	?0011011
Saturnalia tupiniquim	??101011
Plateosaurus engelhardti	00111011
Efraasia minor	00101011
Tawa hallae	00000000
Coelophysis bauri	00000000
Dilophosaurus wetherelli	00000000
Allosaurus fragilis	?0000000
Velociraptor mongoliensis	10000000

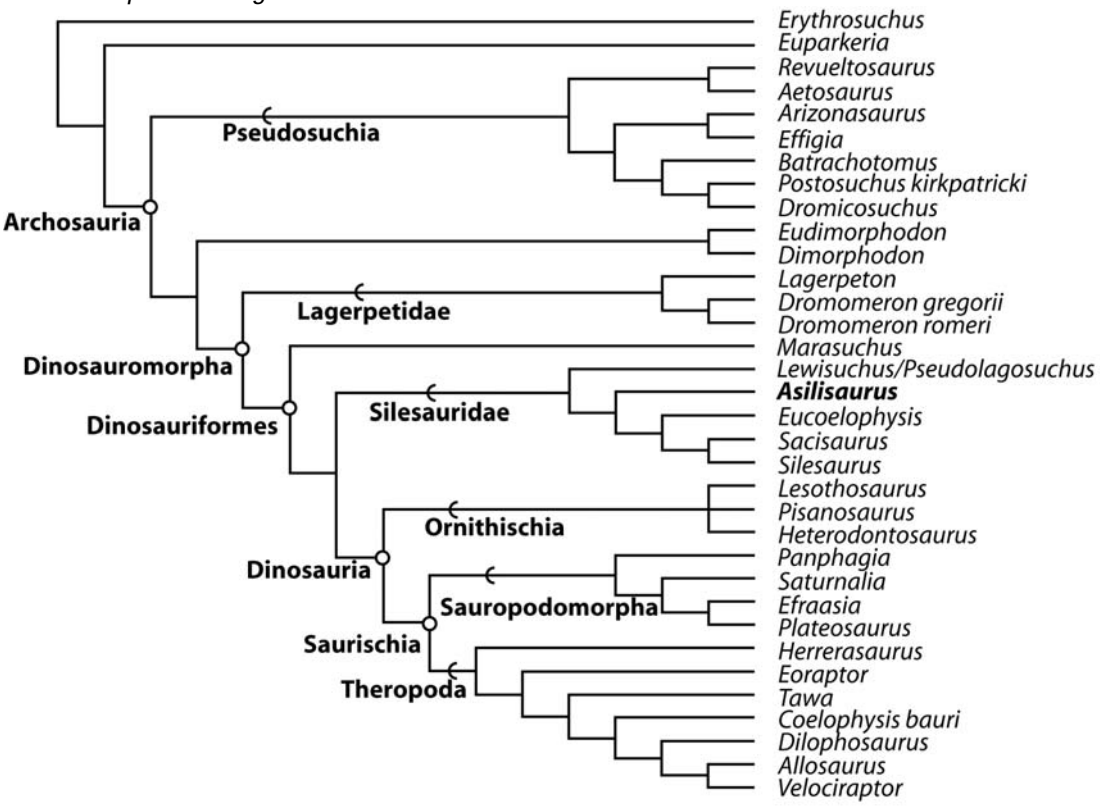

Figure S3. The relationships of avian-line archosaurs as used for the ancestral state and concentrated changes analyses

Table S2: Results of the concentrated changes analysis. Highlighted results indicate significant P values.

Tree 1	**((*Pisanosaurus, Lesothosaurus*) *Heterodontosaurus*)**				
	total gains	**total losses**	**concentrated gains**	**concentrated losses**	**p**
1 vs 8	4	0	2	0	0.401476
2 vs 8	3	0	2	0	0.176910
3 vs 8	4	0	4	0	0.011763
4 vs 8	3	0	3	0	0.044662
5 vs 8	4	0	4	0	0.011763
6 vs 8	2	1	2	1	0.088740
7 vs 8	1	4	0	0	0.064929

Tree 2	**((*Lesothosaurus*, *Heterodontosaurus*) *Pisanosaurus*)**				
	total gains	**total losses**	**concentrated gains**	**concentrated losses**	**p**
1 vs 8	4	0	2	0	0.401476
2 vs 8	3	0	2	0	0.176910
3 vs 8	4	0	4	0	0.011763
4 vs 8	3	1	3	1	0.030391
5 vs 8	2	3	1	1	0.140426
6 vs 8	2	1	2	1	0.088740
7 vs 8	1	4	0	0	0.064929

Tree 3	**((*Pisanosaurus*, *Heterodontosaurus*) *Lesothosaurus*)**				
	total gains	**total losses**	**concentrated gains**	**concentrated losses**	**p**
1 vs 8	4	0	2	0	0.401476
2 vs 8	3	0	2	0	0.176910
3 vs 8	4	0	4	0	0.011763
4 vs 8	3	1	3	1	0.030391
5 vs 8	2	3	1	1	0.140426
6 vs 8	2	0	2	0	0.144464
7 vs 8	1	4	0	0	0.064929

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