

Appendix 1 - Operational Taxa

1.1 Outgroup Taxa

Euparkeria capensis

Age: Anisian, Middle Triassic

Occurrence: Cynognathus Assemblage Zone (B) (Beaufort Group) of South Africa.

Holotype: SAM 5867, skull and partial skeleton.

Referred Material: SAM 6050, partial skull; SAM 6047B, vertebrae, femur, pelvis, pectoral girdle; SAM 6049, dorsal, sacral, and caudal vertebrae, right hind limb, and partial pelvic and pectoral girdles; SAM 6047A, skull, vertebrae, and limb fragments; UMCZ T692, articulated foot with astragalus and calcaneum.

Comments: A non-archosaurian archosauriform from the Middle Triassic. This taxon is regularly used as an outgroup in phylogenetic analyses of dinosaurs due to its 'primitive' archosauriform anatomy

Postosuchus kirkpatricki

Age: Norian, Late Triassic

Occurrence: Post Quarry, Cooper Canyon Formation, Dockum Group

Holotype: TTU-P 9000, skull and partial skeleton.

Referred Material: TTU-P 9002, skull and skeleton.

Comments: A member of Rauisuchidae, a clade within the crocodile line (Pseudosuchia) of archosaurs. This taxon is included to act as an outgroup from within Archosauria.

Austriadactylus cristatus

Age: Norian, Late Triassic

Occurrence: Ankerschlag, Tyrol, Austria.

Holotype: SMNS 56342, a complete skull and partial postcranial skeleton.

Comments: A member of Pterosauiomorpha, *Austriadactylus cristatus* from the Norian of Europe is a good representative of the earliest diverging group of pterosaurs, the Eopterosauria.

Dimorphodon macronyx

= *Pterodactylus macronyx*

Age: Hettangian-Sinemurian, Early Jurassic

Occurrence: Lower Lias, Lyme Regis, Dorset, England.

Holotype: BMNH R1034, nearly complete skull and skeleton.

Referred Material: BMNH R 1035, much of a skull and skeleton; BMNH 41212, postcrania; YPM 350, partial skeleton; YPM 9182, partial skeleton

Comments: An early and well preserved pterosaur. This taxon is included to act an outgroup from within the bird line (Avemetatarsalia) of archosaurs.

1.2 Non-dinosaurian Dinosauromorphs

Lagerpeton chanarensis

Age: Ladinian, Middle Triassic

Occurrence: Los Chañares Formation, Argentina.

Holotype: UNLR 06, articulated right hind limb.

Referred Material: PVL 4619, articulated sacrum, pelvis, and partial right and left hind limbs; PVL 4625, articulated vertebral column including dorsal, sacral, and anterior caudal vertebrae, left pelvis, and left femur; PVL 5000, proximal left femur; MCZ 4121, partial right and left femora.

Comments: A non-dinosaurian dinosauromorph. This taxon provides useful information about the possible plesiomorphic and derived anatomical conditions that are observed in dinosauriforms and other dinosauromorphs.

Dromomeron gregorii

Age: ?Carnian-?Norian, Late Triassic

Occurrence: Otis Chalk Quarry 3, Howard County, Texas; Placerias Quarry, Arizona.

Holotype: TMM 31100-1306, right femur.

Paratypes: TMM 31100-464, right femur; TMM31100-1308, right femur; TMM31100-1234, right femur; TMM 31100-764, right femur; TMM 31100-278, right tibia; TMM 31100-1314, left tibia.

Referred Material: UCMP 25815, distal portion of a left femur from the Placerias Quarry.

Comments: One of three species currently recognised as belonging to the non-dinosaurian dinosauromorph genus *Dromomeron*. Together with *D. romerii* and *D. gigas*, *D. gregorii* provides important information about non-dinosauriform dinosauromorph anatomy.

Dromomeron romerii

Age: Norain, Late Triassic

Occurrence: Site 3, Hayden Quarry, Ghost Ranch, Rio Arriba County, New Mexico.

Holotype: GR 218, left femur.

Paratypes: A right femur, GR 219, and a left tibia, GR 220, may belong to the same individual as the holotype. Additional material includes GR 221, a partial left femur; GR 234, a complete right femur; GR 222, a complete left tibia; and GR 223, a complete astragalocalcaneum.

Referred Material: GR 235, partial articulated skeleton; GR 236, isolated right tibia (cnemial crest crushed); NMMNH P-35379, complete astragalocalcaneum; AMNH FR 2721, distal portion of a femur; AMNH FR 30648, distal portion of a right tibia; AMNH FR 30649, distal portion of a right tibia.

Comments: See above comments for *D. gregorii*.

Dromomeron gigas

Age: ?Norian, Late Triassic

Occurrence: “Quebrada del Puma” Locality, Caucete Department, San Juan Province, Argentina, Quebrada del Barro Formation.

Holotype: PVSJ 898, partial left femur (proximal and distal ends only).

Comments: See above comments for *D. gregorii*.

Ixalerpeton polesinensis

Age: Carnian, Late Triassic

Occurrence: Buriol ravine, São João do Polêsine-RS, Brazil; Alemoa Member, Santa Maria Formation; Candelária Sequence, Paraná Basin.

Holotype: ULBRA-PVT059, partial articulated skeleton including skull roof, braincase, axial elements, partial pectoral and pelvic girdles, partial forelimb and partial hind limb

Comments: Described from material found as part of an assemblage that also contained the basal dinosaur *Buriolestes schultzi*. The material of this taxon is believed to represent a member of the non-dinosauriform dinosauromorph clade Lagerpetidae. Along with *Buriolestes* it is the most recently described taxon included in this study.

PVSJ 883

Age: Carnian, Late Triassic

Occurrence: Valle Pintado in Ischigualasto Provincial Park, San Juan Province, Argentina, lower portion of the *Scaphonyx-Exaeretodon-Herrerasaurus* biozone, La Peña Member, Ischigualasto Formation.

Holotype: PVSJ 883, distal end of a left femur.

Comments: An unnamed dinosauromorph that possesses a number of lagerpetid features including a sharp flange on the antero-medial portion of the distal end of the femur.

Marasuchus lilloensis

= *Lagosuchus lilloensis*

Age: Ladinian, Middle Triassic

Occurrence: Los Chañares Formation, Argentina.

Holotype: PVL 3871, partial articulated skeleton with pectoral and pelvic girdle elements and almost complete fore- and hindlimbs.

Referred Material: PVL 3870, partial skeleton including the maxilla and partial braincase, axial column, pelvis and hind limbs; PVL 3872, partial braincase and axial column; PVL 4670, caudal vertebrae with chevrons; PVL 4671, caudal vertebrae with chevrons; PVL 4672, partial axial column.

Comments: A non-dinosaurian dinosauromorph and dinosauriform from the same formation as *Lagerpeton chanarensis*. This taxon is frequently used in phylogenetic analyses of early dinosaurs because of its supposed proximity to dinosaurs on the ornithodiran line of archosaurs.

Lewisuchus admixtus* / *Pseudolagosuchus majori

= *Lewisuchus admixtus*

= *Pseudolagosuchus majori*

Age: Ladinian, Middle Triassic

Occurrence: Los Chañares Formation, Argentina.

Holotype: (*Lewisuchus admixtus*) - PULR 01, posterior portion of the skull, maxilla, cervical and dorsal vertebrae, scapulocoracoid, and humerus.

Referred Material: (*Pseudolagosuchus majori*) - PVL 4629 (Holotype), complete left femur, tibia, fibula, partial astragalus and calcaneum, complete pubis, fragments of presacral vertebrae, and ribs; PVL 3454, partial postcranium; MACN 18954, partial postcranium; UNLR 53, distal fragments of tibia and fibula, proximal tarsals, and numerous caudal vertebrae.

Comments: This operational taxonomic unit (OTU) comprises two presently valid taxa, *Lewisuchus admixtus* and *Pseudolagosuchus majori*. Both taxa are from Los Chañares Formation in Argentina and are both generally regarded as close dinosaur relatives (e.g. Novas 1996; Langer & Benton 2006). Nesbitt et al. (2007) noted certain silesaurid features in the femoral material of *Pseudolagosuchus*; subsequent studies of both taxa also found evidence for silesaurid features in *Lewisuchus admixtus* and *Pseudolagosuchus majori* (Irmis 2008; Nesbitt 2009). Nesbitt et al. (2010) argued that two taxa probably represented the same taxon as they both come from the same formation, are of roughly the same size and both possess autapomorphies of Silesauridae (although it must be noted that each taxon possess a different set of silesaurid autapomorphies). In their phylogenetic analysis, Nesbitt et al. (2010) scored both taxa separately and as a combine OTU, as did Nesbitt (2011). When scored separately, both taxa were recovered in a polytomy at the base of Silesauridae in the analyses of Nesbitt et al. (2010) and in similar positions in the majority of the analyses that were carried out by Nesbitt (2011). When combined into a single OTU, *Lewisuchus/Pseudolagosuchus* was recovered as the earliest diverging member of Silesauridae in both studies. This provides good evidence for the hypothesis that *Lewisuchus* and *Pseudolagosuchus* do represent the same taxon, as was first suggested by Arcucci (1997, 1998, 2005). However, Bittencourt et al. (2015) treated both taxa as distinct in their phylogenetic analysis and argued that the same should be done in future evolutionary studies of dinosauromorphs as well; Bittencourt et al. (2015) argued that, due to a lack of data, resulting from a lack of overlapping material between the two taxa, there is not yet enough evidence to formally combine *Lewisuchus* and *Pseudolagosuchus*, at least until new material is found. Cabreira et al. (2016) followed Bittencourt et al. (2015) in scoring the taxa as separate OTUs. In their study, Cabreira et al. (2016) recovered the two taxa in a polytomy with a number of other dinosauromorph taxa. Other studies that have carried out phylogenetic analyses of dinosauromorphs, particularly those that focus upon members of Silesauridae, have generally followed Nesbitt et al. (2010) in scoring *Lewisuchus* and *Pseudolagosuchus* together as a single OTU, *Lewisuchus/Pseudolagosuchus* (Kammerer et al. 2012; Martinez et al. 2013; Peacock et al. 2013). This study also follows Nesbitt et al. (2010) in scoring *Lewisuchus* and *Pseudolagosuchus* together as a single OTU, here also named *Lewisuchus/Pseudolagosuchus*, as I agree with the taxonomic assessment of Nesbitt et al. (2010) and find the phylogenetic evidence presented by them to be more convincing than evidence presented by other workers who do not consider the two taxa to be conspecific. However, I also agree with Nesbitt et al. (2010) and Bittencourt et al. (2015) that the two taxa cannot yet be formally synonymised, due to a lack of overlapping material and shared autapomorphies. Despite the fact that it seems very likely that *Lewisuchus* and *Pseudolagosuchus* are conspecific, for now I maintain both generic names for this single OTU. Evidence for the anatomy of this OTU is drawn from specimens of both *Lewisuchus* and *Pseudolagosuchus*.

Silesaurus opolensis

Age: Carnian, Late Triassic

Occurrence: Krasiejów, Opole, Silesia, Poland.

Holotype: ZPAL Ab III/361, dentaries, braincase, pterygoid, frontals, quadrate, surangular, partial postcranium.

Referred Material: ZPAL AbIII/362, braincase, partial postcranium; ZPAL AbIII/363, associated pelvic girdle; ZPAL AbIII/364, braincase, presacral vertebrae, ribs, partial forelimbs, and complete articulated hind limbs.

Comments: The best known member of the non-dinosaurian dinosauriform clade Silesauridae. This taxon preserves cranial and postcranial remains and offers the best insight into the anatomy of a group that are generally considered to be the closest known relatives of dinosaurs.

Sacisaurus agudoensis

Age: Carnian-Norian, Late Triassic

Occurrence: Santa Maria 2 sequence. Top of the Alemoa Member of the Santa Maria Formation or base of the Caturrita Formation, Brazil.

Holotype: MCN PV10041, partial left mandibular ramus.

Referred Material: MCN PV10042, PV10043, PV10044, PV10061, PV10048, dentaries; MCN PV10050, maxilla; MCN PV10051, postorbital; MCN PV10028, PV10029, PV10032, PV10090, PV10097, vertebrae; MCN PV10033, scapula; MCN PV10100, ilium; MCN PV10023, PV10024, pubes; MCN PV10025, ischium; MCN PV10009, PV10010, PV10011, PV- 10013, PV10014, PV10015, PV10016, PV-10018, PV10019, PV10063, PV10075, femora; MCN PV10020, tibia.

Comments: A member of Silesauridae. When it was first described, Ferigolo and Langer (2007) suggested that the beak-like tip of the dentary in *Sacisaurus agudoensis* was homologous to the ornithischian predentary bone. They proposed a close relationship between Ornithischia and Silesauridae, but did not support it with phylogenetic evidence. Subsequent studies have refuted this hypothesis, instead placing Silesauridae outside of Dinosauria and Ornithischia within Dinosauria (Nesbitt et al. 2010; Nesbitt 2011). A recent study by Cabreira et al. (2016) did recover Silesauridae as the sister-taxon of Ornithischia in a phylogenetic analysis, however, no details were given about what lead this particular relationship being recovered. This study does not feel that a Silesauridae-Ornithischia sister-taxon relationship is well supported by evidence at this time, however, for the purposes of objectivity, no assumptions are made when scoring taxa in this analysis. The inclusion of every species that is currently believed to be a member of Silesauridae, plus the broadest range of taxa from within Ornithischia that has ever been utilised in an early dinosaur phylogeny should allow thorough testing of the various hypotheses about where Silesauridae fits in to Dinosauriformes.

Asilisaurus kongwe

Age: Anisian, Middle Triassic

Occurrence: Lifua Member of the Manda Beds, Rahuu Basin, Tanzania.

Holotype: NMT RB9, anterior portion of the dentary.

Paratypes: NMT RB21, anterior cervical vertebra; NMT RB10, left scapulocoracoid; NMT RB11, sacrum; NMT RB225, humerus; NMT RB12, proximal portion of an ischium; NMT RB13, ilium; NMT RB14, proximal portion of the pubis; NMT RB15, anterior portion of a skull; NMT RB16, proximal portion of the left humerus; NMT RB17, left astragalus; NMTRB18, right calcaneum; NMT RB19, 102, 109, 112, 159, 169, 171–172, 179, 185, 211–223, 226, 228–229, femora; NMT RB20, 214, 224, tibiae; NMT RB209, tibia and fibula.

Comments: A non-dinosaurian dinosauriform currently believed to be a member of Silesauridae.

Eucoelophysis baldwini

Age: Norian, Late Triassic

Occurrence: Petrified Forest Member, Chinle Formation, New Mexico, USA

Holotype: NMMNH P-22298, partial postcranium

Referred Material: GR 195, proximal portion of the femur

Comments: This taxon was originally thought to represent a theropod dinosaur, closely related to *Coelophysis bauri* (Sullivan & Lucas 1999). However, following work by Nesbitt et al. (2005), Ezcurra (2006), Irmis et al. (2007b), Nesbitt et al. (2007) and Brusatte et al. (2008), *Eucoelophysis baldwini* is now considered to be a non-dinosaurian dinosauriform. The studies of Ezcurra (2006) and Nesbitt et al. (2007) disagreed on the association of a pubis that Sullivan & Lucas (1999) considered to be part of the holotype specimen of *Eucoelophysis baldwini*. Irmis et al. (2007b), along with Nesbitt et al. (2007), questioned this association in their review of North American Triassic dinosaurs. However, this study has scored *Eucoelophysis baldwini* for anatomical characters of the pubis as I feel that Irmis et al. (2007b) and Nesbitt et al. (2007) did not provide convincing enough evidence to justify the removal of this material from the holotype specimen. While I agree with their assessment that the pubic material of the holotype of *Eucoelophysis baldwini* does not resemble that of other

silesaurids, I would urge caution around the practise of breaking up specimens into individual elements simply because they exhibit a less commonly observed combination of character states, at least when no alternative phylogenetic placement for each elements is suggested or supported by the presence of autapomorphic features or diagnostic combinations of characters.

Lutungutali sitwensis

Age: Anisian, Middle Triassic

Occurrence: upper Ntawere Formation, ~5 km west of Sitwe village, Eastern Province, Zambia

Holotype: NHCC LB32, four partial anterior caudal vertebrae, left and right ilia, incomplete left and right ischia, fragments of pubic shafts.

Comments: A Middle Triassic dinosauriform currently believed to represent a silesaurid.

Diodorus scytobrachion

Age: ?Carnian-?Norian, Late Triassic

Occurrence: Northeastern Argana Basin, 2.9 km east of Imzila, Morocco.

Holotype: MHNM-ARG 30, a partial right dentary.

Referred Material: MHNM-ARG 31, 32, and 33, isolated teeth; MHNM-ARG 34 and 35, humeri; MHNM-ARG 36, a metatarsal; MHNM-ARG 37, a femur.

Comments: A Late Triassic dinosauriform currently believed to represent a silesaurid. *Diodorus scytobrachion* was recovered as the sister-taxon to the South American species *Sacisaurus agudoensis* in a phylogenetic analysis by Kammerer et al. 2012.

Ignotosaurus fragilis

Age: Carnian, Late Triassic

Occurrence: Cancha de Bochas, Ischigualasto Provincial Park, San Juan, Argentina.

Holotype: PVSJ 884, right ilium.

Comments: A Late Triassic dinosauriform currently believed to represent a silesaurid. The holotype and only known specimen of *Ignotosaurus fragilis* was first described by Martinez et al. (2013) in the same work as another new dinosauriform specimen, believed to represent a member of the clade Lagerpetidae. This supposed lagerpetid specimen (PVSJ 883) is only known from a single, distal end of a left femur and is not included in this analysis.

8.2.1.3 Dinosaurs: Ornithischia

Pisanosaurus mertii

Age: Carnian-Norian, Late Triassic

Occurrence: Middle portion of the Ischigualasto Formation, Ischigualasto basin, Argentina.

Holotype: PVL 2577, maxilla and dentary, vertebrae, partial hind limb, mold/impression of the acetabular region of pelvis.

Comments: *Pisanosaurus mertii* has always been considered to represent an early member of Ornithischia (Casamiquela 1967; Bonaparte 1976; Butler et al. 2007, 2008; Nesbitt 2011). Despite the relatively poor quality

of preservation of the holotype and only known specimen, PVL 2577, *Pisanosaurus mertii* is consistently recovered within the ornithischian clade in phylogenetic analyses that include more than one ornithischian taxon (Langer and Benton 2006; Butler et al. 2007, 2008; Irmis et al. 2007a; Nesbitt 2011; Boyd 2015). Other phylogenetic analyses of early dinosaurs often utilise *Pisanosaurus mertii* as the sole representative of Ornithischia, the assumption being that, as the earliest known member of the clade, it provides the best evidence available about the clade's 'primitive' anatomy. Other studies do not include any species of ornithischian, but rather score Ornithischia as a single OTU (e.g. Ezcurra 2010) and in these studies the anatomy of *Pisanosaurus mertii* often informs the character scorings for the supraspecific Ornithischia. Assessment of the material of *Pisanosaurus mertii* found few anatomical features that would normally allow for a referral to Ornithischia; the extensive dentary contribution to the anterodorsal margin of the coronoid process is the only feature of *Pisanosaurus mertii* that unites it with other ornithischians to the exclusion of other dinosauromorphs; there is no evidence for a posteriorly oriented (retroverted) pubis (*contra* Bonaparte 1976) or of a predentary bone. Recently, Agnolin (in prep.) has suggested a different position for *Pisanosaurus mertii* within dinosauromorphia, arguing that the taxon could represent a member of Silesauridae. I agree that elements of *Pisanosaurus mertii*, particularly of the postcranium, are very primitive and do resemble the same elements in certain members of Silesauridae. However, the dentition of *Pisanosaurus mertii*, while superficially similar to certain silesaurids, appears to me to be more like the dentition of certain ornithischian taxa, especially given that *Pisanosaurus mertii* appears to lack the ankylosed teeth that most silesaurid specimens possess. This apparent contradiction in the phylogenetic signals of the cranial and postcranial remains has been noted by other authors as well (Norman et al. 2004; Irmis et al. 2007a). Sereno (1991) suggested that the various elements of *Pisanosaurus mertii* may not be associated, with particular reference to the forelimb, which he considered to be too small to belong with the rest of the holotype. However, as Irmis et al. (2007a) pointed out, looking at the field map and descriptions given by Casamiquela (1967) and Bonaparte (1976), it seems unlikely that the elements of the holotype belong to more than one individual. It may be the case that this mix of plesiomorphic and derived features is simply a result of the 'transitional' nature of *Pisanosaurus mertii*, with only a small number of unambiguous ornithischian features having evolved at the time of this taxon's divergence from the base of the clade. Whatever the case, *Pisanosaurus mertii* is included in this analysis as a single OTU with all of its known elements considered.

Eocursor parvus

Age: ?Norian, Late Triassic

Occurrence: Damplaats Farm, Ladybrand District, Free State, Republic of South Africa, upper part of the lower Elliot Formation.

Holotype: SAM-PK-K8025, partial skull and braincase and partial postcranium.

Comments: An early ornithischian that, along with *Pisanosaurus mertii* and an unnamed putative heterodontosaur from Argentina (Irmis et al. 2007a), provides some evidence for the presence of Ornithischia in the Triassic Period. However, as Irmis et al. (2007a) pointed out, the supposed Triassic age of *Eocursor* is reliant on a biostratigraphic hypothesis that may be inaccurate; the distinction between Triassic and Jurassic formations in the area that *Eocursor* was found is reliant on the supposed identification of a specimen of "*Euskelosaurus*", which is a taxon that is currently in need of a revision (Irmis et al. 2007a). It is possible that this supposed "*Euskelosaurus*" specimen is actually misidentified and that *Eocursor parvus* actually comes from the younger upper Elliot Formation (Hettangian-Sinemurian); personal observation in the field confirms the difficulty correctly distinguishing between the upper and lower Elliot Formations in some areas of the Free State of South Africa. For now this taxon is tentatively regarded as a Triassic ornithischian dinosaur, pending a revision of the stratigraphy of the Elliot Formation. In terms of its phylogenetic position within Ornithischia, *Eocursor parvus* has been somewhat unstable. Recently Boyd (2015) recovered *Eocursor* as a member of Heterodontosauridae. Prior to this, *Eocursor* was recovered in a position between Heterodontosauridae and Genasauria by Butler et al. (2007). The analysis in Chapter 2 of this work produced the same result. Wherever it belongs within the ornithischian lineage, *Eocursor parvus* is certainly an important early taxon and should be included in phylogenetic analyses of early dinosaurs and discussions of their early evolution.

Laquintasaura venezuelae

Age: Hettangian, Early Jurassic

Occurrence: Road-cut between the towns of La Grita and Seboruco, Táchira State, La Quinta Formation, Venezuela.

Holotype: MBLUZ P.1396, an isolated maxillary or dentary tooth.

Referred Material: MBLUZ P.5017, distal part of a left femur; MBLUZ P.5018, proximal part of a left ischium; MBLUZ P.5005, a left astragalocalcaneum.

Comments: A phylogenetic analysis by Barrett et al. (2014) recovered *Laquintasaura venezuelae* in a polytomy with a number of other early ornithischian taxa, as well as Heterodontosauridae, Thyreophora and Neornithischia. In my analysis in Chapter 2, which utilised a modified version of the dataset of Butler et al. 2008a, *Laquintasaura venezuelae* was recovered as the sister-taxon to the North American Thyreophoran species *Scutellosaurus lawleri*.

Lesothosaurus diagnosticus

= *Stormbergia dangershoeki*

Age: Hettangian-Sinemurian, Early Jurassic

Occurrence: upper Elliot Formation, South Africa and Lesotho.

Syntype Series: NHMUK PV RU B17, remains of at least two individuals, including most of one articulated skull; NHMUK PV RU B23, partial skull, nearly complete, disarticulated skull;

Referred Material: NHMUK PV R8501, nearly complete, disarticulated skull with some associated postcranial elements; NHMUK PV R11002, ilium; NHMUK PV R11003, ilium; NHMUK PV R11004, partially articulated posterior section of skull and anterior cervicals, including the braincase, parietals, right squamosal, right quadrate, right posterior lower jaw, axis and third cervical; NHMUK PV R11000, partial postcranial skeleton (“*Stormbergia dangershoeki*” paratype); NHMUK PV R11956, partial skull; SAM-PK-K400, partial postcranial skeleton; SAM-PK-K401, partial postcranial skeleton; SAM-PK-K1105, partial postcranial skeleton (“*Stormbergia dangershoeki*” holotype); SAM-PK-K1106, partial postcranial skeleton; SAM-PK-K1107, partial postcranial skeleton; BP/1/4885, partial postcranial skeleton; BP/1/4731, right ilium; BP/1/4945, partial right ilium, proximal humerus and partial femur; NM QR 3076, nearly complete, partially articulated adult, including skull fragments; MNHN LES17, skull; MNHN LES18, skull.

Comments: This Early Jurassic member of Ornithischia is known from a number of specimens that preserve both cranial and postcranial elements. *Lesothosaurus diagnosticus* provides a lot of useful information about the anatomy of early ornithischians and exhibits an interesting mix of plesiomorphic and conditions. Following the conclusions of Chapter 2, I treat the contemporaneous taxon *Stormbergia dangershoeki* as the adult form of *Lesothosaurus diagnosticus* and include all of the known material of *Stormbergia dangershoeki* within the hypodigm of *Lesothosaurus diagnosticus*. In Chapter 2, the phylogenetic analysis that utilised the modified dataset of Butler et al. (2008) recovered *Lesothosaurus diagnosticus* as an early diverging member of Neornithischia i.e. more closely related to *Parasaurolophus walkeri* than to *Ankylosaurus magniventris* or *Stegosaurus stenops* (Cooper 1985). Other phylogenetic analyses of ornithischian dinosaurs (Butler et al. 2008a; Boyd 2015) have recovered *Lesothosaurus diagnosticus* as a member of Thyreophora i.e. more closely related to *Ankylosaurus magniventris* than to *Triceratops horridus* (Sereno 1998). Whatever the case, *Lesothosaurus diagnosticus* represents an important early ornithischian taxon and offers a relatively large amount of useful anatomical information compared to most other early ornithischian taxa.

Heterodontosaurus tucki

= *Lycorhinus tucki*

Age: Early Jurassic

Occurrence: Clarens Formation (Cave Sandstone) and upper Elliot Formation, Herschel, Cape Province and Free State (unpublished specimens), South Africa.

Holotype: SAM-PK-K337, partial skull.

Referred Material: SAM-PK-K1332, complete skull and skeleton; SAM-PK-K10487, partial skull of a juvenile.

Comments: This taxon is known from a small number of well preserved and informative specimens, including a fully articulated individual with an almost complete skull and postcranial skeleton (SAM-PK-K1332). As the best known member of Heterodontosauridae, *Heterodontosaurus tucki* provides a lot of important information about the anatomy of the earliest diverging members of Ornithischia; it is now generally accepted that heterodontosaurids are among the earliest diverging clades within Ornithischia, contrary to a number of early hypotheses that heterodontosaurids were more derived ornithischians (Butler et al. 2008a; Nesbitt 2011; Boyd 2015). Butler et al. (2008a,b), Nesbitt (2011), Norman et al. (2011) and Galton (2014) have all commented upon features of the anatomy of *Heterodontosaurus tucki* that appear similar to features seen in theropod and saurischian dinosaurs, something that has been frequently overlooked by studies of early dinosaurs because of the supposedly distinct nature of Ornithischia within Dinosauria and the relatively low level of attention that this clade has received in the literature compared to the other dinosaurian clades. What these apparent similarities mean in terms of the evolution and interrelationships of early dinosaurs has never been properly, objectively tested using modern phylogenetic methods. Heterodontosaurids, by virtue of their supposed position within Ornithischia, and the mix of plesiomorphic and derived traits that they appear to possess, may provide some of the most useful and decisive anatomical information in a broad phylogenetic study such as this one. Therefore, I have attempted to include as many valid heterodontosaurid taxa as is possible, including the archetypal species *Heterodontosaurus tucki*.

Abrictosaurus consors

= *Lycorhinus consors*

Age: Hettangian-Sinemurian, Early Jurassic

Occurrence: Stream-side exposure near Nosi, 8.2 km east of Whitehill, southern Lesotho, upper Elliot Formation.

Holotype: NHMUK PV RU B54, partial skull and nearly complete, articulated postcranium.

Source(s): NHMUK PV RU B54; Sereno 2012

Comments: One of four currently recognised and valid heterodontosaurid taxa from the upper Elliot Formation of South Africa and Lesotho, *Abrictosaurus consors* is, after *Heterodontosaurus tucki*, the second most complete Early Jurassic heterodontosaurid, being known from an articulated skeleton that has both cranial and postcranial elements preserved. This taxon lacks the prominent tusk-like caniniform tooth that other heterodontosaurids possess (e.g. *Heterodontosaurus tucki*; SAM-PK-K337, SAM-PK-K1332) and this has been suggested as evidence for sexual dimorphism among Elliot Formation heterodontosaurids i.e. *Abrictosaurus consors* may represent a female and the holotype of *Heterodontosaurus tucki* may represent a male, with the presence of paired 'tusks' restricted to the males of the species (Thulborn 1974; Norman 1985; Norman et al. 2011). Whatever the case regarding sexual dimorphism, *Abrictosaurus consors* represents a valid genus and species of heterodontosaurid from an important early stage of ornithischian evolution and is therefore included in this phylogenetic study.

Fruitadens haagarorum

Age: Tithonian, Late Jurassic

Occurrence: The 'drab floodplain facies' at the base of the Brushy Basin Member of the Morrison Formation, LACM Fruita Paleontological Area, west of Fruita, Mesa County, Colorado, USA.

Holotype: LACM 115747, associated jaws, vertebrae and limb bones of an adult individual.

Referred Material: LACM 115727, proximal ends of both femora, proximal and distal ends of left tibia with attached astragalocalcaneum; LACM 120478, left humerus, partial left femur, and articulated left tibia, fibula, and astragalocalcaneum; LACM 120602, distal caudal vertebra, left astragalocalcaneum and elements of the metatarsus and pes; LACM 128258, right premaxilla, partial left maxilla, originally articulated dentaries, dorsal vertebra, distal caudal vertebra; LACM 128303, poorly preserved anterior left dentary.

Comments: While not an early dinosaur as such (coming from a formation that is believed to be Late Jurassic in age) *Fruitadens haagarorum* does still represent an important taxon for understanding early dinosaur evolution as it is believed to be a member of the early diverging ornithischian clade Heterodontosauridae. What is more,

Fruitadens haagarorum is believed to not be a member of the more exclusive clade Heterodontosaurinae, which consists of the upper Elliot heterodontosaurids, such as *Heterodontosaurus tucki* and *Abrictosaurus consors*, as well as the South American heterodontosaurid *Manidens condorensis*, and is relatively derived within the larger clade Heterodontosauridae (Butler et al. 2010; Sereno 2012). In the analysis in Chapter 2, *Fruitadens haagarorum* is recovered in the same position, inside of Heterodontosauridae but outside of Heterodontosaurinae. Like *Heterodontosaurus tucki* and *Abrictosaurus consors*, *Fruitadens haagarorum* is also known from both cranial and postcranial material and is therefore is a useful source of information on the anatomy of early diverging ornithischian taxa. Along with the Chinese heterodontosaurid species *Tianyulong confuciusi*, *Fruitadens haagarorum* gives us the best insight into the anatomy of non-heterodontosaurin heterodontosaurids.

Manidens condorensis

Age: Aalenian-Bathonian, Middle Jurassic

Occurrence: Queso Rallado locality, Cañadón Asfalto Formation, 2.3 km west of the village of Cerro Cándor, Chubut Province, Argentina.

Holotype: MPEF-PV 3211, partial skeleton, including cranial and postcranial remains.

Referred Material: MPEF-PV 1719, 1786, 1718, 3810, 3811, 3812, 3813, 3814, 3815, 3816 isolated teeth.

Comments: Apart from the currently undescribed Laguna Colorada heterodontosaurid specimen, *Manidens condorensis* is the only definitive heterodontosaurid from South America (while *Pisanosaurus mertii* could be a heterodontosaurid, it has not yet been proven to be). In a phylogenetic analysis by Pol et al. (2011b) *Manidens* was recovered as a member of both Heterodontosauridae and the more exclusive Heterodontosaurinae; Heterodontosaurinae is defined as the most inclusive clade containing *Heterodontosaurus tucki* but not *Tianyulong confuciusi*, *Fruitadens haagarorum* or *Echinodon becklesii* (Sereno 2012). *Manidens* is named for its distinctive teeth, which are highly crenulated and asymmetric (Pol et al. 2011b)

Tianyulong confuciusi

Age: Oxfordian, Late Jurassic

Occurrence: Jianchang County, Western Liaoning Province, People's Republic of China, Tiaojishan Formation.

Holotype: STMN 26-3, partial skeleton including skull.

Referred Material: IVPP V17090, partial skeleton including skull.

Comments: Originally thought to be from the Early Cretaceous, *Tianyulong confuciusi* is now believed to be Late Jurassic in age. This Chinese species is known from two specimens, both of which preserve cranial and postcranial remains. In recent phylogenetic analyses *Tianyulong confuciusi* has proved to be a difficult taxon to place consistently within Ornithischia; Boyd (2015) recovered it as a derived member of Heterodontosauridae, closer to *Heterodontosaurus tucki* than taxa like *Abrictosaurus consors*; Sereno (2012) recovered it in a clade with *Fruitadens haagarorum* and *Echinodon becklesii*, outside of Heterodontosauridae; in Chapter 3 of this work *Tianyulong* is also recovered outside of Heterodontosaurinae, although the members of Heterodontosaurinae and the relationships of those heterodontosaurid taxa that fall outside of it differ from the analysis of Sereno (2015); Pol et al. (2011b) recovered it as the earliest diverging member of the clade Heterodontosauridae (with *Echinodon becklesii* being recovered outside of the clade). Wherever *Tianyulong* belongs in Heterodontosauridae, it represents another well-known member of an early diverging clade of ornithischians and so has the potential to be informative in a study of early dinosaur evolution such as this one.

Echinodon becklesii

Age: Berriasian, Early Cretaceous

Occurrence: Either the Marly or the Cherty Freshwater Member, Middle Purbeck Beds of the Purbeck Formation, Swanage, UK

Paralectotypes: NHMUK PV 48211, partial right maxilla with the tip of the right jugal and part of the right palatine; NHMUK PV 48212, partial right maxilla with 6 teeth; NHMUK PV 48213 partial left dentary with 7 teeth; NHMUK PV 48214, partial right dentary; NHMUK PV 48215a, right dentary with 9 teeth; NHMUK PV 48215b, left dentary with 5 teeth.

Referred Material: NHMUK PV 48229, jaw fragment; NHMUK PV 40723, dentary fragment; DORCM GS 1164-5, 1167, 1171, 1194, 1212-6, 1222-3, isolated teeth.

Comments: A somewhat mysterious ornithischian taxon, known only from partial remains and isolated teeth. Evidence for the possible heterodontosaurid affinities of *Echinodon becklesii* was first presented by Sereno (1991) and then supported by work by Norman and Barrett (2002). Subsequent phylogenetic analyses have not always recovered *Echinodon* within Heterodontosauridae; Pol et al. (2011b) recovered it in a polytomy with *Pisanosaurus mertii*, the clade Heterodontosauridae and the clade Genasauria. Butler et al. (2008a) excluded *Echinodon* from their analyses due to its unstable nature. However, Butler et al. (2010) did include *Echinodon* in their analysis and recovered it as a heterodontosaurid outside of Heterodontosaurinae. In Chapter 2, *Echinodon* was removed from the analysis as an unstable wildcard taxon and so its position within the clade Ornithischia could not be tested in this analysis. If *Echinodon becklesii* truly is a heterodontosaurid then it is a very late surviving one and extends the temporal range of Heterodontosauridae into the Early Cretaceous.

Lycorhinus angustidens

= *Lanasaurus scalpridens*

Age: Hettangian-Sinemurian

Occurrence: Paballong, Transkei (Herschel) District, Cape Province, South Africa, upper Elliot Formation.

Holotype: SAM-PK-K3606, left dentary with 11 teeth (preserved as a mold).

Referred Material: BP/1/4244, left maxilla with 12 teeth ("*Lanasaurus scalpridens*" holotype); BP/1/5253, left maxilla with 15 teeth.

Comments: Only known from fragmentary specimens, *Lycorhinus angustidens* can still be distinguished from the other upper Elliot Formation heterodontosaurids by a unique set of anatomical characters and is considered by most authors to be a distinct, valid taxon (Gow 1975; Hopson 1975; Butler et al. 2008a; Sereno 2012). Sereno (2012) referred another heterodontosaurid specimen, NHMUK PV RU A100, to the hypodigm of *Lycorhinus angustidens* with a short justification. However, having examined the relevant material myself, I cannot substantiate the claims of Sereno (2012) and therefore I do not consider the referral of NHMUK PV RU A100 to *Lycorhinus angustidens* to be justified. In this study, *Lycorhinus angustidens* is scored only from the holotype material and the referred specimens BP/1/4244 and BP/1/5253.

Pegomastax africana

= *Pegomastax africanus*

Age: Hettangian-Sinemurian

Occurrence: Voyizane (= Voisana), Transkei (Herschel) District, Cape Province, South Africa, upper Elliot Formation

Holotype: SAM-PK-K10488, fragmentary skull preserving right and left dentaries and the prementary.

Comments: The most recently named heterodontosaurid taxon from the Early Jurassic upper Elliot Formation.

NHMUK PV RU A100

Age: Hettangian-Sinemurian

Occurrence: Transkei (Herschel) District of the South Africa (close to the type locality of *Lycorhinus angustidens*).

Comments: The taxonomic history of this mysterious heterodontosaurid specimen is complicated. Originally assigned to *Lycorhinus angustidens* by Thulborn (1970), other workers have since regarded NHMUK PV RU A100 either as an indeterminate heterodontosaurid (Charig and Crompton 1974; Porro et al. 2011), a specimen of *Abrictosaurus consors* (Hopson 1975), which was also followed by Galton (1986) Weishampel & Witmer (1990) and Smith (1997), or a specimen of *Lanasaurus scalpridens* (Norman et al. 2011). As mentioned above, this specimen was referred to *Lycorhinus angustidens* by Sereno (2012) and informed the reconstructions of that taxon that were presented in his study. As also stated above, based upon my own observations of the relevant material, the claims that were made by Sereno (2012) about features common to NHMUK PV RU A100 and the known material of *Lycorhinus angustidens* cannot be substantiated. I therefore err on the side of caution and consider NHMUK PV RU A100 to be a heterodontosaurid of indeterminate taxonomic affinities. I include this taxon in this analysis for two reasons: to test the possible systematic positions for the specimen within Heterodontosauridae; to increase the amount of available data on definitive early ornithischians, given their relative rarity in the Triassic and Early Jurassic fossil record.

Emausaurus ernsti

Age: Toarcian, Early Jurassic

Occurrence: Lehmahagen, Grimmen (a Tenuicostatum marine shale), *Dactylioceras tenuicostatum* Zone, near Mecklenburg-Vorpommern, Germany.

Holotype: SGWG 85, skull and fragmentary postcranium with osteoderms

Comments: Generally accepted to be a thyreophoran, this late Early Jurassic taxon is one of only a few valid and well known 'primitive' members of Thyreophora (i.e. diverging earlier than Stegosauria and Ankylosauria) and important for our understanding of the early stages of the ornithischian radiation.

Scelidosaurus harrisoni

Age: Sinemurian, Early Jurassic

Occurrence: lower cliff face, marine mudstone in the Charmouth Mudstone Formation, Charmouth, United Kingdom.

Lectotype: NHMUK PV R1111, an almost complete skeleton.

Referred Material: NHMUK PV R6704 partial postcranium; BRSMG CE12785, partial skeleton with cranial and postcranial elements; CAMSM X 39256, partial postcranium; LYMPH 1997.37.4–10 partial postcranium.

Comments: First described by Owen (1859, 1861), almost every skeletal element of this species is known. As an almost complete, early diverging ornithischian taxon, *Scelidosaurus harrisoni* offers one of the best sources of information on the anatomy of early Ornithischia.

Scutellosaurus lawleri

Age: Sinemurian-Pliensbachian, Early Jurassic

Occurrence: Silty facies of the Kayenta Formation, Rock Head and other nearby localities, northern Arizona.

Holotype: MNA 175, nearly complete, associated skeleton including cranial and postcranial elements, including osteoderms.

Referred Material: MNA 1752, partial disarticulated skeleton; UCMP 130580; UCMP 170829; TMM 43687-16; MCZ 8592; MCZ 8799.

Comments: An Early Jurassic North American ornithischian taxon known from multiple individuals. This taxon, along with other non-eurypodan thyreophorans, such as *Scelidosaurus harrisoni*, provides good amounts of information about the anatomy of the early diverging members of Ornithischia.

Stegosaurus stenops

= *Hypsirhophus discursus*

= *Stegosaurus unguatus*

= *Diracodon laticeps*

= *Stegosaurus duplex*

Age: Kimmeridgian-Tithonian, Late Jurassic

Occurrence: Morrison Formation, USA.

Holotype: USNM 4934, an almost complete skeleton

Referred Material: NHMUK PV R36730; AMNH 650; AMNH 470; AMNH 5752; BYU 12290; CEUM uncatalogued; CM 11341 (composite); DINO 2438; DMNH 1483; DMNH 2818; LHNH (CN) 1; USNM 4714; USNM 4936; USNM 6531; USNM 6646; YPM 1853; YPM 1856 (composite); YPM 1858.

Comments: A well-known, well-nested member of the ornithischian clades Thyreophora and Stegosauria, *Stegosaurus stenops* is included in this analysis to serve as a good representative of these relatively early diverging groups. While fairly derived, *Stegosaurus stenops* does offer useful anatomical information for a study such as this one.

Hexinlusaurus multidentis

= *Yandusaurus multidentis*

Age: ?Bajocian, Middle Jurassic

Occurrence: Lower Shaximiao Formation, Dashanpu, Zigong, Sichuan Province, People's Republic of China.

Holotype: ZDM T6001, a nearly complete, articulated cranium and postcranium.

Referred Material: ZDM T6002, partial skull and postcranium.

Comments: One of the earliest known representatives of the clade Neornithischia, this Middle Jurassic taxon offers insight into the anatomy of non-thyreophoran genasaurian ornithischians. The anatomy of *Hexinlusaurus multidentis* is relative 'primitive' for a neornithischian and is included in this analysis so that the nature of the anatomy of the Ornithischia is better represented than in most other phylogenetic studies of dinosaurs (Yates 2003a; Langer & Benton 2006; Ezcurra 2010; Cabreira et al. 2016).

Agilisaurus louderbacki

Age: ?Bajocian, Middle Jurassic

Occurrence: Lower Shaximiao Formation, Dashanpu, Zigong, Sichuan Province, People's Republic of China.

Holotype: ZDM T6011, a complete, articulated skull and postcranium, lacking only small portions of the limbs.

Comments: Along with *Hexinlusaurus multidentis* and *Xiaosaurus dashanpensis*, *Agilisaurus louderbacki* is one of the earliest known members of Neornithischia, one of two major clades within Genasauria, the other being Thyreophora. Known from good cranial and postcranial material, this taxon offers insight into the anatomy of this important group of ornithischians and better informs our understanding of the anatomy of earlier diverging ornithischian taxa, such as *Lesothosaurus diagnosticus* and *Eocursor parvus*.

Jeholosaurus shangyuanensis

Age: Barremian-Aptian, Early Cretaceous

Occurrence: Lujiatun, Liaoning Province, People's Republic of China, 'Lujiatun Bed,' Yixian Formation.

Holotype: IVPP V12529, a partial skeleton consisting of a skull, a partial axial column and both hind limbs.

Referred Material: IVPP V12530, a skull with articulated cervical vertebrae; IVPP V12542, a skull with a nearly complete axial column, partial forelimb and hind limb, and a nearly complete pelvis; IVPP V15719, a nearly complete skull, partial axial column, pelvic girdle, and hind limbs; IVPP V15939, partial axial column, partial pelvic girdle, and a complete hind limb and pes.

Comments: While not an early dinosaur, this Early Cretaceous member of Neornithischia has a high level of skeletal completeness and retains a lot of ‘primitive’ ornithischian features. Therefore, *Jeholosaurus shangyuanensis* does offer some useful anatomical information for studies of early dinosaur evolution, such as this one. Han et al. (2012) recovered *Jeholosaurus* as a member of Ornithopoda, the largest clade within Ornithischia, while Boyd (2015) recovered it in a much less derived position within Neornithischia, in a clade with *Yueosaurus*, another Early Cretaceous Chinese taxon. I include *Jeholosaurus shangyuanensis* in this analysis to serve as a representative of neornithischians more derived than taxa such as *Hexinlusaurus multidentis* and *Agilisaurus louderbacki*, choosing it over *Yueosaurus tiantaiensis* because it is more complete; *Yueosaurus* does not have any known skull material and has fewer postcranial elements preserved than *Jeholosaurus* does.

Psittacosaurus

Age: ?Hauterivian-Albian, Early Cretaceous

Occurrence: Multiple localities in Asia.

Comments: *Psittacosaurus* is the most species-rich genus of dinosaur currently known and is represented by hundreds of individuals. The genus belongs to Ceratopsia, one of the major ornithischian clades within Neornithischia, and is believed to be one of the more ‘primitive’ members. I include *Psittacosaurus* in this analysis because of what it contributes to our knowledge of ornithischian anatomy and because it extends the coverage of the ornithischian clades in to Cerapoda (*Jeholosaurus* is not always considered to be a member of this clade, see above). However, I consider *Psittacosaurus* as a genus in this analysis, rather than considering individual species, as including each species separately would be time consuming and would add little additional data to the analysis. For character scoring, I rely mainly upon the specimen Nr 2007 | 63 (unpublished photographs), currently regarded as *Psittacosaurus*, supplemented with information from the literature on certain individual species within the genus. As a result, *Psittacosaurus* is one of only two supraspecific taxa included in this analysis, the other being the sauropodomorph *Eucnemesaurus*, as well as one of the youngest taxa.

8.2.1.4 Dinosauria: Theropoda

Eoraptor lunensis

Age: Carnian, Late Triassic

Occurrence: Ischigualasto Formation, San Juan, Argentina.

Holotype: PVSJ 512, complete skeleton, missing only the distal caudal vertebrae.

Comments: A highly controversial early dinosaur taxon; *Eoraptor lunensis* has been recovered in numerous positions within the dinosaurian tree, including as the sister taxon to ‘Eusaurischia’ (Langer & Benton 2006); as a theropod dinosaur, sister taxon to a clade containing *Herrerasaurus ischigualastensis* and Neotheropoda (Serenó et al. 1993; Rauhut 2003); as a sauropodomorph, close to the base of Sauropodomorpha (Martínez et al. 2011); or as a theropod, closer to Neotheropoda than Herrerasauridae is (Nesbitt et al., 2009b; Ezcurra 2010; Nesbitt 2011; Sues et al., 2011). It is also worth noting here that Nesbitt (2011) incorrectly listed *Eoraptor lunensis* as a member of Neotheropoda, a clade which he redefined as the least inclusive clade containing *Coelophysis bauri* and *Passer domesticus* (*sensu* Sereno 2005); in his analysis, Nesbitt (2011) recovered *Eoraptor lunensis* as a theropod outside of the least inclusive clade containing *Coelophysis bauri* and *Passer domesticus*. Nesbitt and Ezcurra (2015) recovered *Eoraptor lunensis* as sister taxon to all other sauropodomorphs, following a re-scoring of this taxon using the new anatomical information that was presented by Sereno et al. (2013). However, Sereno et al. (2013) referred a number of postcranial elements to *Eoraptor*

lunensis with little justification, and this material partly informed their arguments that this taxon was in fact a sauropodomorph and not a theropod. This study finds that the referral of additional material to the taxon by Sereno et al. (2013) is unjustified at present, and, therefore, only anatomical information that can be taken from the holotype specimen (PVSJ 512) is considered in this study. However, it should be noted that Cabreira et al. (2016) recovered *Eoraptor lunensis* as a sauropodomorph more derived than *Buriolestes schultzi*, positioned stemward of all other sauropodomorphs. However, whether or not Cabreira et al. (2016) also considered the dubiously referred postcranial elements when scoring *Eoraptor lunensis* for their characters is unclear. Wherever *Eoraptor lunensis* belongs, this taxon is certainly an important early dinosaur and its relatively high level of skeletal completeness makes it a critically important taxon for phylogenetic studies of early dinosaurs such as this one.

Eodromaeus murphi

Age: Carnian, Late Triassic

Occurrence: Valle de la Luna Member, Ischigualasto Formation, Argentina.

Holotype: PVSJ 560, a nearly complete, although somewhat deformed, skeleton, with some associated cranial elements.

Referred Material: PVSJ 534, left femur, proximal right tibia, and a partially articulated left ankle and hind limb consisting of the astragalus, calcaneum, distal tarsal 3 and 4, and the proximal ends of metatarsals 1-4; PVSJ 561, articulated left maxilla, nasal and most of the jugal and right femur; PVSJ 562, partial disarticulated skeleton including the posterior portion of the skull, axial column, left and right scapulocoracoids; an articulated left forelimb; left and right ischia lacking their distal ends, left femur, tibia and fibula and articulated right distal tibia, fibula, calcaneum and distal tarsal 4, and the distal end of metatarsal 4 in articulation with all phalanges of pedal digit IV; PVSJ 877, anterior cervical centrum.

Comments: In the same phylogenetic analysis that first recovered *Eoraptor lunensis* within Sauropodomorpha, the contemporaneous taxon *Eodromaeus murphi* was recovered as an early diverging member of Theropoda (Martinez et al. 2011). Until the study by Cabreira et al. (2016), few other phylogenetic analyses of early dinosaurs (e.g. You et al. 2014; Martill et al. 2016) included *Eodromaeus murphi*, and so the hypothesis that this taxon represents an early theropod has not been rigorously tested; Nesbitt and Ezcurra (2015) recovered *Eodromaeus murphi* as a theropod but Cabreira et al. (2016) recovered *Eodromaeus murphi* outside of the clade containing Theropoda and Sauropodomorpha (= Eusaurischia), as an early diverging saurischian dinosaur, along with other taxa that are also often traditionally considered to be theropods, such as *Tawa hallae* and *Daemonauros chauliodus* (Nesbitt et al. 2009b; Nesbitt 2011; Sues et al. 2011). This taxon is included in this analysis so that its phylogenetic affinities can be tested further, and because, regardless of where it falls within the dinosaurian tree, it represents an important early dinosaur and is known from a good amount of material.

Tawa hallae

Age: Norian, Late Triassic

Occurrence: Site 2, Hayden Quarry, Ghost Ranch, Rio Arriba County, New Mexico, USA.

Holotype: GR 241, nearly complete, but disarticulated skull and most of an articulated skeleton.

Paratypes: GR 155, ilium, pubes, proximal ischium, femora, sacral vertebra, and caudal vertebrae; GR 242, nearly complete skeleton; GR 243, cervical vertebrae; GR 244, complete right femur.

Referred Material: GR 240, nearly complete femur.

Comments: An early dinosaur (Late Triassic) from North America, *Tawa hallae* is generally considered to be a theropod, falling either just outside of (Nesbitt et al. 2009b; Nesbitt 2011; Sues et al. 2011) or within (Martinez et al. 2011) Neotheropoda. Recently, Cabreira et al. (2016) recovered *Tawa hallae* in a more unconventional position outside of 'Eusaurischia', along with other taxa that are more commonly thought to belong to Theropoda, such as *Daemonauros chauliodus* (Sues et al. 2011). All workers to date agree that *Tawa hallae* is more derived within Saurischia than the clade Herrerasauridae (Nesbitt et al. 2009b; Nesbitt 2011; Sues et al. 2011; Cabreira et al. 2016). Wherever *Tawa hallae* belongs within Dinosauria, it represents another important

early dinosaurian taxon and, by virtue of the fact that it is known from good amounts of both cranial and postcranial material, offers lots of potentially useful information for phylogenetic studies such as this one.

Daemonosaurus chauliodos

Age: Rhaetian, Late Triassic

Occurrence: *Coelophys* Quarry, Ghost Ranch, Rio Arriba County, New Mexico, USA.

Holotype: CM 76821, nearly complete but crushed skull.

Comments: Recovered as a member of Theropoda in the original analysis by Sues et al. (2011), the position of *Daemonosaurus chauliodus* within Saurischia, like that of *Tawa* and *Eodromaeus*, was also recently challenged by Cabreira et al. (2016); in their phylogenetic analysis, Cabreira et al. (2016) recovered *Daemonosaurus chauliodus* as a 'non-eusaurischian' non-theropodan member of Saurischia. Although the only known material of *Daemonosaurus chauliodus* is rushed and difficult to interoperate, I include this taxon in this analysis as it could still offer useful anatomical information about the early members of the clade Saurischia in the interrelationships within it.

Liliensternus liliensterni

= *Halticosaurus liliensterni*

Age: ?Norian-?Rhaetian, Late Triassic

Occurrence: Großen Gleichberg in the Trossingen Formation, Middle Keuper Group, Thuringia, Germany.

Syntype Series: HMN MB.R.2175, two partial skeleton containing cranial and postcranial elements.

Comments: An early theropod, generally considered to be a member of Coelophysoidea (Carrano et al. 2005; Ezcurra & Cuny 2007) or the earliest diverging member of the sister group to coelophysids (Hendrickx et al. 2015). Either way, *Liliensternus liliensterni* provides useful anatomical information on the crania and postcrania of early theropod taxa and is included in this study as a result.

Lophostropheus airelensis

= *Liliensternus airlensis*

Age: Either ?Rhaetian, Late Triassic or ?Hettangian, Early Jurassic Occurrence: Airel quarry (Manche), southeast of the Cotentin peninsula, in the Carentan basin, Normandy, France.

Holotype: [No Collection Number Assigned], incomplete skeleton represented by one tooth, five cervical vertebrae, two caudal dorsal vertebrae, four sacral vertebrae and caudal vertebrae, part of ilium, ischium, proximal pubes.

Comments: An early theropod, generally believed to be a coelophysoid (Ezcurra & Cuny 2007).

Segisaurus halli

Age: ?Pliensbachian-?Toarcian, Early Jurassic

Occurrence: Navajo Sandstone, Segi Canyon, Navajo (Diné) Nation, Coconino County, Arizona.

Holotype: UCMP 32101, a partial postcranial skeleton.

Comments: An Early Jurassic theropod, *Segisaurus halli* is only known from a single, partial postcranium. Nonetheless, this taxon possesses an interesting suite of theropod features and contributes to our understanding of early evolution of Theropoda.

Coelophysis bauri

= *Coelurus bauri*

Age: Norian, Late Triassic

Occurrence: 'Siltstone member', Chinle Formation, Rio Arriba County, New Mexico, USA.

Neotype: AMNH FR 7224, almost complete articulated skeleton.

Referred Material: Numerous specimens from the Ghost Ranch *Coelophysis* quarry in the collections of several North American institutions, including CM 31374, a complete skull (Colbert 1989; Nesbitt et al. 2007; Nesbitt 2011).

Comments: One of the most well-known early theropods, *Coelophysis bauri* is an essential taxon in any study of early dinosaur evolution. It is regarded as a one of the earliest diverging members of Neotheropoda, as part of the more exclusive theropod clades Coelophysidae and Coelophysoidea (Nopsca, 1923, 1928; Gauthier 1986; Rowe & Gauthier 1990; Carrano et al. 2002, 2005; Rauhut 2003; Tykoski & Rowe 2004; Ezcurra & Cuny 2007; Ezcurra & Brusatte 2011; You et al 2014; Martill et al. 2016). By virtue of the fact that almost every skeletal element is known for *Coelophysis bauri*, as a taxon it offers a great deal of important information about early dinosaur and theropod anatomy and is included in this study for that purpose.

Coelophysis rhodesiensis

= *Syntasus rhodesienses*

= *Megapnosaurus rhodesienses*

Age: ?Hettangian-?Pliensbachian, Early Jurassic

Occurrence: Kwengula stream, Southcote Farm, Zimbabwe, Forest Sandstone Formation (= Samkoto Formation).

Holotype: QG/1, a partial skeleton.

Referred Material: Multiple specimens in the collections of the Natural History Museum of Zimbabwe, Bulawayo, Zimbabwe (QC) and the Evolutionary Studies Institute, Witwatersrand University, Johannesburg, South Africa (BP).

Comments: Now considered to be a species of *Coelophysis*, this taxon from the Early Jurassic of southern Africa represents another relatively well known theropod taxon that is generally considered to be a member of Coelophysoidea within the larger clade Neotheropoda (Ezcurra & Cuny 2007). It is known from both cranial and postcranial material.

“Syntarsus” kayentakatae* = *Megapnosaurus kayentakatae

= *Coelophysis kayentakatae*

Age: Sinemurian-Pliensbachian, Early Jurassic

Occurrence: “Rock Head North”, Sand Mesa, southern end of the Adeii Eechii Cliffs, Ward Terrace of the Little Colorado River Valley, Arizona, USA, Silty Facies Member, Kayenta Formation.

Holotype: MNA V2623, skull and partial postcranium.

Paratype: MCZ 9175, a femur.

Referred Material: MNA V100, a partial ilium; MNA V140, fragments of both a humerus and a femur of a juvenile.

Comments: This taxon is one of many early dinosaurs known from the Early Jurassic Kayenta Formation and comes from the same stratigraphic level as *Scutellosaurus lawleri* (Colbert 1981; Rowe 1989). Originally named as *Syntarsus kayentakatae* by Rowe, 1989, and now sometimes considered to belong to the genus *Coelophysis*

(e.g. Bristowe & Raath 2004), this taxon has a somewhat complex taxonomic history. Tykoski and Rowe (2004) highlighted features of this taxon that distinguish it from *Coelophysis*, including a crest on the skull, as is also seen in some other theropod taxa, such as *Sinosaurus triassicus* and *Dilphosaurus wetherilli* (Welles 1954; Hu 1993). Nesbitt et al. (2007) used the name '*Syntarsus*' *kayentakatae* for this taxon, as opposed to *Syntarsus kayentakatae*, as the generic name *Syntarsus* is occupied by genus of beetle (Ivie et al. 2001). This was also followed by Ezcurra and Brusatte (2011) and Nesbitt and Ezcurra (2015) in their phylogenetic analyses of coelophysoid dinosaurs. Given the striking differences between the material of this taxon and that of the taxa that belong to the genus *Coelophysis*, I follow Nesbitt et al. (2007), Ezcurra and Brusatte (2011) and Nesbitt and Ezcurra (2015) in not regarding this taxon as a member of *Coelophysis*. As the generic name *Megapnosaurus* was first proposed to take the place of the preoccupied *Syntarsus* (Ivie et al. 2001) for the Early Jurassic African species *Syntarsus rhodesiensis* (Raath 1969), and this taxon is now considered to be a species of *Coelophysis* (i.e. *Coelophysis rhodesiensis* – Bristowe & Raath 2004; Carrano et al. 2012), the name *Megapnosaurus* should be considered a junior subjective synonym of *Coelophysis* and therefore invalid. If *Megapnosaurus* (Ivie et al. 2001) is invalid as a generic name, then the taxon '*Syntarsus*' *kayentakatae*, if found to be adequately distinct from the two species *Coelophysis*, could, in theory, be given a new generic name, without the risk of it being synonymised with either *Coelophysis* or *Megapnosaurus*. However, for now, this taxon will be referred to as '*Syntarsus*' *kayentakatae* in order to remain consistent with Nesbitt et al. (2007), Ezcurra and Brusatte (2011) and Nesbitt and Ezcurra (2015).

Camposaurus arizonensis

Age: Norian, Later Triassic

Occurrence: Placerias quarry, vicinity of St. Johns, Apache County, Arizona, USA, Mesa Redondo Member of the Chinle Formation.

Holotype: UCMP 34498; right and left distal ends of tibia and fibula fused with their respective astragalocalcanea.

Comments: Nesbitt et al. (2007) considered *Camposaurus arizonensis* as a nomen dubium on the grounds that the only supposed autapomorphy of the taxon was also found in some specimens of *Coelophysis*. However, a reassessment by Ezcurra and Brusatte (2011) demonstrated that *Camposaurus arizonensis* is a valid taxon, distinct from other coelophysoids, including *Coelophysis*. It must be noted though that in the phylogenetic analysis that was carried out by Ezcurra and Brusatte (2011), *Camposaurus arizonensis* was recovered as the sister taxon to *Coelophysis rhodesiensis*, with *Coelophysis bauri* falling stemward of this group. From a cladistic point of view, this would actually make *Camposaurus arizonensis* a member of the genus *Coelophysis*, should both *Coelophysis bauri* and *Coelophysis rhodesiensis* also be considered as valid members. This result was reproduced in the analysis by Nesbitt and Ezcurra (2015). Wherever it belongs within Theropoda, *Camposaurus arizonensis* is worth including in this analysis because, while it is only known from very fragmentary material, it possesses a handful of interesting anatomical features that could potentially unite it with other members of Neotheropoda and with other dinosaurs e.g. fusion of the tibia, fibula and proximal tarsals (= tibiotarsus, 'tibiofibiotarsus').

Lepidus praecisio

Age: ?Norian, Late Triassic

Occurrence: Dockum Site 7 General (TMM locality 41936), near classic Otis Chalk localities, Howard County, Texas, USA, Dockum Group.

Holotype: TMM 41936-1.3, articulated distal ends of the left tibia and fibula and a left astragalocalcaneum.

Referred Material: TMM 41936-1, fragment of left femoral shaft; TMM 41936-1.1, partial left maxilla.

Comments: An early theropod from the Late Triassic, *Lepidus praecisio* has been recovered as a Neotheropod and possibly as a coelophysoid.

Procompsognathus triassicus

Age: Norian, Late Triassic

Occurrence: Middle Stubensandstein Member, Löwenstein Formation, Weiße Steinbruch, quarry of Albert Burrer, Stromberg region near Pfaffenheim, Württemberg, Germany.

Holotype: SMNS 12591, partial postcranial skeleton, now disassociated with SMNS 12591a, a partial skull, now believed to belong to a different taxon

Comments: Following a number of revisions to this taxon's hypodigm, *Procompsognathus triassicus* is now generally considered to be known from just a partial postcranial skeleton (SMNS 12591) and is scored in this study from this material only. Recent phylogenetic analyses have recovered this taxon as a coelophysid (Carrano et al. 2005; Ezcurra & Novas 2007).

Sarcosaurus woodi

Age: Hettangian, Early Jurassic

Occurrence: Blue Lias Formation, Lower Lias Group, near Barrow-on-Soar, England, UK.

Holotype: NHMUK PV 4840/1

Source(s): NHMUK PV 4840/1

Comments: An early European theropod, *Sarcosaurus woodi*, while only known from fragmentary material, still preserves anatomical features suggestive of a position (and perhaps an early divergence) within the clade Neotheropoda. Carrano et al. (2005) recovered *Sarcosaurus woodi* as a member of the clade Coelophysoidea.

Dracoraptor hanigani

Age: Hettangian, Early Jurassic

Occurrence: Blue Lias Formation, Lower Lias Group, Bull Cliff Member, Bristol Channel Basin, Wales, UK.

Holotype: NMW 2015.5G.1–2015.5G.11 is a disarticulated, but associated partial skeleton with elements of the skull and numerous postcranial elements.

Comments: One of the earliest occurring Jurassic theropods, *Dracoraptor hanigani* was recovered as a member of Neotheropoda in the phylogenetic analysis that was carried out by Martill et al. (2016), as the sister taxon to Coelophysidae. Martill et al. (2016), in their study, also note a number of similarities between the anatomy of *Dracoraptor hanigani* and that of the non-neotheropodan theropod taxa *Tawa hallae* and *Daemonosaurus chauliodus*.

Panguraptor lufengensis

Age: Either ?Hettangian-?Pliensbachian, Early Jurassic or ?Sinemurian-?Toarcian, Early Jurassic

Occurrence: Lufeng County, Yunnan Province, China. Shawan Member of the Lufeng Formation.

Holotype: LFGT-0103, an articulated partial skeleton with an almost complete skull.

Comments: Recovered as a member of Coelophysidae more derived than '*Syntarsus*' *kayentakatae* in the analyses by You et al. (2014) and Martill et al. (2016), *Panguraptor lufengensis* most probably represents an early Neotheropod, and, as such, could offer useful anatomical information about the early evolution of this clade within Dinosauria, especially given that it preserves a good amount of cranial and postcranial elements.

Zupaysaurus rougieri

Age: Norian, Late Triassic

Occurrence: Los Colorados Formation, Agua de la Peña Group (La Esquina Fauna), Ischigualasto-Villa Unión Basin, Quebrada de los Jachaleros, La Rioja Province, Argentina.

Holotype: PULR 076, skull and partial postcranium.

Comments: The phylogenetic position of *Zupaysaurus rougieri* has been somewhat controversial. Ezcurra (2007) reassessed *Zupaysaurus rougieri* in a phylogenetic analysis and recovered it in numerous possible places within Coelophysoidea (*sensu* Sereno et al. 2005; Nesbitt & Ezcurra 2015) and, in some analyses within Coelophysidae (*sensu* Sereno 1998). Martill et al. (2016) recovered *Zupaysaurus rougieri* outside of Coelophysoidea while You et al. (2014) recovered it within Coelophysoidea just outside of the more inclusive clade Coelophysidae. Cabreira et al. (2016) recovered *Zupaysaurus rougieri* as the earliest diverging theropod in their analysis (taxa such as *Tawa hallae* and *Daemonosaurus chauliodus* were not considered to be theropods or even ‘eusaurischians’ in their analysis). Wherever *Zupaysaurus rougieri* belongs within Neotheropoda, it certainly represents an important early dinosaur and offers a good amount of anatomical information for a phylogenetic analysis such as this one.

Dilophosaurus wetherilli

= *Megalosaurus wetherilli*

Age: Sinemurian-Pliensbachian, Early Jurassic

Occurrence: Gold Springs. Moenkopi Wash, Landmark Wash, Arizona, USA, Lower portion of the silty facies of the Kayenta Formation.

Holotype: UCMP 37302, a nearly complete skeleton.

Paratype: UCMP 37303, a nearly complete skeleton.

Referred Material: Multiple specimens housed at UCMP, TMM, and MNA.

Comments: One of the most well-known early theropods, *Dilophosaurus wetherilli* offers a good amount of anatomical information about early dinosaurs. Some analyses have recovered *Dilophosaurus wetherilli* as a coelophysoid (e.g. Carrano et al. 2005), but more recent works recover this taxon in a more derived position within Neotheropoda (e.g. Yates 2005).

Dracovenator regenti

Age: Hettangian-Sinemurian

Occurrence: Upper Drumbo Farm, Barkly East district of Eastern Cape, South Africa, upper Elliot Formation.

Holotype: BP/1/5243, a fragmentary skull.

Comments: Thought to be a close relative of the North American taxon *Dilophosaurus wetherilli* (Yates 2005), *Dracovenator regenti* is one of only two valid theropod taxa known from the upper Elliot Formation of southern Africa, the other being *Coelophysis rhodesiensis*. The upper Elliot Formation has yielded a high number of genera and species of sauropodomorph and ornithischian dinosaurs, all appearing to be either herbivores or omnivores, and this raises the interesting question of why so little theropod (~carnivorous dinosaur) material is known from the same formation, given the apparent abundance of prey species. Whatever the explanation, *Dracovenator regenti* certainly gives us a very rare glimpse into the anatomy, evolution and early distribution of the clade Neotheropoda.

Sinosaurus triassicus

= *Dilophosaurus sinensis*

Age: Sinemurian, Early Jurassic

Occurrence: “Dark Red Beds”, Lufeng Formation of Dahuangtian Village, Dawa Village, Jinshan Township, Lufeng County, China.

Holotype: IVPP V34, is a partial maxilla and three associated teeth.

Referred Material: IVPP V30, V31, dorsal vertebrae; KMV8701, a nearly complete skeleton, including a complete skull; LDM–L10, a nearly complete skeleton; ZLJ0003, anterior portion of a skull and almost complete postcrania; ZLJT01, incomplete skull, and several postcranial skeleton fragments.

Comments: Some of the specimens that are now considered to belong to this taxon were once assigned to the genus *Dilophosaurus*, with the species name *Dilophosaurus sinensis* (Hu, 1993). The specimens are now combined into one genus and species, *Sinosaurus triassicus*, which has been shown to be distinct from, and recovered as being derived within Neotheropoda than, *Dilophosaurus* (Rauhut 2003). It is possible that this Early Jurassic specimen represents the much more derived theropod clade Tetanurae (Rauhut 2003), but this hypothesis did not find support in the analysis by Smith et al. (2007), who instead recovered it ('*Dilophosaurus sinensis*') in a clade with *Dilophosaurus wetherilli*, *Dracovenator regenti* and *Cryolophosaurus eillioti* outside of Tetanurae and the clade containing both Tetanurae and Neoceratosauria. Whatever the case, *Sinosaurus triassicus* certainly represents an important early theropod, and potentially offers information on the anatomy of theropods more derived within Neotheropoda than coelophysoid and coelophysid taxa.

Cryolophosaurus eillioti

Age: ?Sinemurian, Early Jurassic

Occurrence: Hanson Formation on Mt. Kirkpatrick, Beardmore Glacier region of the Central Transantarctic Mountains, Antarctica

Holotype: FMNH PR1821: nearly complete skull and associated partial skeleton.

Comments: As with *Sinosaurus triassicus*, the phylogenetic position of *Cryolophosaurus eillioti* within Neotheropoda is contentious. Rauhut (2003), placed this taxon within Tetanurae, along with *Sinosaurus triassicus*, and this was supported by the finds of Carrano et al. (2012). However, phylogenetic analyses by Smith et al. (2007) and Nesbitt et al. (2009b) place *Cryolophosaurus eillioti* close to *Dilophosaurus wetherilli* and outside of the clades Tetanurae and Tetanurae+Neoceratosauria.

Tachiraptor admirabilis

Age: Hettangian, Early Jurassic

Occurrence: Greenish siltstone at the lower third of the 'middle interval' of the La Quinta Formation, 4km northwest of the town of La Grita, Jáuregui municipality, Táchira State, Venezuela.

Holotype: IVIC-P-2867, a nearly complete right tibia.

Referred Material: IVIC-P-2868: proximal left ischium found in the same spot as the type-material.

Comments: Found in the same Formation as the early ornithischian taxon *Laquintasaura venezuelae*, *Tachiraptor admirabilis* is thought to represent a neotheropod more derived than coelophysoids and 'dilophosaurids', but less derived than the members of Ceratosauria; Langer et al. 2014 recovered *Tachiraptor admirabilis* as the sister taxon to *Averostra*.

Elaphrosaurus bambergi

Age: Kimmeridgian, Late Jurassic

Occurrence: German Tendaguru Expedition quarry dd, ~2500 m north of Tendaguru Hill, Lindi, Tanzania, Middle Dinosaur Member, Tendaguru Formation.

Holotype: MB R 4960, partial postcranial skeleton.

Comments: A recent phylogenetic analysis by Rauhut & Carrano (2016) recovered *Elaphrosaurus bambergi* as a member of Ceratosauria, within the more inclusive clade Noasauridae. As such, *Elaphrosaurus bambergi* is more derived within Neotheropoda than coelophysoids and taxa such as *Dilophosaurus wetherilli*. It is included in this analysis to represent such derived theropods.

Ceratosaurus nasicornis

Age: Kimmeridgian-Tithonian, Late Jurassic

Occurrence: Quarry No. 1, Garden Park, near Canon City, Fremont

County, Colorado, USA, Morrison Formation.

Holotype: USNM 4735, a nearly complete skeleton with skull.

Comments: A Late Jurassic, derived member of Neotheropoda, *Ceratosaurus nasicornis* is one of the best well known ceratosaur dinosaurs and offers a lot of useful anatomical information about the group. Most phylogenetic analyses recover *Ceratosaurus nasicornis* within the clade Ceratosauria (part of the larger clade Averostra), which would eventually give rise to the abelisaurid theropods (Langer et al. 2014; You et al. 2014; Hendrickx et al. 2015; Novas et al. 2015; Rauhut et al. 2016).

Eoabelisaurus mefi

Age: Aalenian-Bajocian, Middle Jurassic

Occurrence: Jugo Loco locality, close to the village of Cerro Cóndor, Chubut, Argentina, finely bedded mud-, marl- and limestones, Cañadón Asfalto Formation.

Holotype: MPEF PV 3990, an almost complete skeleton, including the posterior half of the skull.

Comments: An early member of the derived tetanuran clade Abelisauridae, this taxon is included in this study to inform some of the higher relationships within Neotheropoda.

‘Merosaurus newmani’

Age: Hettangian-Sinemurian, Early Jurassic

Occurrence: Charmouth, UK, Blue Lias, Lower Lias Group.

Holotype: NHMUK PV 39496, a partial hind limb.

Referred Material: GSM 109560, a partial proximal femur; GSM 109561, an isolated ungual.

Comments: Originally thought to belong to the ornithischian taxon *Scelidosaurus harrisoni*, hind limb material from the Blue Lias at Charmouth is now considered to be from a theropod dinosaur (Benson 2010a). The material, which is only fragmentary hind limb material, was included in the phylogenetic analyses of Benson (2010a). In this study, Benson (2010a) found that the articulated partial femur and partial tibia and fibula (NHMUK PV 39496) were most likely to be a theropod close to the coelophysid ‘*Syntarsus kayentakatae*’. The remaining material (specimens GSM 109560 and GSM 109561) was scored as separate OTUs. These were found to be indeterminate, largely due to their incomplete nature. The name ‘*Merosaurus newmani*’ has been used for the material informally, but such a taxon has never been formally described. In this study, all of the theropod material collected from the Blue Lias at Charmouth is provisionally treated as being from the same taxon.

Berberosaurus liassicus

Age: Pliensbachian-Toarcian, Early Jurassic

Occurrence: Douar of Tazouda, near the village of Toundoute, Province of Ouarzazate, High Atlas Mountains, Morocco, Upper bone-bed, “Fossil locality B”, Toundoute continental series.

Holotype: Associated postcranial material: MHNM-Pt9, a cervical vertebra; MHNMPt23, anterior part of a sacrum; MHNM-Pt22, a second left metacarpal; MHNM-Pt19, a right femur; MHNM-Pt2, the proximal end of a left tibia; MHNM-Pt16, the distal end of a right tibia; MHNM-Pt20, left fibula.

Referred Material: The proximal end of a right femur (MHNM-To1–218)

Comments: Originally recovered as a ceratosauroid (Allain et al. 2007), this taxon has also been recovered within a clade that contains *Dilophosaurus wetherilli* and *Cryolophosaurus ellioti* and falls stemward of the Ceratosauria+Tetanurae clade (= Averostra) (Langer et al. 2014). Rauhut et al. (2016), on the other hand, recovered it at the earliest diverging ceratosaurian theropod. Wherever it belongs within Neotheropoda, *Berberosaurus liassicus* certainly represents an important Early Jurassic member of Theropoda, and contributes important anatomical information about early theropods.

Condorraptor currumili

Age: Callovian, Middle Jurassic

Occurrence: Las Chacritas locality, west of Cerro C ndor, Patagonia, Argentina, a breccia within a series of lacustrine clays, tuffs and limestones, Ca ad n Asfalto Formation.

Holotype: MPEF-PV 1672, an incomplete left tibia.

Referred Material: MPEF-PV 1694–1695, teeth; MPEF-PV 1673–1675, cervical vertebrae; MPEF-PV 1676–1680, 1697, 1700, 1705, dorsal vertebrae and vertebral fragments; MPEF-PV 1681, 1701, sacral vertebrae; MPEF-PV 1682–1683, 1702, caudal vertebrae; MPEF-PV 1684–1685, 1703, rib fragments and chevron; MPEF-PV 1686–1689, 1696, 1704, partial ilium, pubes and ischium; MPEF-PV 1690–1693, partial femora, metatarsal IV and pedal ungual.

Comments: Generally considered to be a close relative of the contemporaneous taxon *Piatnitzkysaurus floresii*, *Condorraptor currumili* represents a Middle Jurassic averostran neotheropod that is frequently recovered within Tetanurae (Benson 2010; Langer et al. 2014; Rauhut et al. 2016). The known material of *Condorraptor currumili* comes from the Ca ad n Asfalto Formation, which has also yielded a number of other dinosaurian taxa, such as the heterodontosaurid ornithischian *Manidens condorensis* (Pol et al. 2011b).

Eustreptospondylus oxoniensis

= *Magnosaurus oxoniensis*

Age: Callovian, Middle Jurassic

Occurrence: Webb’s Pit, Summertown, Oxfordshire, England, UK, either the *Quenstedtoceras lamberti* or *Peloceras athlete* Biozone, Stewartby Member, Middle Oxford Clay Member.

Holotype: OUMNH J.13558, a partial skull and postcranial skeleton.

Comments: A well-known Middle Jurassic neotheropod, *Eustreptospondylus oxoniensis* offers a good amount of anatomical information on the more derived members of Theropoda.

Megalosaurus bucklandii

= ‘Scrotum humanum’

= *Megalosaurus conybeari*

Age: Bathonian, Middle Jurassic

Occurrence: Taynton Limestone Formation (middle Bathonian Procerites progradilis ammonite zone), Stonesfield, Oxfordshire, England, UK.

Lectotype: OUMNH J.13505, a right dentary.

Paralectotype series: OUMNH J.13577, a posterior dorsal vertebra; OUMNH J.13576, a sacrum; OUMNH J.13579, a proximal caudal vertebra; OUMNH J.13585, an anterior dorsal rib; OUMNH J.13580, a midposterior dorsal rib; OUMNH J.29881, a right ilium; OUMNH J.13563, a right pubis; OUMNH J.13565, a left ischium; OUMNH J.13561, a right femur; OUMNH J.13572, distal portion of a left metatarsal II.

Referred Material: Multiple specimens in various collections, including OUMNH, CAMSM and NHMUK.

Comments: Known from many specimens, this Middle Jurassic neotheropod offers a lot of important anatomical information about derived members of Theropoda.

Magnosaurus nethercombensis

= *Megalosaurus nethercombensis*

Age: Bajocian, Middle Jurassic

Occurrence: *Stephanoceras humphriesianum* ammonite Zone and Subzone, Inferior Oolite Formation, Nethercombe, Dorset, England, UK.

Holotype: OUMNH J.12143, a fragmentary skeleton comprising: right (OUMNH J.12143/1b) and left (OUMNH J.12143/1a) dentaries; OUMNH J.12143/9b and its counterpart OUMNH J.12143/9a, a dorsal vertebra; OUMNH J.12143/8a caudal vertebra; OUMNH J.12143/13-14, impressions of ribs; OUMNH J.12143/10, the ischial peduncle of the right ilium; OUMNH J.12143.12 and OUMNH J.12143/3, the proximal end and shaft of the right pubis, respectively; OUMNH J.12143/11 the proximal end of the left pubis; OUMNH J.12143/6 right femur; OUMNH J.12143/7 left femur; OUMNH J.12143/2, left tibia; OUMNH J.12143/3-4, right tibia; OUMNH J.12143/15-16 and OUMNH (uncatalogued), indeterminate fragments.

Comments: One of the earliest known members of Tetanurae, *Magnosaurus nethercombensis* from the Middle Jurassic of England, provides useful anatomical information for theropods believed to be more derived than the ceratosaurs.

8.2.1.5 Dinosauria: Sauropodomorpha

Saturnalia tupiniquim

Age: Carnian-Norian, Late Triassic

Occurrence: Alemoa Member, Santa Maria Formation, Rio Grande do Sul, Brazil.

Holotype: MCP 3844-PV, a well-preserved, semiarticulated partial skeleton.

Referred Material: MCP 3845-PV, skeleton including the posterior part of the skull with braincase; MCP 3846-PV, an incompletely prepared skeleton.

Comments: Since its discovery (Langer et al. 1999), this important Late Triassic taxon has been regarded as one of the earliest known members of Sauropodomorpha and is consistently recovered near the stem of this clade (e.g. Langer & Benton 2006; Ezcurra 2010; Nesbitt 2011). Ezcurra (2010) recovered *Saturnalia tupiniquim* as a member of an early diverging clade within Sauropodomorpha named Guaibasauridae. This clade also contained a number of other 'basal' sauropodomorphs as well as the enigmatic taxon *Agnosphitys cromhallensis*

Chromogisaurus novasi

Age: Carnian, Late Triassic

Occurrence: Lower levels of the Cancha de Bochas Member of the Ischigualasto Formation. Agua de la Peña Group, Ischigualasto-Villa Unión Basin, Ischigualasto National Park, San Juan Province, Argentina.

Holotype: PVSJ 845, partial skeleton.

Comments: This Late Triassic taxon was recovered in the analysis by Ezcurra (2010) as a basal member of Sauropodomorpha, in a sister-taxa relationship with *Saturnalia tupiniquim* -a small clade termed Saturnaliinae.

Panphagia protos

Age: Carnian, Late Triassic

Occurrence: Ischigualasto Formation, Ischigualasto–Villa Unión Basin Valle Pintado, Hollada de Ischigualasto, Ischigualasto Provincial Park, San Juan Province, Argentina.

Holotype: PVSJ 874, partial skeleton including a braincase.

Comments: Like *Saturnalia tupiniquim*, this Late Triassic taxon has been considered since its discovery to be among the earliest diverging members of Sauropodomorpha (Martinez & Alcober 2009; Ezcurra 2010). As its name suggests, this taxon is believed to be omnivorous, due to the presence of both serrated, recurved teeth and leaf-shaped, denticulate teeth. This morphology has been suggested to be indicative of this taxon's 'transitional' status within Saurischia. It is certainly an early and important dinosaurian taxon and offers good amounts anatomical information for both the cranium and postcranium of early dinosaurs.

Pampadromaeus barberenai

Age: Carnian, Late Triassic

Occurrence: Reddish mudstones of the Alemoa Member, Santa Maria Formation, Rosário do Sul Group, 2 km west of Agudo, Rio Grande do Sul, Brazil.

Holotype: ULBRA-PVT016 disarticulated partial skeleton with most of the skull.

Referred Material:

Comments: This Late Triassic taxon is regarded, along with taxa such as *Saturnalia tupiniquim*, to represent a basal member of Sauropodomorpha. Much like *Panphagia protos*, *Pampadromaeus barberenai* possesses a heterodont dentition possibly indicative of an omnivorous diet. This, along with other features of this taxon's anatomy, has been interpreted as evidence for its 'transitional' status within Saurischia (Careira et al. 2011).

Guaibasaurus candelariensis

Age: Norian, Late Triassic

Occurrence: Middle portion of the Caturrita Formation, Rosário do Sul Group, Paraná Basin, 7.5 km west of Candelária, Rio Grande do Sul, Brazil.

Holotype: MCN PV2355, partial skeleton.

Paratype: MCN PV2356, articulated left hind limb;

Referred Material: UFRGS PV0725T, articulated partial skeleton; MCN PV 10112 unprepared block containing skeletal material.

Comments: The systematic position of *Guaibasaurus candelariensis* has been somewhat controversial, with some studies suggesting a position within Theropoda (e.g. Langer et al. 2011), some a position within Sauropodomorpha (e.g. Ezcurra 2010) and others in a position outside of both of those clades but within Saurischia (e.g. Cabreira et al. 2016). Wherever it belongs, *Guaibasaurus candelariensis* certainly represents an important early dinosaur and offers important anatomical information to this study.

Pantydraco caducus

= *Thecodontosaurus caducus*

Age: ?Rheanian, Late Triassic

Occurrence: Fissure deposits, Pant-y-ffynnon Quarry, near Bonvilston, South Wales.

Holotype: BMNH P24, a nearly complete but disarticulated skull and a partial postcranium.

Paratypes: BMNH P24/3, a right ischium; BMNH P39/2, a left coracoid; BMNH P59/5, a right quadrate; BMNH P64/1, a series of eight proximal-mid caudals; BMNH P65/21, a right ectopterygoid; BMNH P77/1, a series of distal caudal vertebrae, the right ilium, femur, tibia, fibula and pes; BMNH P126/1, a possible proximal pubis; BMNH P141/1, a basioccipital

Comments: *Pantydraco caducus* has, since its discovery, been considered to represent an early diverging sauropodomorph (Yates 2003a) and is recovered by most studies as slightly more derived within the clade than taxa such as *Saturnalia tupiniquim* and *Panphagia protos* (e.g. McPhee et al. 2014; Cabreira et al. 2016).

Thecodontosaurus antiquus

= *Agrosaurus*

Age: ?Norian-?Rhaetian, Late Triassic

Occurrence: Late Triassic fissure fills contained within Early Carboniferous marine limestones. Durdham Down locality at Quarry Steps, off Belgrave Terrace, Clifton, Bristol, England, UK.

Neotype: BRSMG C4529 (BCM 2)

Referred Material: Multiple specimens

Comments: This Late Triassic taxon from the UK is generally considered to be an early diverging sauropodomorph that is more derived than taxa such as *Saturnalia tupiniquim* and *Panphagia protos* (e.g. McPhee et al. 2014)

Efraasia minor

= *Teratosaurus minor*

= *Thecodontosaurus diagnosticus*

Age: Norian, Late Triassic

Occurrence: Middle Löwenstein Formation, Weisser Steinbruch (Quarry), Pfaffenhofen, Germany, lower Löwenstein Formation, Goessel Quarry, Ochsenbach, Germany.

Holotype: SMNS 11838, dorsal vertebrae, one sacral vertebra, right manus, partial left manus, pubes, right femur, tibia, and fibula, and partial right pes.

Referred Material: SMNS 12188–92, 12354, 12667, 12684, 17928.

Comments: Along with taxa such as *Thecodontosaurus antiquus* and *Pantydraco caducus*, *Efraasia minor* is generally considered to be a ‘basal’ member of Sauropodomorpha.

Plateosaurus cullingworthi

= *Plateosaurus cullingworthi*

= *Euskelosaurus*

Age: ?Norian, Late Triassic

Occurrence: Kromme Spruit, South Africa, ?lower Elliot Formation.

Syntype series: SAM-PK-K3341-3356, 3602-3, 3607-9, various postcranial elements.

Comments: This taxon has a complicated taxonomic history. This study only considers material from what van Heerden (1979) termed the ‘second and third specimens’ or paratype material of *Euskelosaurus browni*.

Nambalia roychowdhurii

Age: ?Norian-?Rhaetian, Late Triassic

Occurrence: Upper Maleri Formation, Pranhita–Godavari Basin, north of Nambal village, India.

Holotype: ISI R273/1, a right ilium; ISI R273/2, left femur; ISI R273/3, distal half of the left tibia and fibula with articulated astragalus and calcaneum.

Paratypes: Multiple specimens beginning in ISI R273/-.

Comments: An early sauropodomorph that was recovered near the stem of the lineage in the phylogenetic analysis by Novas et al. 2011.

Arcusaurus pereirabdalorum

Age: ?Pliensbachian, Early Jurassic

Occurrence: Sauropod Quarry, Spion Kop 932, Senekal District, Free State, South Africa, upper Elliot Formation,

Holotype: BP/1/6235, a partial skull

Referred Material: BP/1/6842, 6843, isolated teeth; 6853, incomplete left dentary; 6844, right nasal; 6845, left premaxilla; 6846, right non-terminal pedal phalanx, probably IV-1, 6847, sectioned nonterminal phalanx; 6848, ungual of right pedal digit I; 6849, ungual of left pedal digit III; 6850, distal end of a right humerus; 6851, sacral centrum; 6925, right laterosphenoid; 6926, a fragment from the ischiadic peduncle of a left ilium.

Comments: Analyses by Yates et al. 2011 recovered *Arcusaurus pereirabdalorum* as either an early diverging member of Sauropodomorpha, close to the base of the clade, or as a well-nested member of Anchisauria. Wherever it belongs, *Arcusaurus pereirabdalorum* certainly represents an early sauropodomorph and is therefore of potential interest in a study of early dinosaurs such as this one.

Seitaad ruessi

Age: ?Pliensbachian, Early Jurassic

Occurrence: UMNH VP Locality 191, below remains of “Eagle’s Nest” cliff dwelling, Comb Ridge, San Juan County, Utah, Navajo Sandstone, Glen Canyon Group

Holotype: UMNH VP 18040; articulated partial postcranial skeleton.

Comments: Sertich and Loewen (2010) carried out multiple phylogenetic analyses to try and determine the position of *Seitaad ruessi* using a number of different datasets; their results found this Early Jurassic taxon to be fairly derived within Sauropodomorpha, close to ‘massopondylids’ and other early diverging plateosaurian taxa. Whatever its position within the clade Sauropodomorpha, *Seitaad ruessi* certainly represents an important early dinosaur and such is included in this analysis.

Unaysaurus tolentinoi

Age: Carnian-Norian, Late Triassic

Occurrence: Água Negra district, São Martinho da Serra, 13 km north of Santa Maria, Rio Grande do Sul, Brazil, Caturrita Formation.

Holotype: UFSM11069, partial skeleton including cranial and postcranial elements.

Comments: This Triassic sauropodomorph is recovered by most phylogenetic analyses as a member of Plateosauridae (e.g. Apaldetti et al. 2011; McPhee et al. 2014). Believed to from the Carnian-Norian, it is one of the oldest known members of Plateosauria.

Plateosaurus engelhardti

Age: Norian, Late Triassic

Occurrence: Plateosaurus Quarry, upper Löwenstein Formation, Trossingen, Baden-Württemberg, Germany.

Syntype series: UE 550, 552, 554, 556, 557, 558, 559, 561, 562. As noted by Yates (2003b), the material in this syntype series is not diagnostic; both Yates (2003b) and Nesbitt (2011) treat SMNS 13200, a nearly complete skeleton with a skull, as the unofficial holotype specimen.

Referred Material: Multiple specimens.

Comments: This Triassic taxon is very well known, and offers a good amount of anatomical information on early dinosaurs and sauropodomorphs. Species in the genus *Plateosaurus* are regularly used as operational taxonomic units in analyses of early dinosaurs (e.g. Yates 2003; Ezcurra 2010; Cabreira et al. 2016).

Lufengosaurus huenei

Age: Hettangian, Early Jurassic (Luo and Wu 1994, 1995).

Occurrence: Shawan village, Lufeng County, Yunnan Province, People's Republic of China, Dull Purplish Beds of the Lower Lufeng Formation.

Holotype: IVPP V15, a complete skeleton with skull.

Comments: An early sauropodomorph, *Lufengosaurus huenei* is often recovered by phylogenetic analyses in a close relationship with massospondylid taxa (e.g. Ezcurra 2010; McPhee et al. 2014).

Yunnanosaurus huangi

Age: Sinemurian, Early Jurassic

Occurrence: Huangchiatien village, Lufeng County, Yunnan Province, People's Republic of China, Dark Red Beds of the Lower Lufeng Formation

Holotype: NGMJ 004546, almost complete skeleton with skull.

Comments: An Early Jurassic sauropodomorph from China that is often recovered in a position within (e.g. Barrett et al. 2007), or slightly more derived than (e.g. Ezcurra 2010; McPhee et al. 2014), the group of massospondylid sauropodomorphs.

Coloradisaurus brevis

= *Coloradia brevis*

Age: Norian-Rhaetian, Late Triassic

Occurrence: La Esquina locality, south of Pagancillo village, La Rioja Province, Argentina, Upper section of the Los Colorados Formation, tetrapod-based late Coloradian biochron.

.Holotype: PVL 3967, partial skeleton with a nearly complete skull.

Referred Material: PVL 5904, a partially articulated postcranial skeleton.

Comments: This Late Triassic taxon is often recovered in phylogenetic analyses in a close relationship with massospondylid sauropodomorphs such as *Massospondylus carinatus*.

Leyesaurus marayensis

Age: Either ?Norian, Late Triassic (Bossi & Bonaparte), or ?Hettangian-?Pliensbachian, Early Jurassic (Apaldetti et al. 2011)

Occurrence: Balde de Leyes locality, Caucete Department of San Juan Province, Argentina, red silty mudstones with a low clay cementation, Quebrada del Barro Formation, Marayes-El Carrizal Basin.

Holotype: PVSJ 706, a partial skeleton with a nearly complete skull.

Comments: The analysis by Apaldetti et al. (2011) recovered *Leyesaurus marayensis* as a massospondylid sauropodomorph.

Massospondylus carinatus

Age: Either ?Hettangian-?Sinemurian, Early Jurassic, or ?Pliensbachian-?Toarcian, Early Jurassic-Middle Jurassic

Occurrence: upper Elliot and Clarens Formations, South Africa and Lesotho.

Neotype: BP/1/4934, skull and partial postcranial skeleton.

Referred Material: Multiple specimens from various institutions, including NHMUK, BP and SAM.

Comments: One of the best known Early Jurassic sauropodomorphs, *Massospondylus carinatus* can be found across a wide area of southern Africa and its fossils are a relatively common feature in the exposed portions of the upper Elliot and Clarens Formations of the Stormberg Group. Most modern phylogenetic analyses (e.g. Apaldetti et al. 2011; McPhee et al. 2014, 2015) recover *Massospondylus* within a clade of anatomically similar and contemporaneous sauropodomorphs termed the massospondylids.

Massospondylus kaalae

Age: Either ?Hettangian-?Sinemurian, Early Jurassic, or ?Pliensbachian-?Toarcian, Early Jurassic-Middle Jurassic

Occurrence: Voyizane village, Herschel District, Eastern Cape Province, Republic of South Africa, upper Elliot Formation.

Holotype: SAM-PK-K1325, an incomplete and partially disarticulated skull

Comments: After the type species, *Massospondylus carinatus*, this taxon is the only other currently valid species in the genus *Massospondylus*. It is known from a single, fairly complete skull and is found in the same formation (upper Elliot Formation of South Africa and Lesotho) as *Massospondylus carinatus* and other early dinosaurian taxa such as *Lesothosaurus diagnosticus*, *Abriotosaurus consors*, *Heterodontosaurus tucki* and *Dracovenator regenti*.

Glacialisaurus hammeri

Age: ?Hettangian-?Toarcian, Early Jurassic

Occurrence: Mt. Kirkpatrick, Beardmore Glacier region, Central Transantarctic Mountains, Antarctica, Hanson Formation.

Holotype: FMNH PR1823, a partial right astragalus, medial and lateral distal tarsals, and partial right metatarsus preserved in articulation with each other.

Referred Material: FMNH PR1822, a distal left femur.

Comments: This sauropodomorph from the Early Jurassic Hanson Formation of Antarctica is often recovered as a close relative of massospondylid taxa such as *Massospondylus carinatus* (e.g. Smith & Pol 2007; Apaldetti et al. 2011). Along with the theropod taxon *Cryolophosaurus ellioti*, *Glacialisaurus hammeri* extends the geographic range of the taxa sampled in this study to include Antarctica.

Riojasaurus incertus

Age: Norian-Rhaetian, Late Triassic

Occurrence: La Rioja Province, Argentina, Los Colorados Formation

Holotype: PVL 3808, partial postcranial skeleton

Referred Material: Multiple specimens, including ULR 56, an almost complete skull.

Comments: A large-bodied plateosaurian sauropodomorph, often recovered as a member of a monophyletic Riojasauridae (e.g. McPhee et al. 2014, 2015a,b).

Eucnemesaurus fortis

= cf. *Euskelosaurus*

= *Aliwalia rex*

Age: Norian-Rhaetian, Late Triassic

Occurrence: Free State and Eastern Cape Province, South Africa, lower Elliot Formation.

Holotype: TM 119, a fragmentary posterior postcranial skeleton

Referred Material: NMW 1889-XV-39, 1876-VIIB124, proximal and distal ends of a left femur (holotype of *Aliwalia rex*); BP/1/6107, 6110–6115, 6220, incomplete postcranial skeleton.

Comments: The material that is currently assigned to *Eucnemesaurus fortis* includes what was formerly the hypodigm of *Aliwalia rex* (Galton, 1985), a taxon that was believed to represent a carnivorous theropod or herrerasaurid dinosaur. Yates (2007) argued that the material belonging to both *E. fortis* and *A. rex* represented the same sauropodomorph taxon and this has generally been accepted to be correct (McPhee et al. 2014, 2015a), despite the variation in morphologies that appear to be exhibited by the various specimens e.g. the cross-section of the femur is more circular in BP/1/6111 than in TM 119, and the anterior trochanter is broader. Whether this is intraspecific variation or has taxonomic significance remains to be tested. Analyses by McPhee et al. (2015a) recovered *E. fortis* and *E. entaxonis* as sister taxa, in a position near *Riojasaurus incertus* (a group that is less derived than massospondylids) in some analyses. However, with the monophyly of Riojasauridae constrained against, their analyses recovered *Eucnemesaurus* as polyphyletic, with *E. fortis* and *E. entaxonis* in different positions within Sauropodomorpha; *E. entaxonis* is recovered as a more derived taxon, inside of the clade Sauropodiformes, closer to more robust sauropodomorph taxa like *Blikanasaurus cromptoni* than to massospondylids and riojasaurids. Whether or not the more ‘primitive’ sauropodomorph anatomical conditions that are exhibited by the referred specimens of *E. fortis* such as BP/1/6110–6111 contributed to this effect was also not tested or discussed. Given the range of morphologies exhibited by the specimens currently assigned to *E. fortis* and the uncertainty regarding the phylogenetic signal that they may be causing, this study considers the holotype material of *E. fortis* and the anatomically distinct referred material as separate OTUs. The material overlaps in terms of the elements represented and so, if they do belong to the same taxon, should form a monophyletic group in the phylogenetic analyses.

Eucnemesaurus entaxonis

Age: Norian-Rhaetian, Late Triassic

Occurrence: Aliwal North, Eastern Cape Province, Republic of South Africa, lower Elliot Formation.

Holotype: BP/1/6234, a partial postcranial skeleton.

Comments: A second valid species of the Triassic sauropodomorph *Eucnemesaurus*. As discussed above, analyses by McPhee et al. (2015a) placed *Eucnemesaurus entaxonis* as either a ‘riojasaurid’ sauropodomorph or as a more derived sauropodiform, in a position closer to more robust sauropodomorph taxa like *Blikanasaurus cromptoni*. The monophyly of *Eucnemesaurus* and the possible relationships of each of its species within sauropodomorpha will be tested in this study.

Xingxiulong chengi

Age: Hettangian, Early Jurassic

Occurrence: Sankeshu Village, Jinshan Town, Lufeng County, Yunnan Province, People's Republic of China, Dull Purplish Beds of the Lower Lufeng Formation.

Holotype: LFGT-D0002, partial skull and partial postcranium

Referred Material: LFGT-D0001, articulated postcranial skeleton; LFGT-D0003, partial skull and partial postcranium.

Comments: A massopodan sauropodomorph from the Early Jurassic of China, known from cranial and postcranial material. In the phylogenetic analysis that was carried out by You et al. (2017), *Xingxiulong chengi* was recovered as the sister-taxon to *Jingshanosaurus xinwaensis*.

Jingshanosaurus xinwaensis

Age: Hettangian, Early Jurassic

Occurrence: Xingwa Village, Jingshan Town, Lufeng, Yunnan Province, People's Republic of China, Dull Purplish Beds of the Lower Lufeng Formation.

Holotype: LV003, a complete skeleton including a complete skull

Comments: An Early Jurassic sauropodiform from China that is known from a complete skeleton, including a complete skull.

Sefapanosaurus zastronensis

Age: Either Norian-Rhaetian, Late Triassic, or Hettangian-Sinemurian, Early Jurassic

Occurrence: Zastron, Free State, South Africa, Elliot Formation.

Holotype: BP/1/386, incomplete articulated left pes.

Referred Material: Multiple specimens (BP).

Comments: An early diverging sauropodiform sauropodomorph from either the Late Triassic or Early Jurassic part of the Elliot Formation (Otero et al. 2015).

Leonerasaurus taquetrensis

Age: ?Sinemurian-?Toarcian, Early Jurassic

Occurrence: Cañadón Las Leoneras, south of Cañadón del Zaino, Chubut Province, Central Patagonia, Argentina, Leoneras Formation

Holotype: MPEF-PV 1663, a partial dentary, isolated teeth and a partial postcranium.

Comments: A derived massopodan sauropodomorph from the Early Jurassic, *Leonerasaurus taquetrensis* is known mainly from postcranial remains (although some teeth and a partial dentary is preserved). Like *Anchisaurus polyzelus*, *L. taquetrensis* possesses an elongate, strap-like preacetabular process.

***Melanorosaurus readi* Haughton, 1924**

Age: Norian-Rhaetian, Late Triassic

Occurrence: Thaba 'Nyama, Cape Province, South Africa, lower Elliot Formation

Holotype: SAM 3449-3450, partial postcranium.

Referred Material: NM QR1551, postcranial elements from multiple individuals; NM QR 3314, complete skull and postcranial skeleton.

Comments: A large bodied sauropodiform from the Late Triassic lower Elliot Formation of southern Africa.

Meroktenos thabanensis

= *Melanorosaurus thabanensis*

Age: Norian-Rhaetian, Late Triassic

Occurrence: Thabana Morena, Mafeteng district, Lesotho, lower Elliot Formation.

Holotype: MNHN.F.LES16, partial postcranial skeleton.

Referred Material: MNHN.F.LES351, partial postcranial skeleton.

Comments: Represented by postcranial material originally assigned to the hypodigm of the contemporaneous sauropodomorph genus *Melanorosaurus*, this Late Triassic taxon was recovered in a phylogenetic analysis by Peyre de Fabrègues and Allain (2016) as a derived member of sauropodomorpha, closely related to taxa such as *Blikanasaurus cromptoni*.

Anchisaurus polyzelus

= *Megadactylus polyzelus*

= *Amphisaurus polyzelus*

Age: ?Hettangian-?Sinemurian, Early Jurassic

Occurrence: Springfield, Massachusetts, USA, Portland Formation, Hartford Basin, Newark Supergroup

Holotype: ACM 41109, a partial postcranial skeleton.

Referred Material: YPM 1883, a skull and partial postcranium; YPM 208, a partial postcranium; YPM 209, partial skull and postcranium.

Comments: An Early Jurassic massopodan sauropodomorph that may be synonymous with the larger *Ammosaurus major* (Yates 2010).

Sarhsaurus aurifontanalis

Age: Sinemurian–Pliensbachian, Early Jurassic

Occurrence: Gold Spring Wash drainage basin, Arizona, USA, middle third of the ‘Silty Facies’, Kayenta Formation.

Holotype: TMM 43646-2, a partial skull and an almost complete postcranial skeleton.

Referred Material: TMM 43646-3, a partial postcranial skeleton from the same quarry as the holotype specimen.

Comments: Somewhat difficult to place phylogenetically, *Sarhsaurus aurifontanalis* could represent a very basal, non-massopodan sauropodomorph (Rowe et al. 2011), a sauropod (Rowe et al. 2011) or a plateosaurian that falls somewhere between Plateosauridae and Massospondylidae (Apaldetti et al. 2011).

Aardonyx celestae

Age: Hettangian-Sinemurian, Early Jurassic

Occurrence: Marc’s Quarry (MQ), Spion Kop, Senekal District, Free State, South Africa, upper Elliot Formation.

Holotype: BP/1/6254, a partial maxilla; BP/1/6505, a partial maxilla (may be part of the same maxilla as the holotype specimen)

Referred Material: Multiple postcranial elements from the holotype quarry

Comments: A massopodan sauropodomorph from the Early Jurassic of South Africa.

Pulanesaura eocollum

Age: Hettangian-Sinemurian, Early Jurassic

Occurrence: Spion Kop, Senekal District, Free State, South Africa, upper Elliot Formation.

Holotype: BP/1/6882, neural arch of a dorsal vertebra.

Referred Material: Multiple elements from the same assemblage as the holotype specimen.

Comments: A derived sauropodomorphs from the Early Jurassic of South Africa, *Pulanesaura eocollum* is thought to represent an important taxon for our understanding of the transition between non-sauropodan sauropodomorphs and ‘true’ sauropods (McPhee et al. 2015b).

Antetonitrus ingenipes

Age: ?Norian, Late Triassic

Occurrence: Welbedacht and Edelweiss farms, Ladybrand District, Free State, South Africa, ?lower Elliot Formation.

Holotype: BP/1/4952, partial postcranial skeleton.

Referred Material: BP/1/4952b, c, multiple elements collected with holotype from the type locality; NM QR1545, an assemblage of approximately three individuals; BP/1/5091, multiple postcranial elements recovered from the type locality two years after the original excavation.

Comments: A sauropodiform that may possibly be from the Late Triassic lower Elliot Formation of southern Africa, *Antetonitrus ingenipes* is often recovered as a sauropodiform that is closely related to *Lessemsaurus sauropoides* from the Triassic of Argentina (Pol & Powell 2007; MCPhee et al. 2014, 2015a,b).

Lessemsaurus sauropoides

Age: Norian-Rhaetian, Late Triassic

Occurrence: La Rioja Province, Argentina, tetrapod-based biochron, Los Colorados Formation.

Holotype: PVL 4822-1, a partial axial column

Referred Material: PVL 4822, partial postcranium

Comments: A derived sauropodiform from the Late Triassic of Argentina, *Lessemsaurus sauropoides* is often found to be the sister-taxon of *Antetonitrus ingenipes* from the Elliot Formation South Africa in phylogenetic analyses of early sauropodomorphs (e.g. MCPhee et al. 2014, 2015a,b).

Camelotia borealis

Age: ?Rhaetian, Late Triassic

Occurrence: Wedmore, Somerset, England, United Kingdom, Wedmore Stone, Westbury Formation.

Holotype: BMNH R2870-R2874, R2876-R2878, a partial postcranium.

Comments: A large sized Late Triassic sauropodiform, known from a partial postcranium.

Gongxianosaurus shibeiensis

Age: ?Toarcian, Early Jurassic

Occurrence: Hongshacun Hamlet, Shibeixiang Village, Gongxian County, People's Republic of China, dark purple silty mudstones, Dongyuemiao Member, Ziliujing Formation.

Holotype: Not given, almost complete postcranial skeleton.

Comments: A sauripodiform from the Early Jurassic of China.

Blikanasaurus cromptoni

Age: Either ?Carnian, Late Triassic, or Norian-Rhaetian, Late Triassic

Occurrence: Herschel district, Eastern Cape Province, South Africa, lower Elliot Formation.

Holotype: SAM-PK-K403, associated hind limb elements.

Comments: This Late Triassic sauropodomorph was recovered in a phylogenetic analysis by McPhee et al. (2014a) in a derived position in Sauropodomorpha, just outside of the clade Sauropoda. Taken together, the supposed phylogenetic position near the origin of sauropods, the apparent Triassic occurrence of this taxon and the robustness of its skeletal elements all provide good evidence that Sauropodomorpha was already a diverse and disparate clade by the end of the Triassic, which is strikingly different to the state of Ornithischia during the same time interval.

Tazoudasaurus naimi

Age: Toarcian, Early Jurassic

Occurrence: Douar of Tazouda, Toundoute, Province of Ouarzazate, High Atlas Mountains, Morocco.

Holotype: To 2000–1, partial skeleton including cranial and postcranial elements.

Referred Material: To 2000–2, associated remains of a juvenile individual.

Comments: One of the earliest occurring 'true' sauropods, *Tazoudasaurus naimi* is, along with other closely related taxa, included in this analysis to add anatomical information for derived members of sauropodomorpha and to ensure character polarity

Vulcanodon karibaensis

Age: ?Toarcian, Early Jurassic

Occurrence: Unnamed Island (126/127), Lake Kariba, Zimbabwe

Holotype: QG24, a partial postcranial skeleton.

Referred Material: QG152, a partial scapula.

Comments: A large bodied sauripodiform from the Early Jurassic of Zimbabwe. Despite its name, *Vulcanodon karibaensis* is only known from postcranial remains; the teeth from which it gets its name are probably from a carnivorous theropod dinosaur.

Isanosaurus attavipachi

Age: Norian-Rhaetian, Late Triassic

Occurrence: Phu Nok Khian hill, Ban Non Thaworn village, Chaiyaphum Province, Khorat Plateau, Thailand, dark red sandstones, Nam Phong Formation.

Holotype: CH4, a partial postcranial skeleton

Comments: One of the earliest occurring ‘true’ sauropods, *Isanosaurus attavipachi* is known from limited postcranial material. Despite this, *I. attavipachi* is consistently recovered within Sauropoda in phylogenetic analyses (e.g. McPhee et al. 2015a).

Kotasaurus yamanpalliensis

Age: Sinemurian-Pliensbachian, Early Jurassic

Occurrence: Yamanpalli village, Telangana, India, Kota Formation, Pranhita-Godavari basin.

Holotype: 21/SR/PAL, an ilium.

Referred Material: Multiple elements collected at the same locality as the holotype specimen.

Comments: A sauropodiform from the Early Jurassic of India, *Kotasaurus yamanpalliensis* is known from many postcranial elements from the same locality as the sauropodiform *Barapsaurus tagorei* (Yadagiri 2001).

Cetiosaurus oxoniensis

= *Ceteosaurus oxoniensis*

= *Ornithopsis oxoniensis*

= *Cardiodon oxoniensis*

Age: Bathonian

Occurrence: Bletchington Station, Enslow Bridge, Oxfordshire, Forest Marble sediments.

Lectotype: OUMNH J13605-13613, J13615-16, J13619-J13688, J13899, a partial postcranial skeleton.

Paralectotype: OUMNH J13614, a partial postcranium; OUMNNH J13617-8, J13780-1, a partial postcranium; OUMNH J13596, a partial braincase.

Referred Material: LCM G468.1968, a partial skeleton.

Comments: Following a taxonomic review by Upchurch and Martin (2003), the only valid species now considered to fall within the genus *Cetiosaurus* is *Cetiosaurus oxoniensis*. All Material described by Upchurch and Martin (2003) in this review is considered as part of the hypodigm of this taxon, including a single, isolated tooth crown (OUMNH J13597). A braincase that was described by Galton and Knoll (2006) is also considered to belong to *C. oxoniensis* in this study.

Shunosaurus lii

Age: ?Bajocian, Middle Jurassic

Occurrence: Lower Shaximiao Formation, Dashanpu, Zigong, Sichuan Province, People's Republic of China.

Holotype: IVPP V9065, a nearly complete skeleton, including a nearly complete skull.

Referred Material: Multiple specimens.

Comments: A sauropod from the Early Jurassic of China. Like *Spinophorosaurus nigerensis*, *Shunosaurus lii* possesses weaponised spines of dermal bone on the caudal portion of the tail.

Barapasaurus tagorei

Age: Sinemurian-Pliensbachian, Early Jurassic

Occurrence: Pochampalli, Gadchiroli district, Maharashtra, India, Kota Formation, Pranhita-Godavari basin.

Holotype: ISIR 50, a sacrum.

Referred Material: Multiple specimens.

Comments: A sauropod from the same formation in India as *Kotasaurus yamanpalliensis*.

8.2.1.6 Dinosauria: Herrerasauridae

Herrerasaurus ischigualastensis

= *Frenguellisaurus ischigualastensis*

Age: Carnian, Late Triassic

Occurrence: Ischigualasto Formation, Argentina.

Holotype: PVL 2566, dorsal, sacral, and caudal vertebrae, ilium, pubis, ischium, right femur, metatarsals, phalanges, left astragalus.

Referred Material: PVSJ 373, a well preserved articulated postcranial skeleton; PVSJ 407, nearly complete articulated skeleton with skull.

Comments: The best known member of the clade Herrerasauridae, *Herrerasaurus ischigualastensis* is regularly included in phylogenetic analyses of early dinosaurs. The exact position for the clade Herrerasauridae within Dinosauria has been somewhat controversial in the past, with the main competing hypotheses being that the clade represents a group of early theropod dinosaurs (e.g. Sues et al. 2011), or that they represent ‘non-eusaurischian’ saurischian dinosaurs i.e. fall stem-ward of the traditional theropod-sauropodomorph dichotomy (e.g. Novas et al. 2011); it has even been suggested that herrerasaurids are not dinosaurs at all (e.g. Brinkman & Sues 1987). Wherever the clade belongs, it is certainly the case that, as a member of Herrerasauridae, *Herrerasaurus ischigualastensis* can provide a lot of useful anatomical information for a phylogenetic study of early dinosaurs such as this one.

Sanjuansaurus gordilloi

Age: Carnian, Late Triassic

Occurrence: Cancha de Bochas Member, Ischigualasto Formation, Ischigualasto Provincial Park, San Juan, Argentina.

Holotype: PVSJ 605, an incomplete skeleton, including fragmentary skull material.

Comments: A second herrerasaurid taxon known from the Ischigualasto Formation of Argentina.

Chindesaurus bryansmalli

Age: Norian, Late Triassic

Occurrence: Petrified Forest Member, Chinle Formation, Petrified Forest National Park, Arizona, USA.

Holotype: PEFO 10395, fragmentary skeleton.

Referred Material: PEFO 33982, proximal femur; nine vertebrae; ilium fragment, bone fragments; TMM 31100–523, a proximal end of a femur.

Comments: Generally considered to represent a saurischian dinosaur, *Chindesaurus bryansmalli* appears very similar to members of Herrerasauridae and has been considered to be an herrerasaurid taxon by a number of authors (e.g. Long & Murray 1995; Novas 1997; Hunt et al. 1998). Langer (2004) considered *Chindesaurus bryansmalli* to be a saurischian dinosaur that lay closer to Herrerasauridae than to Eusaurischia and Ezcurra (2010) and Cabreira et al. (2016) both recovered it as a ‘non-eusaurischian’ saurischian dinosaur in their phylogenetic analyses. It seems likely that, whatever the position of *Chindesaurus bryansmalli* within Dinosauria, this taxon can contribute useful anatomical information to this study.

Staurikosaurus pricei

Age: Carnian-Norian, Late Triassic

Occurrence: Alemoa Member, Santa Maria Formation, Rio Grande do Sul state, Brazil.

Holotype: MCZ 1669, incomplete skeleton, including fragmentary skull material.

Comments: Known from only a single specimen, *Staurikosaurus pricei*, along with *Herrerasaurus ischigualastensis*, is used in the current definition of Herrerasauridae - *Herrerasaurus*, *Staurikosaurus*, their most recent common ancestor, plus all its descendants (Novas, 1992; Langer et al., 2010). It offers important anatomical information on early dinosaurs.

Caseosaurus crosbyensis

Age: ?Carnian, Late Triassic

Occurrence: Tecovas Formation, Dockum Group, Crosby County, Texas, USA.

Holotype: UMMP 8870, a partial right ilium.

Referred material: NMMNH P-35995, a partial right ilium.

Comments: Known from two incomplete right ilium, *Caseosaurus crosbyensis* has, since the time of its discovery, been considered to represent a saurischian dinosaur (Case 1927; Long & Murry 1995; Hunt et al. 1998). Nesbitt et al. (2009) argued that not enough information could be obtained from the holotype of this taxon to confidently refer it to Dinosauria. However, in Chapter 5 of this study, *Caseosaurus crosbyensis* was redescribed and recovered in a position within Herrerasauria. This suggested position for *Caseosaurus crosbyensis* within Herrerasauria, as well its implications, can be tested as part of this larger and more comprehensive phylogenetic analysis of early dinosaurs and other dinosauiromorphs.

8.2.1.7 Dinosauriformes *incertae sedis*

Nyasasaurus parringtoni

Age: Anisian, Middle Triassic

Occurrence: Lifua Member of the Manda Beds, Rahuu Basin, Tanzania.

Holotype: NHMUK PV R6856, right humerus, three partial presacral vertebrae and three sacral vertebrae.

Referred Material: SAM-PK-K10654 three cervical vertebrae and two posterior presacral vertebrae.

Comments: When first named, it was suggested that *Nyasasaurus parringtoni* may represent the oldest known dinosaur, coming from the Anisian aged Lifua Member of the Manda Beds and possessing a number of anatomical traits traditionally associated with dinosaurs (e.g. an elongate deltopectoral crest that is more than 30 percent of the length of the humerus; at least three sacral vertebrae) (Nesbitt et al. 2013). The phylogenetic analysis carried out by Nesbitt et al. (2013) could not resolve this taxon’s position within Dinosauria but provided some evidence for its dinosaurian affinities. The holotype and referred specimens of *Nyasasaurus parringtoni* were also scored as separate OTUs by Nesbitt et al. (2013) and this yielded a similar result to the analysis that combined both specimens into a single OTU i.e. inconclusive, but suggesting a position within or

very close to Dinosauria. It could be noted here that in the analysis of Nesbitt et al. (2013), the referred specimen of *Nyasasaurus parringtoni* (SAM-PK-K10654) was recovered as a member of Theropoda when it was scored as a separate OTU from the holotype specimen (NHMUK PV R6856). The referral of SAM-PK-K10654 to *Nyasasaurus parringtoni* is not based upon the shared possession of any autapomorphies and there is almost no overlap between this specimen the holotype specimen. It may be the case that these two specimens actually represent distinct dinosauriform species. Following Nesbitt et al. (2013), this study includes the known material of *Nyasasaurus parringtoni* as a single OTU and as multiple OTUs (holotype and referred specimens) in separate analyses in order to test whether or not the material that is currently referred to this taxon possibly represents more than one species of dinosaur.

Saltopus elginensis

Age: ?Carnian-?Norian, Late Triassic

Occurrence: Lossiemouth West Quarry, Lossiemouth town, Morayshire, Scotland. Lossiemouth Sandstone Formation.

Holotype: NHMUK PV R3915, partial postcrania

Comments: This enigmatic taxon is often excluded from large scale phylogenetic analyses of early dinosaurs due to the poor quality of preservation of the holotype material and relatively low level of skeleton completeness. While this taxon is incomplete, a certain amount of useful anatomical information can be obtained from the known material, and this may prove to be informative in discussions of early dinosaur evolution and character acquisitions (e.g. the possession of two sacral vertebrae). Whether this taxon is a dinosauriform or a non-dinosauriform dinosauiromorph (or something else entirely) is currently uncertain.

Agnosphitys cromhallensis

= *Agnostiphys cromhallensis*

Age: ?Norian-?Rhaetian, Late Triassic

Occurrence: Cromhall Quarry (Lower Carboniferous limestones, Triassic fissure deposits), Avon, England.

Holotype: VMNH 1745, left ilium.

Referred Material: VMNH 1751, left maxilla; VMNH 1748, left astragalus, VMNH 1749, right astragalus; VMNH 1750, right humerus; AUP 11095A, isolated tooth (dubious association).

Comments: A Triassic taxon with an unusual suite of anatomical characters. Some elements (such as the humerus) appear more similar to those seen in non-dinosaurian dinosauiromorph taxa, while others (such as the ilium and astragali) appear to be more similar to those in dinosaurs. Of particular note is the maxilla (VMNH 1751) which bears sharp, recurved and serrated teeth that are ankylosed into the jaw. This condition is reminiscent of the condition in members of the non-dinosaurian dinosauriform clade Silesauridae. The partial remains of *Agnosphitys cromhallensis* are known from fissure fill deposits and the association of the material is questionable. It is possible that this enigmatic taxon represents a chimera i.e. a taxon composed of material from multiple genera or species. Ezcurra (2010) included *Agnosphitys cromhallensis* in his phylogenetic analysis of early dinosaurs, but only considered the holotype material of this taxon (a left ilium) when scoring it using the characters in his dataset. In the analysis by Ezcurra (2010), *Agnosphitys cromhallensis* was recovered as a sauropodomorph, in the clade Guaibasauridae. For the holotype material of *Agnosphitys cromhallensis* as guaibasaurid affinity seems plausible, based upon its general morphology. As there is a chance that the material of *Agnosphitys cromhallensis* does represent a chimera, this study includes the material of this taxon as both a single OTU and as multiple OTUs (comprising various combinations of the known elements) in separate analyses; this may allow the hypothesis that the known elements within the hypodigm of *Agnosphitys cromhallensis* represent multiple taxa to be tested systematically for the first time.

Note: for references for works cited in this appendix, see main thesis.

Appendix 2 – Anatomical Character Sets

2.1 Character set from Chapter 3

ORDERED: 24, 35, 39, 60, 68, 71, 117, 145, 167, 169, 174, 180, 197, 199, 206, 214, 215, 222, 251, 269, 272, 286, 289, 303, 305, 307, 313, 322, 333, 334, 338, 353, 360, 376, 378, 387, 393, 442, 446

1. Skull proportions: 0, preorbital skull length more than 45% of basal skull length; 1, preorbital length less than 45% of basal skull length (modified from Butler et al., 2008).
2. Skull length (rostral–quadrate): 0, 15% or less of body length; 1, 20–30% of body length (modified from Butler et al., 2008).
3. Skull length: 0, longer than two thirds of the femoral length; 1, shorter than two-thirds of the femoral length (Gauthier, 1986; Ezcurra, 2010; Nesbitt, 2011).
4. Skull shape: 0, with a deep snout (depth of skull just anterior to the orbit is subequal to depth of the rostral portion of the skull); 1, tapered rostrally (depth of skull just anterior to the orbit is far greater than the depth of the rostral portion of the skull). NEW
5. Profile of premaxilla: 0, convex; 1, with an inflection at the base of the anterodorsal process (Upchurch, 1995; Ezcurra, 2010).
6. Premaxilla, edentulous anterior region: 0, absent, first premaxillary tooth is positioned adjacent to the symphysis; 1, present, first premaxillary tooth is inset the width of one or more crowns (Butler et al., 2008).
7. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process), length: 0, does not contact lacrimal; 1, contacts the lacrimal, excludes maxilla–nasal contact (Butler et al., 2008)
8. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process), width: 0, wide, plate-like; 1, thin, bar like (modified from Gauthier, 1986; Rauhut, 2003; Langer and Benton, 2006; Smith et al., 2007; Nesbitt, 2011).
9. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process): 0, extends posteriorly to form part of the posterior margin of the external naris; 1, restricted to the ventral border of the external naris (Langer and Benton, 2006; Nesbitt, 2011).
10. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process), relationship with anteroventral process of the nasal: 0, broad sutured contact; 1, point contact; 2, no contact (modified from Gauthier, 1986; Yates, 2007; Ezcurra 2010).

11. Position of the ventral (oral) margin of the premaxilla: 0, roughly level with the maxillary tooth row; 1, deflected ventral to maxillary tooth row; 2, raised, positioned dorsal to the maxillary tooth row (modified from Butler et al., 2008).
12. Premaxillary foramen (anterior premaxillary foramen): 0, absent; 1, present (Yates, 2007; Butler et al., 2008; Ezcurra, 2010).
13. Second anterior premaxillary foramen (often connected to the premaxillary foramen by a distinct anteroventrally oriented groove): 0, absent; 1, present. NEW
14. Premaxillary palate: 0, strongly arched, forming a deep, concave palate; 1, horizontal or only gently arched (Butler et al., 2008).
15. Fossa-like depression positioned on the premaxilla-maxilla boundary: 0, absent; 1, present (Butler et al., 2008).
16. Premaxilla–maxilla diastema: 0, absent, maxillary teeth continue to anterior end of maxilla; 1, present, substantial diastema of at least one crown’s length between maxillary and premaxillary teeth (Butler et al., 2008).
17. Form of diastema; 0, flat; 1, arched ‘subnarial gap’ between the premaxilla and maxilla (Butler et al., 2008).
18. Premaxilla, narial fossa: 0, absent; 1, present (modified from Sereno, 1999; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
19. Narial fossa surrounding external nares on lateral surface of premaxilla, position of ventral margin of fossa relative to the ventral margin of the premaxilla: 0, closely approaches the ventral margin of the premaxilla; 1, separated by a broad flat margin from the ventral margin of the premaxilla (Butler et al., 2008).
20. External nares, position of the ventral margin: 0, below or level with the ventral margin of the orbits; 1, above the ventral margin of the orbits (modified from Butler et al., 2008).
21. External naris, size: 0, entirely overlies the premaxilla; 1, extends posteriorly to overlie the maxilla (modified from Butler et al., 2008).
22. External naris, shape (in adults): 0, rounded or elliptical; 1, subtriangular, with an acute posteroventral corner (Galton and Upchurch, 2004; Ezcurra, 2010).
23. Level of the anterior margin of the external naris: 0, anterior to the midlength of the premaxillary body; 1, posterior to the midlength of the premaxillary body (Rauhut, 2003; Ezcurra, 2010).

24. Level of the posterior margin of the external naris: 0, anterior to or level with the premaxilla-maxilla suture; 1, posterior to the first maxillary alveolus; 2, posterior to the midlength of the maxillary tooth row and the anterior margin of the antorbital fenestra (Wilson and Sereno, 1998; Yates, 2007; Ezcurra, 2010). ORDERED
25. Anterior premaxillary foramen, position: 0, positioned outside of the narial fossa; 1, positioned on the rim of, or inside, the narial fossa (modified from Sereno et al., 1993; Yates, 2007; Ezcurra, 2010).
26. Subnarial foramen between the premaxilla and maxilla: 0, absent; 1, present (modified from Benton and Clark, 1988; Parrish, 1993; Juul, 1994; Benton, 1999; Nesbitt, 2011).
27. Deep elliptic fossa present along sutural line of the nasals: 0, absent; 1, present; 2, fenestra (internasal fenestra) present (modified from Butler et al., 2008).
28. Internal antorbital fenestra size: 0, large, generally at least 15% of the skull length; 1, very much reduced, less than 10% of skull length, or absent (Butler et al., 2008).
29. External antorbital fenestra: 0, present; 1, absent (Butler et al., 2008).
30. Antorbital fenestra, shape: 0, triangular; 1, oval or circular; 2, rectangular (modified from Butler et al., 2008).
31. Additional opening(s) or fossa anteriorly within the antorbital fossa (promaxillary foramen, promaxillary fossa): 0, absent; 1, present (modified from Carpenter, 1992; Rauhut, 2003; Smith et al., 2007; Butler et al., 2008; Nesbitt, 2011).
32. Additional opening(s) in the antorbital fenestra (promaxillary foramen), shape: 0, wide and circular; 1, narrow recess or slit-like. NEW
33. Maxilla, rostralateral surface between the ventral border of the antorbital fossa and the alveolar margin is pierced by a small foramen: 0, absent; 1, present. NEW
34. Anterior profile of the maxilla: 0, slopes continuously towards the anterior tip; 1, with a strong inflection (notch) at the base of the ascending ramus, creating an anterior ramus with parallel dorsal and ventral margins (Sereno et al., 1996; Langer and Benton, 2006; Ezcurra, 2010; Nesbitt, 2011).
35. Maxilla, lateral surface: 0, completely smooth; 1, sharp longitudinal ridge present; 2, rounded/bulbous longitudinal ridge present (Gower, 1999; Weinbaum and Hungerbühler, 2007; Nesbitt, 2011). ORDERED
36. Maxilla, buccal emargination: 0, absent; 1, present (Butler, 2005; Irmis et al., 2007; Irmis et al., 2007; Butler et al 2008; Nesbitt, 2011).

37. Ridge or lateral swelling of lateral surface of the dentary (possibly associated with a fleshy cheek in life): 0, absent, 1, present (Gauthier, 1986; Galton and Upchurch, 2004; Pol et al., 2011b).
38. Slot in maxilla for lacrimal: 0, absent; 1, present (Butler et al., 2008).
39. Antorbital fossa: 0, restricted to the lacrimal; 1, restricted to the lacrimal and dorsal process of the maxilla; 2, present on the lacrimal, dorsal process of the maxilla and the dorsal margin of the posterior process of the maxilla (the ventral border of the antorbital fenestra) (Nesbitt et al., 2009c; Nesbitt, 2011) ORDERED
40. Dorsoventral extension of lacrimal antorbital fossa: 0, through more than half of the bone height; 1, is restricted to the ventral half of the bone (Langer, 2004; Pol et al., 2011b).
41. Nasal: 0, does not possess a posterolateral process that envelops part of the anterior (rostral) ramus of the lacrimal; 1, possesses a posterolateral process that envelops part of the anterior ramus of the lacrimal (Yates, 2003; Langer and Benton, 2006; Nesbitt, 2011).
42. Nasal: 0, does not form part of the dorsal border of the antorbital fossa; 1, forms part of the dorsal border of the antorbital fossa (modified from Sereno et al., 1994; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
43. Ventral rim of the antorbital fossa: 0, parallel to tooth row, 1, ventrally sloped in its caudal part (Langer, 2004; Pol et al., 2011b).
44. Lacrimal, shape: 0, dorsoventrally short and block-shaped; 1, dorsoventrally elongate and shaped like and inverted L (Rauhut, 2003; Ezcurra, 2010).
45. Descending process of lacrimal: 0, curved, subvertically oriented (at its dorsal half), 1, straight and obliquely oriented along its entire length (Pol et al., 2011b).
46. Length of the anterior (rostral) ramus of the lacrimal: 0, greater than half the length of the ventral ramus, 1, less than half the length of the ventral ramus (Yates, 2007; Pol et al., 2011b).
47. Lacrimal: 0, does not fold over (overhang) the posterior/posterodorsal part of the antorbital fenestra; 1, folds over (overhangs) the posterior/posterodorsal part of the antorbital fenestra (modified from Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).
48. Dorsal crest(s) on the skull, formed by dorsoventral expansion of the lacrimals and/or nasals (naso-lacrimal crest): 0, absent; 1, present. NEW
49. Accessory ossification(s) in the orbit (palpebral/ supraorbital): 0, absent; 1, present (Butler et al., 2008).

50. Palpebral/supraorbital: 0, free, projects into orbit from contact with lacrimal/prefrontal; 1, incorporated into orbital margin (Butler et al., 2008).
51. Palpebral, shape in dorsal view: 0, rod-shaped; 1, plate-like with wide base (Butler et al., 2008).
52. Palpebral/supraorbital, number: 0, one; 1, two; 2, three (Butler et al., 2008).
53. Free palpebral, length, relative to anteroposterior width of orbit: 0, does not traverse entire width of orbit; 1, traverses entire width of orbit (Butler et al., 2008).
54. Exclusion of the jugal from the posteroventral margin of the external antorbital fenestra by lacrimal–maxilla contact: 0, absent; 1, present (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; Butler et al., 2008; Nesbitt, 2011).
55. Anterior ramus of jugal, proportions: 0, deeper than wide; 1, wider than deep (modified from Butler et al., 2008).
56. Anterior ramus of jugal: 0, not as deep as the posterior ramus of the jugal; 1, deeper than the posterior ramus of the jugal (modified from Butler et al., 2008).
57. Position of maximum widening of the skull: 0, beneath the jugal–postorbital bar; 1, posteriorly, beneath the infratemporal fenestra (Butler et al., 2008).
58. Jugal (or jugal–epijugal) ridge dividing the lateral surface of the jugal into two planes: 0, absent; 1, present and sharp; 2, present and rounded; 3, restricted to a bulbous ridge (modified from Butler et al., 2008; Nesbitt, 2011).
59. Epijugal: 0, absent; 1, present (Butler et al., 2008).
60. Ornamentation on jugal: 0, absent; 1, present as small rugose surface; 2, present as well developed jugal boss (modified from Butler et al., 2008). ORDERED
61. Jugal, anterior extent of the slot for the quadratojugal: 0, well posterior of the posterior edge of the dorsal process of the jugal; 1, at or anterior to the posterior edge of the dorsal process of the jugal (Nesbitt, 2011).
62. Jugal, posterior process: 0, lies dorsal to the anterior process of the quadratojugal; 1, lies ventral to the anterior process of the quadratojugal; 2, is level with the anterior process of the quadratojugal and overlaps it/splits the anterior process of the quadratojugal; 3, is level with the anterior process of the quadratojugal and is split by the anterior process of the quadratojugal (forked, bifurcated) (modified from Butler et al., 2008; Nesbitt, 2011).

63. Jugal–postorbital bar, width broader than infratemporal fenestra: 0, absent; 1, present (Butler et al., 2008).
64. Jugal–postorbital joint: 0, elongate scarf joint; 1, short butt joint (Butler et al., 2008).
65. Jugal, posterior ramus: 0, forms anterior and/or ventral margin of infratemporal fenestra; 1, forms part of posterior margin, expands towards squamosal (Butler et al., 2008).
66. Jugal-lacrima relationship: 0, lacrima overlapping lateral surface of jugal or abutting it dorsally; 1, jugal overlapping lacrima laterally (Serenio et al., 1993; Ezcurra, 2010).
67. Ratio of minimum depth of jugal below the orbit to the distance between the anterior end of the jugal and the anteroventral corner of the infratemporal fenestra: 0, less than 0.2; 1, roughly equal to or greater than 0.2 (modified from Galton, 1985; Yates, 2007; Ezcurra 2010).
68. Lateral temporal fenestra, maximum anteroposterior length of ventral half: 0, more than twice the maximum anteroposterior length of the dorsal half; 1, less than twice the maximum anteroposterior length of the dorsal half; 2, maximum anteroposterior length of the dorsal half is greater than that of the ventral half. NEW, ORDERED
69. Postorbital, orbital margin: 0, relatively smooth curve; 1, prominent and distinct projection into orbit (orbital flange) (Butler et al., 2008).
70. Contact between dorsal process of quadratojugal and descending process of the squamosal: 0, present; 1, absent (Butler et al., 2008).
71. Form of contact between the quadratojugal and the squamosal: 0, small, thin point contact; 1, large, quadratojugal has broad contact with the ventral margin of the descending process of the squamosal as a butt joint; 2, large, quadratojugal has broad contact with the posterior margin of the descending process of the squamosal as an elongate scarf joint. NEW, ORDERED
72. Quadratojugal, shape: 0, L-shaped, with elongate anterior process; 1, subrectangular with long axis vertical, short, deep anterior process (Butler et al., 2008). ORDERED
73. Quadratojugal, ventral margin: 0, approaches the mandibular condyle of the quadrate; 1, well-separated from the mandibular condyle of the quadrate (Butler et al., 2008).
74. Quadrate, head: 0, partially exposed laterally; 1, 1 (Serenio and Novas, 1994; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt, 2011).
75. Quadrate shaft: 0, convex in lateral view; 1, reduced in anteroposterior width and straight in lateral view (Butler et al., 2008).

76. Quadrate, angled: 0, posteroventrally or vertical; 1, anteroventrally (Nesbitt, 2007, Nesbitt, 2011).
77. Paraquadratic foramen or notch, size: 0, absent or small; 1, large (Butler et al., 2008).
78. Paraquadratic foramen, orientation: 0, posterolateral aspect of quadrate shaft; 1, lateral aspect of quadrate or quadratojugal (Butler et al., 2008).
79. Paraquadratic foramen, position: 0, on quadrate-quadratojugal boundary; 1, located within quadratojugal (Butler et al., 2008).
80. Quadrate mandibular articulation: 0, quadrate condyles subequal in size; 1, medial condyle is larger than lateral condyle; 2, lateral condyle is larger than medial (Butler et al., 2008).
81. Paired frontals: 0, short and broad; 1, narrow and elongate (more than twice as long as wide) (Butler et al., 2008).
82. Supratemporal fenestrae, anteroposterior elongation: 0, absent, fenestrae are subcircular to oval in shape; 1, present (Butler et al., 2008).
83. Supratemporal fossa: 0, absent anterior to the supratemporal fenestra; 1, present anterior to the supratemporal fenestra, extends onto the dorsal surface of the frontal (modified from Gauthier, 1986; Novas, 1996; Nesbitt, 2011).
84. Squamosal, ventral process: 0, wider than one-quarter of its length; 1, narrower than one-quarter of its length (Yates, 2003; Langer and Benton, 2006; Nesbitt, 2011).
85. Ventral ramus of squamosal form: 0, more than half of the caudal border of the lower temporal fenestra, 1, less than half of the caudal border of the lower temporal fenestra (Langer, 2004; Pol et al., 2011b).
86. Paroccipital process: 0, extends laterally or dorsolaterally; 1, extends ventrally or ventrolaterally (Rauhut, 2003; Ezcurra, 2010; Nesbitt, 2011).
87. Paroccipital process: 0, expanded distally; 1, distal end pendent (modified from Rauhut, 2003; Ezcurra, 2010; Nesbitt, 2011).
88. Paroccipital processes, proportions: 0, short and deep (height $\geq 1/2$ length); 1, elongate and narrow (height $< 1/2$ length) (Butler et al., 2008).
89. Opisthotic, ventral ramus (crista interfenestralis): 0, extends further laterally than lateral-most edge of exoccipital in posterior view; 1, covered by the lateral-most edge of exoccipital in posterior view (Gower, 2002; Nesbitt, 2011).

90. Posttemporal foramen/fossa, position: 0, totally enclosed with the paroccipital process; 1, forms a notch or foramen in the dorsal margin of the paroccipital process, enclosed dorsally by the squamosal (Butler et al., 2008).
91. Exoccipital, relative positions of the exits of the hypoglossal nerve (XII): 0, aligned in a nearly anteroposterior plane; 1, aligned subvertically; 2, combined into single exit (modified from Nesbitt, 2011).
92. Exoccipital, lateral surface: 0, without subvertical crest (metotic strut); 1, with clear crest (metotic strut) lying anterior to both external foramina for hypoglossal nerve (XII); 2, with clear crest (metotic strut) present anterior to the more posterior external foramina for hypoglossal nerve (XII) (modified from Gower, 2002; Nesbitt, 2011).
93. Exoccipitals: 0, meet along the midline on the floor of the endocranial cavity (basioccipital excluded from the ventral border of the foramen magnum); 1, do not meet along the midline on the floor of the endocranial cavity (modified from Gower and Sennikov, 1996; Gower, 2002; Nesbitt, 2011).
94. Supraoccipital: 0, excluded from dorsal border of foramen magnum by mediodorsal midline contact between opposite exoccipitals; 1, contributes to border of foramen magnum (Gower, 2002, Nesbitt, 2011).
95. Supraoccipital, rugose ridge on the anterolateral edges: 0, absent; 1, present (Nesbitt, 2011).
96. Shape of the supraoccipital: 0, diamond shaped or triangular; 1, semi-lunate/crescentic (Yates, 2003; Ezcurra, 2010).
97. Supraoccipital, proportions: 0, taller than wide or as wide as tall; 1, wider than tall. NEW
98. Perilymphatic foramen: 0, with an incompletely ossified border; 1, border entirely ossified such that the ventral ramus of the opisthotic forms a perilymphatic loop incorporating a loop closure suture with itself (Gower, 2002; Nesbitt, 2011).
99. Basisphenoid, relative to the basioccipital: 0, longer than, or subequal in length to, basioccipital; 1, shorter than basioccipital (Butler et al., 2008).
100. Parabasisphenoid, ventral recess: 0, shallow; 1, well-developed. NEW
101. Parabasisphenoid, foramina for entrance of cerebral branches of internal carotid artery into the braincase positioned on the surface: 0, ventral; 1, lateral (modified from Parrish, 1993; Gower and Sennikov, 1996; Gower, 2002; Nesbitt et al., 2009c; Nesbitt, 2011).

102. Parabasisphenoid, laterally positioned foramina for entrance of cerebral branches of internal carotid artery into the braincase: 0, located anteriorly; 1, located posteriorly (modified from Parrish, 1993; Gower and Sennikov, 1996; Gower, 2002; Nesbitt et al., 2009c; Nesbitt, 2011).
103. Parabasisphenoid, recess (median pharyngeal recess, hemispherical sulcus, hemispherical fontanelle): 0, absent; 1, present (modified from Nesbitt and Norell, 2006; Nesbitt, 2011).
104. Parabasisphenoid, anterior tympanic recess on the lateral side of the braincase: 0, absent; 1, present (Makovicky and Sues, 1998; Rauhut, 2003; Nesbitt, 2011).
105. Parabasisphenoid, between basal tubera and basipterygoid processes: 0, approximately as wide as long or wider; 1, significantly elongated, at least 1.5 times longer than wide (Rauhut, 2003; Nesbitt, 2007; Nesbitt, 2011).
106. Basal tubera, shape: 0, knob-shaped; 1, plate-shaped (Butler et al., 2008).
107. Basipterygoid processes, orientation: 0, anterior as well as ventrolateral or anteroventral; 1, entirely ventral; 2, posteroventral (modified from Butler et al., 2008)
108. Basipterygoid processes and basal tubera: 0, basipterygoid processes ventrally offset relative to the basal tubera; 1, basipterygoid process and basal tubera are horizontally aligned to one another. NEW
109. Dorsoventrally deep (deeper than 50% of snout depth) median palatal keel formed of the vomers, pterygoids and palatines: 0, absent; 1, present (Butler et al., 2008).
110. Pterygovomerine keel, length: 0, less than 50% of palate length; 1, more than 50% of palate length (Butler et al., 2008).
111. Ectopterygoid, ventral recess: 0, absent; 1, present (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011).
112. Ectopterygoid, body: 0, arcs; 1, straight, does not arc (modified from Nesbitt, 2011).
113. Ectopterygoid, direction of arc: 0 arcs anteriorly; 1, arcs anterodorsally (modified from Nesbitt, 2011).
114. Ectopterygoid, jugal process: 0, broad; 1, slender. NEW
115. Vestibule, medial wall: 0, incompletely ossified; 1, almost completely ossified (Gower, 2002; Nesbitt, 2011).

116. Lagenar/cochlea recess: 0, absent or short and strongly tapered; 1, present and elongated and tubular (Gower, 2002; Nesbitt, 2011).
117. Foramen for trigeminal nerve and middle cerebral vein: 0, combined and undivided; 1, at least partially subdivided by prootic; 2, fully divided (modified from Gower and Sennikov, 1996; Gower, 2002; Nesbitt, 2011). ORDERED
118. Auricular recess: 0, largely restricted to prootic; 1, extends onto internal surface of epiotic/supraoccipital (Gower, 2002; Nesbitt, 2011).
119. Cortical remodeling of surface of skull dermal bone: 0, absent; 1, present (Butler et al., 2008).
120. Predentary: 0, absent; 1, present (Sereno, 1986; Butler et al., 2007, 2008b; Nesbitt, 2011).
121. Predentary size: 0, short, posterior premaxillary teeth oppose anterior dentary teeth; 1, roughly equal in length to the premaxilla, premaxillary teeth only oppose predentary (Butler et al., 2008).
122. Predentary, rostral end in dorsal view: 0, rounded; 1, pointed (Butler et al., 2008).
123. Predentary, ventral process: 0, well-developed; 1, very reduced or absent (Butler et al., 2008).
124. Dentary, anterior extremity: 0, rounded; 1, tapers to a sharp point (Nesbitt, 2011).
125. Dentary, anterior swelling: 0, absent; 1, present, anterior end is expanded dorsoventrally just posterior to the anterior tip. NEW
126. Dentary symphysis: 0, restricted to the rostral margin of the dentary (V-shaped), or absent entirely; 1, expanded along the ventral border of the bone (spout shaped) (Sereno, 1999; Butler et al., 2008 Pol et al., 2011b).
127. Anterior half of the dentary, position of the Meckelian groove: 0, dorsoventral centre of the dentary; 1, restricted to the ventral border (Nesbitt, 2011).
128. Dentary, anterior extent of the Meckelian groove: 0, ends short of the dentary symphysis; 1, present through the dentary symphysis (Nesbitt, 2011).
129. Dentary tooth row (and edentulous anterior portion) in lateral view: 0, relatively straight; 1, anterior end downturned; 2, anterior end strongly upturned (dentary ventrally bowed) (modified from Butler et al., 2008 and Nesbitt, 2011).

130. Dorsal and ventral margins of the dentary along the posterior two thirds of the dentary tooth row: 0, converge anteriorly; 1, subparallel (modified from Butler et al., 2008).
131. Transverse groove (sulcus, external mandibular groove) running along the dentary beneath and parallel to tooth row: 0, absent; 1, present.
132. Articular, glenoid of the mandible located: 0, level with or marginally dorsal to the dorsal margin of the dentary; 1, well ventral of the dorsal margin of the dentary (modified from Gauthier, 1986; Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011; Pol et al., 2011b).
133. Maximum depth of mandible: 0, less than 150% depth of mandible beneath tooth row; 1, roughly 160% or more of the depth of mandible beneath tooth row (modified from Sereno, 1986, 1999; Butler, 2005; Irmis et al., 2007; Butler et al., 2008; Nesbitt, 2011).
134. Anterodorsal margin of coronoid process formed by posterodorsal process of dentary: 0, absent; 1, present (Butler et al., 2008).
135. Splenial, foramen in the ventral part: 0, absent; 1, present (modified from Rauhut, 2003; Langer and Benton, 2006; Smith et al., 2007; Nesbitt, 2011).
136. External mandibular fenestra, situated on dentary-surangular-angular boundary: 0, present; 1, absent (Butler et al., 2008).
137. External mandibular fenestra between the surangular, angular and dentary, proportions: 0, small, rounded or elliptical with anteroposterior length is less than 4 times the dorsoventral depth; 1, fenestra is a greatly elongate ellipse, length is greater than 4 times the dorsoventral depth. NEW
138. Small fenestra positioned dorsally on the surangular-dentary joint: 0, absent; 1, present (Butler et al., 2008).
139. Foramen located on the dorsal (and sometimes lateral) face of the surangular (surangular foramen): 0, present; 1, absent. NEW
140. Surangular foramen: 0, both foramen (anterior, dorsally positioned and posterior, laterally positioned) remain open; 1 only the foramen on the dorsal surface of the surangular, anterior to or at the point of maximum mandibular depth remains open; 2, only the foramen located laterally, posterior to the point of maximum mandibular depth remains open. NEW
141. Ridge or process on lateral surface of surangular, anterior to jaw suture: 0, absent or very poorly developed; 1, present, strong anteroposteriorly extended ridge; 2, present, dorsally directed finger-like process (Butler et al., 2008).

142. Anteroposteriorly extending groove on the dorsal surface of the surangular (dorsal surface formed by medial inflection of the lateral surangular): 0, absent; 1, present. NEW
143. Retroarticular process: 0, elongate; 1, rudimentary or absent (Butler et al., 2008).
144. Retroarticular process in lateral and dorsal view: 0, does not taper caudally, 1, tapers caudally (Yates, 2003; Pol et al., 2011b).
145. Retroarticular process, upturn: 0, present and strong, retroarticular forms nearly a right angle with the rest of the mandible; 1, present and subtle, retroarticular is slightly upturned at its distal end; 2, absent, retroarticular extends straight out from the caudal part of the mandible, or turns slightly downward (new). ORDERED
146. Mandibular osteoderm: 0, absent; 1, present (Butler et al., 2008).
147. Dentary teeth: 0, present along almost entire length of the dentary; 1, absent in the anterior portion; 2, completely absent (modified from Parrish, 1994; Parker, 2007; Nesbitt, 2011).
148. Number of dentary teeth: 0, 17 or fewer; 1, 18 or more (Wilson and Sereno, 1998; Pol et al., 2011b).
149. First dentary tooth: 0, lies at the extreme rostral end of the dentary; 1, is inset a short distance from the rostral tip of the dentary (Sereno, 1999; Pol et al., 2011b).
150. Premaxillary teeth: 0, present; 1, absent, premaxilla edentulous (Butler et al., 2008).
151. Premaxillary teeth, number: 0, six or more; 1, five; 2, four; 3, three; 4, two; 5, one or none (modified from Butler et al., 2008).
152. Premaxillary teeth, crown expanded above root: 0, crown is unexpanded mesiodistally above root, no distinction between root and crown is observable; 1, crown is at least moderately expanded above root (Butler et al., 2008).
153. Premaxillary teeth increase in size posteriorly: 0, absent; 1, present, posterior premaxillary teeth are significantly larger in size than anterior teeth (Butler et al., 2008).
154. Premaxillary teeth size: 0, anterior premaxillary teeth are smaller than most maxillary teeth; 1, anterior premaxillary teeth are subequal to maxillary teeth; 2, anterior premaxillary teeth are enlarged relative to maxillary teeth. NEW
155. Premaxillary caniniform tooth, distinct from anterior premaxillary teeth: 0, absent; 1, present, squat caniniform (greater in diameter than in apicobasal height); 2, present, long caniniform (greater in apicobasal height than in diameter). NEW

156. Maxillary and dentary crowns, shape: 0, blade-like, with continuous mesial and distal edges; 1, subtriangular or 'diamond shaped', with a distinct kink present in mesial and distal edges (modified from Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).
157. Maxillary and dentary crowns, dimensions: 0, apicobasally taller than they are mesiodistally wide; 1, apicobasally shorter than they are mesiodistally wide. NEW
158. Enamel on maxillary/dentary teeth: 0, symmetrical; 1, asymmetrical (Butler et al., 2008).
159. Apicobasally extending ridges on maxillary/dentary teeth: 0, absent; 1, present (Butler et al., 2008).
160. Apicobasally extending ridges on lingual/labial surfaces of maxillary/dentary crowns confluent with marginal denticles: 0, absent; 1, present (Butler et al., 2008).
161. Tooth implantation, teeth ankylosed into the alveoli (ankylotheodont): 0, absent (free at the base of tooth); 1, present (modified from Gauthier, 1984; Benton and Clark, 1988; Benton, 1990; Bennett, 1996; Nesbitt et al., 2009c; Nesbitt, 2011).
162. Prominent primary ridge on labial side of maxillary teeth: 0, absent; 1, present (Butler et al., 2008).
163. Prominent primary ridge on lingual side of dentary teeth: 0, absent; 1, present (Butler et al., 2008).
164. Position of maxillary/dentary primary ridge: 0, centre of the crown surface, giving the crown a relatively symmetrical shape in lingual/labial view; 1, offset, giving crown asymmetrical appearance (Butler et al., 2008).
165. Labial side of maxillary/dentary teeth, profile: 0, evenly convex in mesiodistal aspect (D-shaped profile), 1, with greater labiolingual expansion at the base of the tooth. NEW
166. Moderately developed lingual expansion of crown (cingulum) on maxillary/dentary teeth: 0, absent; 1, present (Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).
167. Dentition: 0, homodont; 1, slightly heterodont, with small observable changes across tooth rows; 2, markedly heterodont, clearly distinct types of teeth present (modified from Parrish, 1993; Nesbitt, 2011). ORDERED
168. Heterodont dentary dentition: 0, no substantial heterodonty is present in dentary dentition; 1, single, enlarged, caniniform anterior dentary tooth, crown is not mesiodistally expanded above root; 2, multiple anterior dentary teeth are recurved but are not enlarged relative to other dentary teeth; 3 multiple anterior dentary teeth are recurved and are enlarged relative to other dentary teeth (modified from Butler et al., 2008).

169. Maxillary/dentary tooth, serrations: 0, absent; 1, present as small fine knifelike serrations; 2, present and enlarged and coarser (lower density) denticles. (modified from Gauthier et al., 1988; Juul, 1994; Dilkes, 1998; Irmis et al., 2007; Butler et al., 2008; Nesbitt, 2011). ORDERED
170. Distribution of the serrations along the mesial and distal carinae of the teeth: 0, extended along most of the length of the crown; 1, restricted to the upper half of the crown (Yates, 2003; Ezcurra, 2010).
171. Peg-like tooth located anteriorly within dentary, lacks recurvature and denticles, strongly reduced in size: 0, absent; 1, present (Butler et al., 2008).
172. Alveolar foramina ('special foramina') medial to maxillary/ dentary tooth rows: 0, present; 1, absent (Butler et al., 2008).
173. Recurvature in premaxillary teeth: 0, present, 1, absent. NEW
174. Recurvature in majority of maxillary and dentary teeth: 0, strong recurvature present; 1, weak recurvature present; 2, recurvature absent (modified from Butler et al., 2008) ORDERED
175. Maxillary teeth, posterior cutting edge of posterior maxillary teeth: 0, concave or straight; 1, convex (modified from Sues et al., 2003; Clark et al., 2004; Nesbitt, 2011).
176. Medial or lateral overlap of adjacent crowns in maxillary and dentary teeth: 0, absent; 1, present (Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).
177. Tooth crown, maxillary/dentary teeth: 0, not mesiodistally expanded; 1, mesiodistally expanded above root in cheek teeth (Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).
178. Extensive planar wear facets across multiple maxillary/dentary teeth: 0, absent; 1, present (Weishampel and Witmer, 1990; Nesbitt, 2011; Han et al., 2012).
179. Position of maximum apicobasal crown height in dentary/maxillary tooth rows: 0, anterior portion of tooth row; 1, central portion of tooth rows; 2, posterior portion of tooth rows (Gauthier, 1986; Butler et al., 2008; Pol et al., 2011b).
180. Conical, often unserrated tooth crowns: 0, absent, 1, present together with serrated crowns, 2, encompasses all dental elements of maxilla and dentary (new). ORDERED
181. Palatal teeth present on palatal process of the pterygoid: 0, present; 1, absent (Juul, 1994; Gower and Sennikov, 1997; Nesbitt et al., 2009c; Nesbitt, 2011).

182. Teeth on transverse processes of pterygoids: 0, present; 1, absent (Gauthier, 1984; Juul, 1994; Bennett, 1996; Gower and Sennikov, 1997; Nesbitt et al., 2009c; Nesbitt, 2011).
183. Close-packing and quicker replacement eliminates spaces between alveolar border and crowns of adjacent functional teeth: 0, absent; 1, present (Butler et al., 2008).
184. Anterior dentary teeth, orientation: 0, vertical or inclined posteriorly; 1, inclined anteriorly (procumbent).
185. Line from the mesiodistal centre of the base of the tooth to the tip of tooth curves anteriorly in dentary teeth: 0, absent; 1, present (modified from Kammerer et al., 2012).
186. Length of the atlantal intercentrum: 0, greater than that of the axial intercentrum; 1, shorter than that of the axial intercentrum (Yates and Kitching, 2003; Pol et al., 2011b).
187. Axis, dorsal margin of the neural spine: 0, expanded posterodorsally; 1, arcs dorsally, where the anterior portion height is equivalent to the posterior height (Nesbitt, 2011).
188. Cervical vertebrae, deep recesses on the anterior face of the neural arch, lateral to the neural canal (prechonos of Welles, 1984): 0, absent; 1, present (Nesbitt, 2011).
189. Epiphyses on anterior (postaxial) cervicals: 0, absent; 1, present (modified from Gauthier, 1986; Novas 1996; Langer and Benton, 2006; Butler et al., 2008; Nesbitt, 2011).
190. Epiphyses: 0, absent in posterior cervical vertebrae (6–9); 1, present in posterior cervical vertebrae (6–9) (Serenio et al., 1993; Langer and Benton, 2006; Nesbitt, 2011).
191. Epiphyses overhanging the rear margin of the postzygapophyses: 0, absent, epiphyses do not overhang the postzygapophyses in any postaxial cervical vertebrae; 1, present in at least some postaxial cervical vertebrae (modified from Yates, 2003; Pol et al., 2011b).
192. Third cervical vertebra, centrum length: 0, subequal to the axis centrum; 1, longer than the axis centrum (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011).
193. Cervicals 4–9, form of central surfaces: 0, amphicoelous; 1, at least slightly opisthocoelous or heterocoelous (Butler et al., 2008).
194. Cervical number: 0, seven/eight; 1, nine; 2, ten or more (Butler et al., 2008).
195. Anterior to middle cervical vertebrae, diapophysis and parapophysis: 0, well separated; 1, nearly touching (Nesbitt, 2011).

196. Anterior cervical vertebrae, neural arch, posterior portion ventral to the postzygapophysis: 0, smooth posteriorly or has a shallow fossa; 1, with a deep excavation (modified from Langer and Benton, 2006; Nesbitt, 2011).
197. Cervical vertebrae, pneumatic features (pleurocoels) in the anterior portion of the centrum: 0, absent; 1, present as fossae; 2, present as foramina (modified from Holtz, 1994; Rauhut, 2003; Smith et al., 2007; Nesbitt, 2011). ORDERED
198. Cervical vertebrae, rimmed depression on the posterior part of the centrum: 0, absent; 1, present (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2011).
199. Elongation of cervical centrum (cervicals 3–5): 0, less than 3.0 times the centrum height, 1, 3.0–4.0 times the centrum height, 2, >4.0 times the centrum height (Upchurch, 1998; Pol et al., 2011b). ORDERED
200. Cervical vertebrae, distal end of neural spines: 0, laterally expanded in the middle of the anteroposterior length; 1, expansion absent. NEW
201. Posterior cervical and/or dorsal vertebrae, hyposphene-hypantrum accessory intervertebral articulations: 0, absent; 1, present (Gauthier, 1986; Juul, 1994; Benton, 1999; Rauhut, 2003; Langer and Benton, 2006; Weinbaum and Hungerbühler, 2007; Nesbitt, 2011).
202. Hyposphene in the cervical and/or dorsal vertebrae, height: 0, less than the height of the neural canal; 1, equal to or greater than the height of the neural canal (modified from Gauthier, 1986; Yates, 2007; Ezcurra, 2010).
203. Prezygaodiapophyseal lamina on the cervical vertebrae: 0, absent; 1, present. NEW
204. Postzygaodiapophyseal lamina on cervical neural arches 4 to 8: 0, absent; 1, present (Yates, 2003; Ezcurra, 2010; Pol et al., 2011b).
205. Laminae of the cervical neural arches 4–8: 0, well developed, tall laminae; 1, weakly developed, low ridges (Wilson and Sereno, 1998; Ezcurra, 2010).
206. Angle formed between pre- and postzygapophyses on anterior-to-middle cervical vertebrae: 0, very large, around 40 degrees, or over; 1, large, around 30 degrees; 2, small, around 20 degrees (new). ORDERED
207. Ventral keels on cranial cervical centra: 0, present, 1, absent (Upchurch, 1998; Pol et al., 2011b).
208. Ventral keels on the vertebrae at the cervicodorsal transition: 0, absent; 1, present (Rauhut, 2003; Ezcurra, 2010).

209. Cervical ribs: 0, slender and elongated; 1, short and stout (Gauthier, 1986; Benton and Clark, 1988; Juul, 1994; Benton, 1999; Nesbitt, 2011).
210. Dorsal vertebrae, neural spine lateral expansion of the distal end: 0, absent; 1, present with a flat dorsal margin (spine table); 2, present with a rounded dorsal margin (Nesbitt, 2011).
211. Dorsal vertebrae (mid- to posterior dorsal), neural spine anteroposterior expansion of distal end: 0, absent; 1, present, distal end of neural spine is anteroposteriorly longer than base of neural spine. NEW
212. Posterior dorsal vertebrae, neural spine inclination: 0, anteriorly inclined; 1, vertical or posteriorly inclined. NEW
213. Parapophyses contact with the centrum in vertebrae caudal to the twelfth presacral element: 0, do not contact; 1, contact (Langer, 2004; Pol et al., 2011b).
214. Dorsals, number: 0, 12–14; 1, 15; 2, 16 or more (modified from Butler et al., 2008). ORDERED
215. Sacral, number: 0, two; 1, three; 2, four/five; 3, six or more (Butler et al., 2008). ORDERED
216. Posterior sacral ribs are longer than anterior sacral ribs: 0, absent; 1, present, marginally longer; 2, present, considerably longer (modified from Butler et al., 2008).
217. Sacral centra: 0, separate; 1, at least partially co-ossified (modified from Nesbitt, 2011).
218. Sacral vertebrae, prezygapophyses and complimentary postzygapophyses: 0, separate; 1, co-ossified (Nesbitt, 2011).
219. Fusion of the sacral neural spines: 0, absent; 1, present. NEW
220. Sacral vertebrae, centra articular rims: 0, present in sacrum; 1, absent or nearly obliterated (modified from Nesbitt, 2007, 2011).
221. “Insertion” of a sacral vertebra between the first and second primordial sacral vertebrae: 0, absent; 1, present (Nesbitt, 2011).
222. Number of dorsosacral vertebrae: 0, none; 1, one; 2, two (Gauthier, 1986; Yates, 2007; Ezcurra, 2010). ORDERED

223. Sacral ribs: 0, almost entirely restricted to a single sacral vertebra; 1, shared between two sacral vertebrae (Nesbitt, 2011).
224. First primordial sacral, articular surface of sacral rib: 0, circular; 1, C-shaped in lateral view; 2, rectangular (modified from Langer and Benton, 2006; Nesbitt, 2011).
225. Possession of a caudosacral vertebra: 0, absent; 1, present. NEW
226. Length of first caudal centrum: 0, greater than its height; 1, much less than its height (Yates, 2003; Ezcurra, 2010).
227. Anterior caudal vertebrae, neural spines: 0, up to 50% taller than the centrum; 1, more than 50% taller than the centrum (Butler et al., 2008).
228. Length of base of the proximal caudal neural spines: 0, greater than half the length of the neural arch, 1, less than half the length of the neural arch (Gauthier 1986, Yates and Kitching, 2003; Ezcurra, 2010).
229. Length of midcaudal centra: 0, greater than twice the height of their proximal faces; 1, less than twice the height of their proximal faces (Yates and Kitching, 2003; Pol et al., 2011b).
230. Distal caudal vertebrae, prezygapophyses: 0, not elongated; 1, elongated beyond the anterior face of the centrum (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2007; Nesbitt, 2011).
231. Elongated prezygapophyses of the distal caudals: 0, elongated less than $\frac{1}{4}$ of the length of the adjacent centrum; 1, elongated more than $\frac{1}{4}$ of the length of the adjacent centrum (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2007; Nesbitt, 2011).
232. Position of postzygapophyses in proximal caudal vertebra: 0, protruding with an interpostzygapophyseal notch visible in dorsal view; 1, placed on either side of the caudal end of the base of the neural spine without any interpostzygapophyseal notch (Yates and Kitching, 2003; Pol et al., 2011b).
233. Chevron shape: 0, rod-shaped, often with a slight distal expansion; 1, strongly expanded distally, triangular or 'boat' shaped (modified from Butler et al., 2008).
234. Length of the longest chevron: 0, less than the length of the preceding centrum, 1, greater than the length of the preceding centrum (Yates and Kitching, 2003; Pol et al., 2011b).
235. Gastralia: 0, present; 1, absent (Butler et al., 2008).

236. Gastralium, form: 0, forming extensive ventral basket with closely packed elements; 1, elements well separated (modified from Nesbitt, 2011).
237. Ossified clavicles: 0, absent; 1, present (Butler et al., 2008).
238. Clavicles: 0, unfused; 1, fused into a furcula (modified from Gauthier, 1986; Sereno, 1991; Benton, 1999; Benton and Walker, 2002; Nesbitt, 2011).
239. Sternal plates: 0, absent; 1, present (modified from Butler et al., 2008).
240. Proportions of humerus and scapula: 0, scapula longer or subequal to the humerus; 1, humerus longer than the scapula (Butler et al., 2008).
241. Scapula, blade height versus distal width: 0, less than 3 times distal width; 1, more than 3 times distal width (Sereno, 1999).
242. Minimum width of scapula: 0, less than or equal to 20% of its length; 1, more than 20% of its length (Gauthier, 1986; Ezcurra, 2010).
243. Scapula, blade-shape: 0, strongly expanded distally; 1, weakly expanded, near parallel-sided (Butler et al., 2008).
244. Scapula acromion shape: 0, weakly developed or absent; 1, well-developed spine-like (Butler et al., 2008).
245. Orientation of dorsal margin of the acromion process of the scapula: 0, posteroventrally, forming an acute angle with the dorsoventral axis of the scapula; 1, posteriorly or subhorizontally, forming an obtuse or right angle with the dorsoventral axis of the scapula (Novas, 1996; Pol et al., 2011b).
246. Scapulocoracoid, anterior margin: 0, distinct notch between the two elements; 1, uninterrupted edge between the two elements (Parrish, 1993; Benton, 1999; Nesbitt, 2011).
247. Coracoid: 0, subcircular in lateral view; 1, with postglenoid process (notch ventral to glenoid) (Nesbitt, 2011).
248. Coracoid, posteroventral edge, deep groove: 0, absent; 1, present (Nesbitt, 2011).
249. Coracoid, posteroventral portion: 0, smooth; 1, possesses a “swollen” tuber (biceps tubercle, posteroventral process) (Nesbitt, 2011).

250. Glenoid, orientation: 0, posterolaterally; 1, directed posteroventrally (Fraser et al., 2002; Nesbitt, 2011).
251. Humerus/femur ratio: 0, roughly equal to or less than 0.6; 1, greater than 0.6 but less than 0.8; 2, greater than 0.8 (modified from Gauthier, 1986). ORDERED
252. Deltopectoral crest: 0, less than 30% the length of the humerus; 1, more than 30% the length of the humerus (Bakker and Galton, 1974; Benton, 1990; Juul, 1994; Novas, 1996; Benton, 1999).
253. Humerus, apex of deltopectoral crest situated at a point corresponding to: 0, less than 30% down the length of the humerus; 1, more than or equal to 30% down the length of the humerus but less than 50% down the length of the humerus; 2, more than 50% down the length of the humerus (modified from Bakker and Galton, 1974; Benton, 1990; Juul, 1994; Novas, 1996; Benton, 1999, Nesbitt, 2011).
254. Deltopectoral crest orientation: 0, slants at $<60^\circ$ to the transverse axis of the distal condyles, 1, perpendicular to the transverse axis of the distal condyles (Sereno, 1999; Pol et al., 2011b).
255. Deltopectoral crest form/development: 0, rudimentary, is at most a thickening of the humerus; 1, well-developed, projects as a distinct flange (modified from Butler et al., 2008).
256. Humeral shaft in anterior/posterior view: 0, relatively straight; 1, bowed ventrally (new).
257. Head of humerus is separated from prominent medial tubercle on proximal surface by a groove: 0, absent; 1, present (Han et al., 2012).
258. Humerus, proximal articular surface: 0, continuous with the deltopectoral crest; 1, separated by a gap from the deltopectoral crest (Nesbitt, 2011).
259. Humerus, distinct fossa on posterodorsal surface, just below the proximal edge: 0, absent; 1, present (new).
260. Humerus, distal end width: 0, narrower or equal to 30% of humerus length; 1, greater than 30% of humerus length (Langer and Benton, 2006).
261. Maximum transverse expansion of the distal end of the humerus: 0, greater than 50% of the maximum transverse expansion of the proximal humerus; 1, less than or equal to 50% of the maximum transverse expansion of the proximal humerus (new).
262. Ulna, lateral tuber (radius tuber) on the proximal portion: 0, absent; 1, present (Nesbitt, 2011).
263. Olecranon process on proximal ulna: 0, absent; 1, present (modified from Wilson and Sereno, 1998; Ezcurra, 2010).

264. Olecranon process: 0, not greatly enlarged; 1, greatly enlarged as a single ossification; 2, greatly enlarged with a separate ossification forming a strongly striated proximoanterior portion (modified from Wilson and Sereno, 1998; Ezcurra, 2010).
265. Radial fossa, bounded by an anterolateral process, on proximal ulna: 0, absent; 1, present (modified from Wilson and Sereno, 1998; Ezcurra, 2010).
266. Form of radial fossa: 0, shallow; 1, deep (new).
267. Radius, length: 0, longer than 80% of humerus length; 1, shorter than 80% of humerus length (Langer and Benton, 2006).
268. Proximal carpals (radiale, ulnare): 0, equidimensional; 1, elongate (Benton and Clark, 1988; Parrish, 1993; Benton and Walker, 2002; Clark et al., 2004; Nesbitt, 2011).
269. Proximal width of the first metacarpal respect to its length: 0, less than 65% of its length, 1, 65%-80% of its length, 2, greater than 80% of its length, 3: broader proximally than long (Sereno, 1999; Pol et al., 2011b). ORDERED
270. First distal carpal: 0, is narrower transversely than metacarpal I, 1, is subequal, or greater, in transverse width compared to metacarpal one (Sereno, 1999; Pol et al., 2011b).
271. Second distal carpal: 0, completely covers the proximal end of metacarpal II; 1, does not completely cover the proximal end of metacarpal II (Yates and Kitching, 2003; Ezcurra, 2010).
272. Manual length (measured as the average length of digits I–III): 0, accounts for less than 0.3 of the total length of humerus plus radius; 1, more than 0.3 but less than 0.4 of the total length of humerus plus radius; 2, more than 0.4 of the total length of humerus plus radius (modified from Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011). ORDERED
273. Metacarpals, proximal ends: 0, overlap; 1, abut one another without overlapping (Sereno and Wild, 1992; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Butler et al., 2008; Nesbitt, 2011).
274. Metacarpals I and V: 0, both substantially shorter in length than metacarpal III; 1, only metacarpal I longer than or subequal to metacarpal III; 2, only metacarpal V longer than or subequal to metacarpal III; 3, both are longer than or subequal to metacarpal III (modified from Butler et al., 2008).
275. Distal carpal V: 0, present; 1, absent (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).
276. Distal carpal V: 0, smaller than or roughly equal in size to other distal carpals; 1, greater in size than other distal carpals (modified from Yates, 2007; Ezcurra, 2010).

277. Penultimate phalanx of the second and third fingers: 0, shorter than or equal to the first phalanx; 1, longer than the first phalanx (modified from Butler et al., 2008).
278. Metacarpal V: 0, present; 1, absent. NEW
279. Manual digit V: 0, possesses one or more phalanges; 1, phalanges absent (modified from Bakker and Galton, 1974; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
280. Extensor pits on the dorsal surface of the distal end of metacarpals and manual phalanges: 0, absent or poorly developed; 1, deep, well-developed (Serenio et al., 1993; Langer and Benton, 2006; Butler et al., 2008; Nesbitt, 2011).
281. Manual unguals strongly recurved with prominent flexor tubercle: 0, present; 1, absent (modified from Butler et al., 2008).
282. Metacarpal I, width at the middle of the shaft accounts for: 0, less than 0.35 of the total length of the bone; 1, more than 0.35 of the total length of the bone (modified from Bakker and Galton, 1974; Langer and Benton, 2006; Nesbitt, 2011).
283. Digit I with metacarpal: 0, longer than the ungual; 1, subequal or shorter than the ungual (Serenio, 1999; Langer and Benton, 2006; Nesbitt, 2011).
284. Manual digit I, first phalanx: 0, is not the longest non-ungual phalanx of the manus; 1, is the longest non-ungual phalanx of the manus (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011).
285. Metacarpal I, distal condyles: 0, approximately aligned or slightly offset; 1, lateral condyle strongly distally expanded relative to medial condyle (modified from Bakker and Galton, 1974, Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
286. Ventrolateral twisting of the transverse axis of the distal end of the first phalanx of manual digit one relative to its proximal end: 0, absent, 1, present proximodorsal lip aligned with dorsal margin of medial distal condyle, 2, present proximodorsal lip aligned with central region of medial ligament pit of the distal condyle (Serenio, 1999; Pol et al., 2011b; Otero et al., 2015). ORDERED
287. Metacarpal II: 0, shorter than metacarpal III; 1, equal to or longer than metacarpal III (Gauthier, 1986; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
288. Manual digits I–III: 0, blunt unguals on at least digits II and III; 1, trenchant unguals on digits I–III (Gauthier, 1986; Juul, 1994; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011).

289. Manual digit IV: 0, five or four phalanges; 1, three or two phalanges; 2, one phalanx; 3, phalanges absent (Gauthier, 1986; Benton and Clark, 1988; Sereno et al., 1993; Novas, 1996; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011). ORDERED
290. Metacarpal IV, shaft width: 0, about the same width as that of metacarpals I–III; 1, significantly narrower than that of metacarpals I–III (modified from Sereno et al., 1993; Langer and Benton, 2006; Nesbitt, 2011).
291. Metacarpals IV and V, position: 0, level with metacarpals I–III; 1, ventral to metacarpals I–III (Sereno, 1993; Ezcurra, 2010).
292. Acetabulum: 0, completely closed; 1, open to at least some degree (modified from Butler et al., 2008).
293. Ilium, anterior preacetabular (= anterior, cranial process) process: 0, short and does not extend anterior to the pubic peduncle; 1, long and extends anterior to the pubic peduncle (modified from Galton, 1976; Benton, 1985; Sereno, 1986; Juul, 1994; Gower, 2000; Hutchinson, 2001a; Langer and Benton, 2006; Nesbitt and Norell, 2006; Butler et al., 2008b; Nesbitt, 2011).
294. Ilium, relative lengths of preacetabular (= anterior, cranial process) and postacetabular processes (= posterior process): 0, anterior process much shorter than the posterior process of the ilium; 1, anterior process subequal or longer than the posterior process of the ilium (modified from Galton, 1976; Benton, 1985; Sereno, 1986; Juul, 1994; Gower, 2000; Hutchinson, 2001a; Langer and Benton, 2006; Nesbitt and Norell, 2006; Butler et al., 2008b; Nesbitt, 2011).
295. Shape of preacetabular process: 0, rounded/rectangular, blunt profile; 1, triangular and pointed; 2, elongated and strap-like; 3, expanded dorsoventrally towards its anterior end producing a hatchet-shaped profile (i.e. possesses an anteroventral lobe) (Sereno, 1999; Pol et al., 2011b).
296. Preacetabular process, length: 0, less than 50% of the length of the ilium; 1, more than 50% of the length of the ilium (Butler et al., 2008).
297. Length of the preacetabular process of the ilium: 0, less than twice its depth; 1, greater than twice its depth (Yates and Kitching, 2003; Pol et al., 2011b).
298. Dorsal margin of preacetabular process and dorsal margin of ilium above acetabulum: 0, narrow, not transversely expanded; 1, dorsal margin is transversely expanded to form a narrow shelf (Butler et al., 2008).
299. Ilium, dorsal portion: 0, height about the same or shorter than the distance from the dorsal portion of the supraacetabular rim to the pubis-ischium contact; 1, expanded dorsally, height markedly taller than the dorsal portion of the supraacetabular rim to the pubis-ischium contact (Nesbitt, 2011).
300. In dorsal view preacetabular process of the ilium expands mediolaterally towards its distal end: 0, absent; 1, present (Butler et al., 2008).

301. Dorsal margin of the ilium in lateral view: 0, relatively straight or convex; 1, concave (saddle-shaped), postacetabular process is upturned (modified from Butler et al., 2008).

302. Shape of the caudal margin of the postacetabular process of the ilium: 0, rounded or bluntly pointed, 1, square ended (Yates, 2003; Pol et al., 2011b).

303. Ilium, distinct fossa present for the attachment of the caudifemoralis brevis muscle (brevis shelf): 0, absent; 1, present as an embankment on the lateral side of the posterior portion of the ilium; 2, present, not visible in lateral view and is in the form of a fossa on the dorsal margin of the ilium and/or the ventral surface of postacetabular process (modified from Gauthier and Padian, 1985; Gauthier, 1986; Juul, 1994; Novas, 1996; Benton, 1999; Hutchinson, 2001a; Butler et al., 2008; Nesbitt, 2011).
ORDERED

304. Ilium, ridge connecting the posterior portion of the supraacetabular rim to the posterior portion of the ilium: 0, absent; 1, present (modified from Langer and Benton, 2006; Nesbitt, 2011).

305. Ilium, ridge (or buttress) extending from the middle of the supraacetabular crest to the lateral edge of the preacetabular process: 0, absent; 1, present, low and rounded swelling; 2, present, pronounced and sharp (buttress) (new). ORDERED

306. Ilium, ventral margin of the acetabulum: 0, convex; 1, straight; 2, concave (Bakker and Galton, 1974; Gauthier and Padian, 1985; Gauthier, 1986; Juul, 1994; Novas, 1996; Benton, 1999; Fraser et al., 2002; Langer and Benton, 2006; Nesbitt, 2011).

307. Length of the postacetabular process as a percentage of the total length of the ilium: 0, more than 35%; 1, 35%-25%; 2, 20% or less (Butler et al., 2008). ORDERED

308. Medioventral acetabular flange of ilium, closes the acetabulum: 0, present, partially or fully closes the acetabulum; 1, absent (modified from Butler et al., 2008).

309. Ilium, ischiadic peduncle: 0, part of the main body of ilium, continuous with distal portion of the acetabular wall; 1, posterior portion is distinct from the main body of the ilium and the acetabular wall, is a ventrally/posteroventrally extending body. NEW

310. Ilium, ischiadic peduncle orientation: 0, mainly vertical in lateral aspect; 1, well expanded posteriorly to the anterior margin of the postacetabular embayment (Langer and Benton, 2006; Butler et al., 2008; Nesbitt, 2011).

311. Supra-acetabular 'crest' or 'flange': 0, present; 1, absent (Butler et al., 2008).

312. Ilium, supraacetabular crest (supraacetabular rim): 0, projects laterally or ventrolaterally; 1, projects ventrally (Gauthier, 1986; Nesbitt, 2011).

313. Supraacetabular crest of ilium: 0, not extended along (only at the base of) the pubic peduncle; 1, extended along the pubic peduncle as a faint ridge; 2, extended along the full length of the pubic peduncle and contacts the distal end as a well-developed crest (Ezcurra, 2010). ORDERED
314. Pubic peduncle of ilium: 0, longer in length than ischiadic peduncle; 1, shorter in length than ischiadic peduncle (modified from Butler et al., 2008).
315. Length of the pubic peduncle of ilium: 0, greater than twice the craniocaudal width of its distal end, 1, less than twice the craniocaudal width of its distal end (when excluding contribution of medioventral acetabular wall to craniocaudal width) (modified from Sereno, 1999; Ezcurra, 2010; Pol et al., 2011b).
316. Heavy reduction in dorsoventral depth of the ischiadic peduncle of the ilium, peduncle is almost completely lost: 0, absent; 1, present. NEW
317. Ilium, acetabular antitrochanter: 0, absent; 1, present (Sereno and Arcucci, 1994; Novas, 1996; Benton, 1999; Fraser et al., 2002; Irmis et al., 2007; Nesbitt, 2011; Nesbitt, 2011).
318. Ilium, extensive, highly rugose areas on the dorsal and lateral surfaces of the pre- and postacetabular processes: 0, absent; 1, present. NEW
319. Ischium, shape of shaft: 0, relatively straight; 1, curved along length (modified from Butler et al., 2008).
320. Ischium-pubis, contact: 0, present and extended ventrally; 1, present and reduced to a thin proximal contact; 2, absent (modified from Benton and Clark, 1988; Novas, 1996; Nesbitt, 2011).
321. Ischial shaft, cross-section: 0, compressed mediolaterally into thin sheet (rectangular); 1, subcircular/ovoid and bar-like (rod-like); 2, triangular or D-shaped (new).
322. Ischial shaft: 0, tapers distally; 1, expands weakly, or is parallel-sided, distally; 2, distally expanded into a distinct 'foot' or 'boot' (modified from Butler et al., 2008). ORDERED
323. Ischium, obturator process: 0, absent; 1, confluent with the pubic peduncle (obturator plate); 2, offset from the pubic peduncle (modified from Gauthier, 1986; Novas, 1993; Rauhut, 2003; Nesbitt, 2011).
324. Ischium, proximal portion of the ventral margin: 0, continuous ventral margin; 1, notch present; 2, abrupt change in angle between the proximal end and the shaft (modified from Sereno et al., 1996; Rauhut, 2003; Nesbitt, 2011).
325. Ischium, proximal articular surfaces: 0, articular surfaces with the ilium and the pubis continuous; 1, articular surfaces with the ilium and the pubis continuous but separated by a fossa; 2, articular surfaces

with the ilium and the pubis separated by a large, nonarticulating concave surface (modified from Irmis et al., 2007; Nesbitt, 2011). ORDERED

326. Ischium length: 0, about the same length or shorter than the dorsal margin of iliac blade; 1, longer than the dorsal margin of iliac blade (Juul, 1994; Nesbitt et al., 2009c; Nesbitt, 2011).

327. Groove on the dorsal margin of the ischium: 0, absent; 1, present (Butler et al., 2008).

328. Distinct obturator process of ischium (when separated from the pubic process of the ischium), form: 0, present as a rounded expansion of ventral margin; 1, present as distinct tab ('tab-shaped') (modified from Butler et al., 2008).

329. Ischium, medial contact with antimere: 0, restricted to the medial edge; 1, extensive contact but the dorsal margins are separated; 2, extensive contact and the dorsal margins contact each other (Nesbitt, 2011).

330. Ischium, cross section of the distal portion: 0, platelike; 1, rounded or semicircular; 2, subtriangular or D-shaped (modified from Sereno, 1999; Langer and Benton, 2006; Irmis et al., 2007; Yates, 2007; Ezcurra, 2010; Nesbitt, 2011).

331. Ischial symphysis, length: 0, ischium forms a median symphysis with the opposing blade along at least 50% of its length; 1, ischial symphysis present distally only (elongate interischial fenestra) (Yates, 2003; Butler et al., 2008; Pol et al., 2011b).

332. Pubis, orientation: 0, anteroventral; 1, rotated posteroventrally (= opisthopubic) (Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).

333. Shaft of pubis (postpubis), shape in cross-section: 0, blade-shaped; 1, rod-like; 2, rod-like, but with a tapering medial margin (teardrop-shaped) (modified from Butler et al., 2008). ORDERED

334. Shaft of pubis (postpubis), length: 0, longer than or approximately equal in length to the ischium; 1, reduced, extends two-thirds to one-half of the length of the ischium; 2, splint-like (modified from Butler et al., 2008). ORDERED

335. Pubic plate length: 0, less than 40% of the pubic shaft length; 1, more than 40% of the pubic shaft length (Pol and Powell, 2007).

336. Pubic shaft, shape: 0, posteriorly bowed; 1, relatively straight; 2, anteriorly bowed (modified from Sereno, 1999; Ezcurra and Novas, 2007; Ezcurra, 2010).

337. Body of pubis, size: 0, relatively large, makes substantial contribution to the margin of the acetabulum; 1, reduced in size, rudimentary, nearly excluded from the acetabulum (Butler et al., 2008).

338. Openings in the body of the pubis (obturator foramen): 0, absent, no obturator process or notch; 1, one, single obturator foramen or obturator notch present; 2, two, distinct second opening in the main body ("ceratosaur" foramen). NEW, ORDERED
339. Combined transverse width of both pubes: 0, less than 75% of their length; 1, more than 75% of their length (Cooper, 1984; Ezcurra, 2010).
340. Pubis/femur length: 0, less than or equal to 0.5; 1, more than 0.5 but less than 0.7; 2, equal to or more than 0.7 (modified from Novas, 1996; Pol et al., 2011b).
341. Body of the pubis, dorsolaterally rotated so that obturator foramen is obscured in lateral view: 0, absent; 1, present (modified from Butler et al., 2008).
342. Prepubic process: 0, absent; 1, present (Serenio, 1986; Butler et al., 2008; Nesbitt, 2011).
343. Prepubic process: 0, compressed mediolaterally, dorsoventral height exceeds mediolateral width; 1, rod-like, mediolateral width exceeds dorsoventral height (Butler et al., 2008).
344. Prepubic process, length: 0, stub-like and poorly developed, extends only a short distance anterior to the pubic peduncle of the ilium; 1, elongated into distinct anterior process (Butler et al., 2008).
345. Extended prepubic process, extends beyond distal end of preacetabular process of ilium: 0, absent; 1, present (modified from Butler et al., 2008).
346. Extent of pubic symphysis: 0, elongate; 1, restricted to distal end of pubic blade, or absent (Butler et al., 2008).
347. Pubis, pubic apron: 0, present; 1, absent. NEW
348. Pubis, median gap below the pubic apron: 0, present; 1, absent, distal pubes swollen and contact along their medial surfaces. NEW
349. Pubis, anteroposterior expansion of the distal portion: 0, present; 1, absent. NEW
350. Pubis, level of anteroposterior expansion of the distal portion: 0, large, distal portion is expanded to over 2.0 times the width of the mid-shaft forming a distinct 'boot'; 1, reduced, distal portion is expanded up to 2.0 times the width of the mid-shaft (knob-like swelling). NEW
351. At least some fusion of the pelvic elements (ilium, ischium pubis fused at their points of contact): 0, absent; 1, present. NEW

352. Tibia (or fibula)-femur length: 0, femur longer or about the same length as the tibia; 1, tibia longer (modified from Gauthier, 1986; Sereno, 1991; Juul, 1994; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011).
353. Femur, proximal portion, anteromedial tuber: 0, absent; 1, small and rounded; 2, offset medially (or posteriorly) relative to the posteromedial tuber (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, 2011). ORDERED
354. Femur, proximal portion, posteromedial tuber: 0, present and small; 1, present and largest of the proximal tubera; 2, absent (Novas, 1996; Nesbitt, 2005a; Irmis et al., 2007; Nesbitt, 2011).
355. Femur, proximal portion, anterolateral tuber: 0, present as an expansion; 1, absent, the anterolateral face is flat (modified from Sereno and Arcucci, 1994; Irmis et al., 2007; Nesbitt, 2011).
356. Femur, medial articular surface of the head in dorsal view: 0, rounded; 1, flat/ straight (Nesbitt, 2011).
357. Femoral head, narrowness (maximum anteroposterior breadth of femoral head < 30% of transverse width of the proximal surface of the femur): 0, absent, maximum anteroposterior breadth of femoral head is greater than 30% of transverse width of the proximal surface of the femur; 1, present, maximum anteroposterior breadth of femoral head is less than 30% of mediolateral width of the proximal surface of the femur. NEW
358. Femur, ventral to the proximal head: 0, smooth transition from the femoral shaft to the head; 1, notch; 2, concave emargination (Sereno and Arcucci, 1994a; Novas, 1996; Nesbitt, 2011).
359. Femoral shape in medial/lateral view: 0, bowed anteriorly along length; 1, relatively straight (Butler et al., 2008).
360. Medial bowing of the femur: 0, present, strong sigmoidal profile in anterior/posterior view; 1, present, small medial bowing forming gentle continuous curve; 2, absent, femur is straight in anterior/posterior view (new). ORDERED
361. Cross section of the mid-shaft of the femur: 0, roughly circular or elliptical, with the long axis running anteroposteriorly; 1, elliptical, with the long axis oriented mediolaterally (modified from Wilson and Sereno, 1998; Ezcurra, 2010).
362. Femur, femoral head orientation (long axis of the femoral head angle with respect to the transverse axis through the femoral condyles: 0, anterior; 1, anteromedial; 2, medial (modified from Benton and Clark, 1988; Hutchinson, 2001b; Nesbitt, 2011).
363. Femur, femoral head in medial and lateral views: 0, rounded; 1, hook shaped (Sereno and Arcucci, 1994a; Irmis et al., 2007; Nesbitt, 2011).

364. Femur, dorsolateral margin of the proximal portion: 0, smooth; 1, dorsolateral trochanter (modified from Nesbitt, 2011).
365. Dorsolateral trochanter, form: 0, sharp ridge; 1, rounded ridge (modified from Nesbitt, 2011).
366. Dorsolateral trochanter, fusion to the anterior trochanter: 0, absent, anterior trochanter and dorsolateral trochanter are separated by a gap; 1, present. NEW
367. Femur, anterior trochanter (lesser trochanter, M. iliofemoralis cranialis insertion): 0, absent; 1, present (modified from Bakker and Galton, 1974; Gauthier, 1986; Novas, 1992; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt et al., 2009c; Nesbitt, 2011).
368. Femur, anterolateral side of the femoral head: 0, featureless; 1, ventral emargination present (Serenio and Arcucci, 1994a; Irmis et al., 2007; Nesbitt, 2011).
369. Femur, anterior trochanteric shelf proximal to the attachment site of the M. caudifemoralis (insertion site for the M. iliofemoralis externus): 0, present; 1, absent (modified from Gauthier, 1986; Rowe and Gauthier, 1990; Novas, 1992, 1996; Langer and Benton, 2006; Nesbitt, 2011).
370. Anterior trochanter (lesser trochanter), morphology: 0, a very small, round tubercle; 1, elongate ridge that is oriented proximodistally (finger-like or spike-like); 2, broadened, prominent, 'wing' or 'blade' shaped (modified from Bakker and Galton, 1974; Gauthier, 1986; Novas, 1992; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt et al., 2009c; Nesbitt, 2011).
371. Broadened (wing or blade shaped) anterior trochanter, broadness in comparison with the greater trochanter: 0, as broad as the greater trochanter; 1, greater trochanter is broader. NEW
372. Anterior trochanter, completely connected to the shaft of the femur: 0, present; 1, absent, anterior trochanter is separated from the shaft by a marked cleft (modified from Bakker and Galton, 1974; Gauthier, 1986; Novas, 1992; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt et al., 2009c).
373. Level of most proximal point of anterior trochanter (lesser trochanter) relative to level of proximal femoral head: 0, anterior trochanter is positioned distally on the shaft; 1, anterior trochanter positioned proximally, approaches level of proximal surface of femoral head (modified from Butler et al., 2008).
374. Position of the anterior trochanter (lesser trochanter) in anterior view: 0, near the centre of the anterior face of the femoral shaft; 1, close to the lateral margin of the femoral shaft (Yates, 2007; Ezcurra, 2010).
375. Femur, proximal surface: 0, rounded and smooth; 1, transverse groove present (modified from Ezcurra, 2006; Nesbitt, 2011).

376. Transverse groove on femur, form: 0, transverse groove is shallow, poorly developed and is straight; 1, transverse groove is deep and well developed and is straight; 2, transverse groove is deep and well developed and is curved (modified from Ezcurra, 2006; Nesbitt, 2011). ORDERED
377. Fourth trochanter of femur: 0, absent; 1, present (modified from Butler et al., 2008).
378. Fourth trochanter of femur, shape: 0, low, mound-like and rounded; 1, raised, prominent ridge (aliform); 2, raised and pendant or rod-like (modified from Butler et al., 2008; Nesbitt, 2011). ORDERED
379. Fourth trochanter, position: 0, located entirely on proximal half of femur; 1, positioned at midlength, or distal to midlength (Butler et al., 2008).
380. Fourth trochanter: 0, symmetrical, with distal and proximal margins forming similar low-angle slopes to the shaft; 1, asymmetrical (modified from Langer and Benton, 2006; Nesbitt, 2011).
381. Pendent fourth trochanter, lateral deflection in distal section: 0, absent; 1, present. NEW
382. Transverse expansion of distal femur, ratio of the transverse width of the distal femur to the anteroposterior depth of the medial condyle: 0, greater than 1.5; 1, less than 1.5. NEW
383. Femur, distal condyles of the femur divided posteriorly: 0, less than 1/4 the length of the shaft; 1, between 1/4 and 1/3 the length of the shaft (Nesbitt, 2011).
384. Femur, anterior surface of the distal portion: 0, smooth; 1, distinct scar orientated mediolaterally; 2, scar oriented proximodistally (modified from Nesbitt et al., 2009a; Nesbitt, 2011).
385. Femur, crista tibiofibularis (fibular condyle, tibiofibular crest): 0, smaller or equal in size to the medial condyle; 1, larger than the medial condyle (modified from Sereno and Arcucci, 1994a; Irmis et al., 2007; Butler et al., 2008; Nesbitt, 2011).
386. Lateral condyle of distal femur, position and size in ventral view: 0, positioned relatively laterally; 1, strongly inset medially (modified from Butler et al., 2008).
387. Tibia, proximal portion, cnemial crest: 0, absent; 1, present and anteriorly straight; 2, present and curved anterolaterally (Benton and Clark, 1988; Juul, 1994; Novas, 1996; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011). ORDERED
388. Cnemial crest, anteroposterior length in proximal view: 0, between 0.25 and 0.4 times the anteroposterior width of the proximal tibia; 1, over 0.5 times the anteroposterior width of the proximal tibia. NEW

389. Tibia, proximal surface: 0, flat or convex; 1, concave, the posterior condyles of the tibia are separated from the cnemial crest by a concave surface (Nesbitt, 2011).
390. Tibia, lateral (fibular) condyle of the proximal portion: 0, offset anteriorly from the medial condyle; 1, level with the medial condyle at its posterior border (Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
391. Tibia, lateral margin of the lateral condyle of the proximal portion: 0, rounded; 1, squared off (Nesbitt, 2011).
392. Tibia, lateral side of the proximal portion: 0, smooth; 1, dorsoventrally oriented crest present (fibular crest) (Gauthier, 1986; Rauhut, 2003; Nesbitt, 2011).
393. Tibia, posterolateral flange (posterolateral process, descending process) of the distal portion: 0, absent; 1, present and contacts fibula; 2, present and extends well posterior to the fibula (modified from Novas, 1992; Juul, 1994; Benton, 1999; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
ORDERED
394. Tibia, posterolateral margin of the distal end: 0, straight or convex; 1, concave (Irmis et al., 2007; Nesbitt, 2011).
395. Mediocranial corner of distal tibia forms: 0, rounded, obtuse or near right angle, 1, sharp, acute angle (Langer, 2004; Pol et al., 2011b).
396. Tibia, posterior side of the distal portion: 0, smooth and featureless; 1, dorsoventrally oriented groove or gap (Nesbitt, 2011).
397. Notch in distal tibia (with respective bump in the proximal astragalus): 0, absent, 1, present (modified from Novas, 1996; Langer, 2004; Nesbitt, 2011; Pol et al., 2011b).
398. Lateral migration of the proximodistally oriented groove on the distal tibia: 0, absent; 1, present. NEW
399. Tibia, anterior diagonal tuberosity (anteromedial sheet of Galton, 2014) located proximomedial to the anterior ascending process: 0, absent; 1, present (Ezcurra and Brusatte, 2011).
400. Tibia, proximodistally oriented ridge on the posterior face of the distal end: 0, absent; 1, present. NEW
401. Maximum expansion of distal tibia relative to proximal: 0, distal tibia is considerably less expanded than proximal tibia; 1, maximum expansion of distal tibia is roughly equal to that of proximal tibia, or greater (new).

402. Transverse width of the distal tibia: 0, subequal to or less than the anteroposterior width (distal tibia is square/circular); 1, greater than the anteroposterior width (around 1.25 times or more) (modified from Gauthier, 1986; Ezcurra, 2010).
403. Distal articular surface of tibia, forms an oblique angle with the long axis of the tibia in anterior and posterior views: 0, absent, inner and outer malleoli are roughly level with one another distally, forming a near right angle between the articular surface the condyles form and the long axis; 1, present, outer malleolus extends further distally than the inner malleolus creating an oblique between the articular surface and the long axis; 2, present, inner malleolus extends further distally. NEW
404. Fibula, attachment site for the M. iliofibularis, form: 0, knob shaped, robust; 1, crest shaped, low (modified from Sereno, 1991; Nesbitt, 2011).
405. Fibula, attachment site for the M. iliofibularis, location: 0, near the proximal portion; 1, near the mid-point between the proximal and distal ends (modified from Sereno, 1991; Nesbitt, 2011).
406. Fibula, anterior edge of the proximal portion: 0, rounded; 1, tapers to a point and arched anteromedially (Nesbitt, 2011).
407. Fibula respect to tibia at the middle of their shafts: 0, wider than half the width of the tibia, 1, subequal or narrower than half the width of the tibia (Langer, 2004; Pol et al., 2011b).
408. Fibula, distal end is strongly reduced and splint-like: 0, absent; 1, present (Han et al., 2012).
409. Tibia, fibula and proximal tarsals, fused (or partly fused) as a tibiotarsus (tibiofibulatarsus): 0, absent; 1, present. NEW
410. Astragalus and calcaneum, relative sizes: 0, astragalus and calcaneum roughly equal in size; 1, calcaneum greatly reduced in comparison to astragalus (Sereno and Arcucci, 1994).
411. Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus: 0, present, 1, absent with a largely vertical fibular facet (Sereno, 1999).
412. Fibular facet on the lateral margin of the proximal surface of the astragalus: 0, large; 1, reduced to small articulation (Butler et al., 2008).
413. Astragalus, dorsally expanded process on the posterolateral portion of the tibial facet: 0, absent or poorly expanded; 1, expanded into a distinct, raised process (posterior ascending process of Sereno and Arcucci, 1994, pyramidal process of Nesbitt and Ezcurra, 2015) (modified from Sereno and Arcucci, 1994; Nesbitt, 2011).
414. Astragalus, anterior ascending flange (anterior process, ascending process): 0, absent; 1, present (modified from Gauthier, 1986; Novas, 1992, 1996; Benton, 1999; Rauhut, 2003; Nesbitt, 2011).

415. Anterior ascending flange of the astragalus: 0, less than or equal to the height of the dorsoventral extent of the posterior side of the astragalus; 1, greater in height than the dorsoventral height of the posterior side astragalus (modified from Gauthier, 1986; Novas, 1992, 1996; Benton, 1999; Rauhut, 2003; Nesbitt, 2011).
416. Astragalus, anterior hollow: 0, shallow depression; 1, reduced to a foramen (extensor canal) (Nesbitt, 2011).
417. Astragalus, proximal surface: 0, lacks a marked rimmed and elliptical fossa posterior to the anterior ascending process; 1, possesses a marked rimmed and elliptical fossa posterior to the anterior ascending process (Langer and Benton, 2006; Nesbitt, 2011).
418. Astragalus, posterior groove: 0, present; 1, absent (Serenio, 1991; Nesbitt et al., 2009c; Nesbitt, 2011).
419. Astragalus in distal view, symmetry: 0, astragalar body is fairly symmetric, medial and lateral margins are about equal in depth; 1, astragalar body is strongly asymmetric, medial margin is at least 1.4 times as deep as lateral margin. NEW
420. Distal articular surface of astragalus: 0, relatively flat or weakly convex; 1, extremely convex and 'roller shaped' (Smith and Pol, 2007; Ezcurra, 2010).
421. Astragalus-calcaneum, articulation: 0, free; 1, coossified (Serenio and Arcucci, 1994; Irmis et al., 2007; Nesbitt, 2011; Han et al., 2012).
422. Calcaneum, proximal surface: 0, facet for tibia absent; 1, well-developed facet for tibia present (Butler et al., 2008).
423. Calcaneum, calcaneal tuber: 0, present; 1, absent (Gauthier, 1986; Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2011).
424. Calcaneum, shape: 0, proximodistally compressed with a short posterior projection and medial process; 1, transversely compressed, with the reduction of these projections (modified from Langer and Benton, 2006; Nesbitt, 2011).
425. Calcaneum, fossa on the lateral surface: 0, absent; 1, present (Yates, 2007; Ezcurra, 2010).
426. Distal tarsals: 0, ossified; 1, not ossified. NEW
427. Distal tarsal 4, posterior prong: 0, blunt; 1, pointed (Langer and Benton, 2006; Nesbitt, 2011).

428. Distal tarsal 4, medial side: 0, without a distinct medial process present in the anteroposterior middle of the element; 1, with a distinct medial process present in the anteroposterior middle of the element (Nesbitt, 2011).
429. Distal tarsal 4, proximal surface: 0, flat; 1, distinct, proximally raised region on the posterior portion (heel of Sereno and Arcucci, 1994, 1994) (Nesbitt, 2011).
430. Medial distal tarsal: 0, articulates distally with metatarsal 3 only; 1, articulates distally with metatarsals 2 and 3 (Butler et al., 2008).
431. Medial distal tarsal: 0, not enlarged; 1, enlarged. NEW
432. Metatarsal III: 0, roughly equal to or shorter than 50% of tibial length; 1, longer than 50% of tibial length (modified from Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2011).
433. Longest metatarsal: 0, metatarsal III is the longest; 1, metatarsal IV is the longest. NEW
434. Metatarsals, midshaft diameters: 0, both I and V subequal or greater than II–IV in diameter; 1, only diameter of metatarsal I greater than or equal to diameter of metatarsals II–IV; 2, only diameter of metatarsal V greater than or subequal to the diameters of metatarsal II–IV; 3, both I and V have diameters less than metatarsals II–IV (modified from Sereno, 1991; Juul, 1994; Novas, 1996; Benton, 1999; Nesbitt, 2011).
435. Metatarsal I: 0, reaches the proximal surface of metatarsal II; 1, does not contact the ankle joint and attaches onto the medial side of metatarsal II (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2011).
436. Metatarsal I: 0, subequal or greater in length than metatarsal II; 1, significantly shorter in length than metatarsal II. NEW
437. Metatarsal II, proximal articular surface: 0, subrectangular; 1, hour-glass shaped (Sereno, 1991; Pol and Powell, 2007).
438. Fusion of distal tarsals to proximal ends of metatarsals: 0, absent; 1, present. NEW
439. Metatarsal IV, distal articulation surface: 0, broader than deep and nearly symmetrical; 1, deeper than broad (or as broad as it is deep) and asymmetrical (modified from Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).
440. Metatarsal IV, proximal portion, possesses an elongated lateral expansion that overlaps the anterior surface of metatarsal V: 0, absent; 1, present (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).

441. Metatarsal V: 0, present; 1, absent. NEW
442. Metatarsal V, phalanges: 0, present and “fully” developed first phalanx; 1, present and “poorly” developed first phalanx; 2, without phalanges (modified from Gauthier, 1984; Parrish, 1993; Nesbitt, 2011). ORDERED
443. Metatarsal V shape: 0, proximal and distal ends subequal in breadth, 1, proximal end is wider than the distal end, metatarsal V is triangular or y-shaped, with wide proximal surface and pointed distal end (Galton and Upchurch, 2004; Pol et al., 2011b).
444. Metatarsal V, length: 0, longer than 50% of metatarsal III; 1, shorter than 50% of metatarsal III (modified from Butler et al., 2008).
445. Metatarsals fused or partly fused into tarsometatarsus: 0, absent; 1, present. NEW
446. Digit 1: 0, metatarsal I robust and well-developed, distal end of phalanx 1–1 projects beyond the distal end of metatarsal II; 1, metatarsal I reduced, end of phalanx 1–1 does not extend much beyond the end of metatarsal II if at all; 2, metatarsal I reduced to a vestigial splint or absent, does not bear digits (Butler et al., 2008). ORDERED
447. Non-terminal phalanges, shape: 0, elongate; 1, subquadrangular (Pol and Powell, 2007).
448. Pedal digit 4 phalangeal number: 0, five or more; 1, four or fewer (Butler et al., 2008).
449. Majority of pedal unguals, shape: 0, claw-like; 1, hoof-like (modified from Butler et al., 2008).
450. Shape of the ungual of pedal digit I: 0, shallow, pointed, with convex sides and a broad ventral surface; 1, deep, abruptly tapering, with flattened sides and a narrow ventral surface. (McPhee et al. 2015).
451. Unguals of digits II–IV: 0, deeper than broad, with curved ventral surfaces; 1, broader than deep, with flat plantar surfaces. NEW
452. Epaxial ossified tendons present along vertebral column: 0, absent; 1, present (Butler et al., 2008).
453. Ossified hypaxial tendons, present on caudal vertebrae: 0, absent; 1, present (Butler et al., 2008).
454. Parasagittal row of dermal osteoderms on the dorsum of the body: 0, absent; 1, present (Butler et al., 2008).
455. Lateral row of keeled dermal osteoderms on the dorsum of the body: 0, absent; 1, present (Butler et al., 2008).

456. U-shaped cervical/pectoral collars composed of contiguous keeled osteoderms: 0, absent; 1, present (Butler et al., 2008).

457. Singular and unbranched filamentous integumentary structures covering, or partially covering, the outer body: 0, absent; 1, present. NEW

2.2 Character set from Chapter 7

ORDERED: 25 35 39 40 41 49 61 68 69 72 114 140 161 163 168 175 179 191 193 200 209 210 216 245 262 265 278 281 297 299 301 307 312 316 319 327 328 332 346 353 369 371 383 389 436 440

1. Skull proportions: 0, preorbital skull length more than 45% of basal skull length; 1, preorbital length less than 45% of basal skull length (modified from Butler et al., 2008).
2. Skull length (rostral–quadrate): 0, 15% or less of body length; 1, 20–30% of body length (modified from Butler et al., 2008).
3. Skull length: 0, longer than two thirds of the femoral length; 1, shorter than two-thirds of the femoral length (Gauthier, 1986; Ezcurra, 2010; Nesbitt, 2011).
4. Skull shape: 0, with a deep snout (depth of skull just anterior to the orbit is subequal to depth of the rostral portion of the skull); 1, tapered rostrally (depth of skull just anterior to the orbit is far greater than the depth of the rostral portion of the skull) (new).
5. Profile of premaxilla: 0, convex; 1, with an inflection at the base of the anterodorsal process (Upchurch, 1995; Ezcurra, 2010).
6. Premaxilla, edentulous anterior region: 0, absent, first premaxillary tooth is positioned adjacent to the symphysis; 1, present, first premaxillary tooth is inset the width of one or more crowns (Butler et al., 2008).
7. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process), length: 0, does not contact lacrimal; 1, contacts the lacrimal, excludes maxilla–nasal contact (Butler et al., 2008)
8. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process), width: 0, wide, plate-like; 1, thin, bar like; 2, reduced/absent (modified from Gauthier, 1986; Rauhut, 2003; Langer and Benton, 2006; Smith et al., 2007; Nesbitt, 2011).
9. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process): 0, extends posteriorly to form part of the posterior margin of the external naris; 1, restricted to the ventral border of the external naris (Langer and Benton, 2006; Nesbitt, 2011).

10. Premaxilla, posterodorsal process (maxillary process, posterolateral process, subnarial process), relationship with anteroventral process of the nasal: 0, broad sutured contact; 1, point contact; 2, no contact (modified from Gauthier, 1986; Yates, 2007; Ezcurra 2010).
11. Position of the ventral (oral) margin of the premaxilla: 0, roughly level with the maxillary tooth row; 1, deflected ventral to maxillary tooth row; 2, raised, positioned dorsal to the maxillary tooth row (modified from Butler et al., 2008).
12. Premaxillary foramen (anterior premaxillary foramen): 0, absent; 1, present (Yates, 2007; Butler et al., 2008; Ezcurra, 2010).
13. Second anterior premaxillary foramen (often connected to the premaxillary foramen by a distinct anteroventrally oriented groove): 0, absent; 1, present (new).
14. Premaxillary palate: 0, strongly arched, forming a deep, concave palate; 1, horizontal or only gently arched (Butler et al., 2008)
15. Fossa-like depression positioned on the premaxilla-maxilla boundary: 0, absent; 1, present (Butler et al., 2008).
16. Premaxilla–maxilla diastema: 0, absent, maxillary teeth continue to anterior end of maxilla; 1, present, substantial diastema of at least one crown's length between maxillary and premaxillary teeth (Butler et al., 2008).
17. Form of diastema; 0, flat; 1, arched 'subnarial gap' between the premaxilla and maxilla (Butler et al., 2008).
18. Premaxilla, overall form: 0, block-like, square and deep; 1, oval shaped, thin (new).
19. Premaxilla, narial fossa: 0, absent; 1, present (modified from Sereno, 1999; Langer and Benton, 2006; Irmis et al., 2007; Butler et al., 2008; Nesbitt, 2011).
20. Narial fossa surrounding external nares on lateral surface of premaxilla, position of ventral margin of fossa relative to the ventral margin of the premaxilla: 0, closely approaches the ventral margin of the premaxilla; 1, separated by a broad flat margin from the ventral margin of the premaxilla (Butler et al., 2008).
21. External nares, position of the ventral margin: 0, below or level with the ventral margin of the orbits; 1, above the ventral margin of the orbits (Butler et al., 2008).
22. External naris, size: 0, entirely overlies the premaxilla; 1, extends posteriorly to overlie the maxilla (Butler et al., 2008).

23. External naris, shape (in adults): 0, rounded or elliptical; 1, subtriangular, with an acute posteroventral corner (Galton and Upchurch, 2004; Ezcurra, 2010).
24. Level of the anterior margin of the external naris: 0, anterior to the midlength of the premaxillary body; 1, posterior to the midlength of the premaxillary body; 2, posterior to the anteriormost point of the premaxilla-maxilla boundary (modified from Rauhut, 2003; Ezcurra, 2010).
25. Level of the posterior margin of the external naris: 0, anterior to or level with the premaxilla-maxilla suture; 1, posterior to the first maxillary alveolus; 2, posterior to the midlength of the maxillary tooth row and the anterior margin of the antorbital fenestra (and Sereno, 1998; Yates, 2007; Ezcurra, 2010).
ORDERED
26. Anterior premaxillary foramen, position: 0, positioned outside of the narial fossa; 1, positioned on the rim of, or inside, the narial fossa (Sereno et al., 1993; Yates, 2007; Ezcurra, 2010).
27. Subnarial foramen between the premaxilla and maxilla: 0, absent; 1, present (Benton and Clark, 1988; Parrish, 1993; Juul, 1994; Benton, 1999; Nesbitt, 2011).
28. Fossa present along sutural line of the nasals: 0, absent; 1, present; 2, fenestra (internasal fenestra) present (modified from Butler et al., 2008).
29. Internal antorbital fenestra size: 0, large, generally at least 15% of the skull length; 1, very much reduced, less than 10% of skull length, or absent (Butler et al., 2008).
30. Antorbital fenestra, shape: 0, triangular; 1, oval or circular; 2, rectangular; 3, constricted anteroposteriorly, with rounded antero- and posteroventral margins, tear-drop shaped (modified from Butler et al., 2008).
31. Additional opening(s) or fossa anteriorly within the antorbital fossa (promaxillary foramen, promaxillary fossa): 0, absent; 1, present (Carpenter, 1992; Rauhut, 2003; Smith et al., 2007; Butler et al., 2008; Nesbitt, 2011).
32. Additional opening(s) in the antorbital fossa (promaxillary foramen), shape: 0, wide and circular; 1, narrow recess or slit-like (new).
33. Maxilla, rostrrolateral surface between the ventral border of the antorbital fossa and the alveolar margin is pierced by a small foramen: 0, absent; 1, present (new).
34. Anterior profile of the maxilla: 0, slopes continuously towards the anterior tip; 1, with a strong inflection (notch) at the base of the ascending ramus, creating an anterior ramus with parallel dorsal and ventral margins (Sereno et al., 1996; Langer and Benton, 2006; Ezcurra, 2010; Nesbitt, 2011).

35. Maxilla, lateral surface: 0, completely smooth; 1, sharp longitudinal ridge present; 2, rounded/bulbous longitudinal ridge present (Gower, 1999; Weinbaum and Hungerbühler, 2007; Nesbitt, 2011).
ORDERED
36. Maxilla, buccal emargination: 0, absent; 1, present (Butler, 2005; Irmis et al., 2007; Irmis et al., 2007; Butler et al 2008; Nesbitt, 2011).
37. Ridge or lateral swelling of lateral surface of the dentary (possibly associated with a fleshy cheek in life): 0, absent, 1, present (Gauthier, 1986; Galton and Upchurch, 2004; Pol et al., 2011b).
38. Slot in maxilla for lacrimal: 0, absent; 1, present (Butler et al., 2008).
39. Antorbital fossa: 0, restricted to the lacrimal; 1, restricted to the lacrimal and dorsal process of the maxilla; 2, present on the lacrimal, dorsal process of the maxilla and the dorsal margin of the posterior process of the maxilla; 3, absent (the ventral border of the antorbital fenestra) (modified from Nesbitt et al., 2009c; Nesbitt, 2011). ORDERED
40. Dorsoventral extension of lacrimal antorbital fossa: 0, through more than half of the bone height; 1, is restricted to the ventral half of the bone; 2, lacrimal antorbital fossa is lost completely, despite the presence of a maxillary antorbital fossa (modified from Langer, 2004; Pol et al., 2011b). ORDERED
41. Nasal: 0, does not possess a posterolateral process that envelops part of the anterior (rostral) ramus of the lacrimal; 1, possesses a posterolateral process that envelops part of the anterior ramus of the lacrimal; 2, possesses a posterolateral process that envelops part of the dorsal process (= nasal process) of the maxilla (modified from Yates, 2003; Langer and Benton, 2006; Nesbitt, 2011). ORDERED
42. Nasal: 0, does not form part of the dorsal border of the antorbital fossa; 1, forms part of the dorsal border of the antorbital fossa (Sereno et al., 1994; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
43. Ventral rim of the antorbital fossa/foramen: 0, parallel to tooth row, 1, ventrally sloped in its caudal part (Langer, 2004; Pol et al., 2011b).
44. Lacrimal, shape: 0, dorsoventrally short and block-shaped; 1, dorsoventrally elongate and shaped like and inverted L (Rauhut, 2003; Ezcurra, 2010).
45. Descending process of lacrimal: 0, curved, subvertically oriented (at its dorsal half), 1, straight and obliquely oriented along its entire length (Pol et al., 2011b).
46. Length of the anterior (rostral) ramus of the lacrimal: 0, greater than half the length of the ventral ramus, 1, less than half the length of the ventral ramus (Yates, 2007; Pol et al., 2011b).

47. Lacrimal: 0, does not fold over (overhang) the posterior/posterodorsal part of the antorbital fenestra; 1, folds over (overhangs) the posterior/posterodorsal part of the antorbital fenestra (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).
48. Lacrimal foramen (= lacrimal fenestra): 0, absent; 1, present (Molnar et al. 1990; Smith et al., 2010).
49. Dorsal crest(s) on the skull, formed by dorsoventral expansion of the lacrimals and/or nasals (naso-lacrimal crest): 0, absent; 1, present and anteroposteriorly elongate; 2, present and shortened anteroposteriorly (new). ORDERED
50. Accessory ossification(s) in the orbit (palpebral/ supraorbital): 0, absent; 1, present (Butler et al., 2008).
51. Palpebral/supraorbital: 0, free, projects into orbit from contact with lacrimal/prefrontal; 1, incorporated into orbital margin (Butler et al., 2008).
52. Palpebral, shape in dorsal view: 0, rod-shaped; 1, plate-like with wide base (Butler et al., 2008).
53. Palpebral/supraorbital, number: 0, one; 1, two; 2, three (Butler et al., 2008).
54. Free palpebral, length, relative to anteroposterior width of orbit: 0, does not traverse entire width of orbit; 1, traverses entire width of orbit (Butler et al., 2008).
55. Orbit, shape: 0, circular; 1, elongated dorsoventrally, oval (new).
56. Exclusion of the jugal from the posteroventral margin of the antorbital fenestra by lacrimal–maxilla contact: 0, absent; 1, present (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; Butler et al., 2008; Nesbitt, 2011).
57. Anterior ramus of jugal, proportions: 0, deeper than wide; 1, wider than deep (modified from Butler et al., 2008).
58. Anterior ramus of jugal: 0, not as deep as the posterior ramus of the jugal; 1, deeper than the posterior ramus of the jugal (modified from Butler et al., 2008).
59. Position of maximum widening of the skull: 0, beneath the jugal–postorbital bar; 1, posteriorly, beneath the infratemporal fenestra (Butler et al., 2008).
60. Jugal (or jugal–epijugal) ridge dividing the lateral surface of the jugal into two planes: 0, absent; 1, present and sharp; 2, present and rounded; 3, restricted to a bulbous ridge (Butler et al., 2008; Nesbitt, 2011).
61. Ornamentation on jugal: 0, absent; 1, present as small rugose surface; 2, present as well developed jugal boss/jugal horn (modified from Butler et al., 2008). ORDERED

62. Jugal, anterior extent of the slot for the quadratojugal: 0, well posterior of the posterior edge of the dorsal process of the jugal; 1, at or anterior to the posterior edge of the dorsal process of the jugal (Nesbitt, 2011).
63. Jugal, posterior process: 0, lies dorsal to the anterior process of the quadratojugal; 1, lies ventral to the anterior process of the quadratojugal; 2, is level with the anterior process of the quadratojugal and overlaps it/splits the anterior process of the quadratojugal; 3, is level with the anterior process of the quadratojugal and is split by the anterior process of the quadratojugal (forked, bifurcated) (Butler et al., 2008; Nesbitt, 2011).
64. Jugal–postorbital bar, width broader than infratemporal fenestra: 0, absent; 1, present (Butler et al., 2008).
65. Jugal–postorbital joint: 0, elongate scarf joint; 1, short butt joint (Butler et al., 2008).
66. Jugal, posterior ramus: 0, forms anterior and/or ventral margin of infratemporal fenestra; 1, forms part of posterior margin, expands towards squamosal (Butler et al., 2008).
67. Jugal-lacrimal relationship: 0, lacrimal overlapping lateral surface of jugal or abutting it dorsally; 1, jugal overlapping lacrimal laterally (Serenio et al., 1993; Ezcurra, 2010).
68. Ratio of minimum depth of jugal below the orbit to the distance between the anterior end of the jugal and the anteroventral corner of the infratemporal fenestra: 0, less than 0.2; 1, roughly equal to or greater than 0.2; 2, depth of jugal is subequal to the distance between the anterior end of the jugal and the anteroventral corner of the infratemporal fenestra (modified from Galton, 1985; Yates, 2007; Ezcurra 2010). ORDERED
69. Lateral temporal fenestra, maximum anteroposterior length of ventral half: 0, more than twice the maximum anteroposterior length of the dorsal half; 1, less than twice the maximum anteroposterior length of the dorsal half; 2, maximum anteroposterior length of the dorsal half is greater than that of the ventral half (new)., ORDERED
70. Postorbital, orbital margin: 0, relatively smooth curve; 1, prominent and distinct projection into orbit (orbital flange) (Butler et al., 2008).
71. Contact between dorsal process of quadratojugal and descending process of the squamosal: 0, present; 1, absent (Butler et al., 2008).
72. Form of contact between the quadratojugal and the squamosal: 0, small, thin point contact; 1, large, quadratojugal has broad contact with the ventral margin of the descending process of the squamosal as a butt joint; 2, large, quadratojugal has broad contact with the posterior margin of the descending process of the squamosal as an elongate scarf joint (new)., ORDERED

73. Quadratojugal, shape: 0, L-shaped, with elongate anterior process; 1, subrectangular with long axis vertical, short, deep anterior process (Butler et al., 2008).
74. Quadratojugal, ventral margin: 0, approaches the mandibular condyle of the quadrate; 1, well-removed from the mandibular condyle of the quadrate (Butler et al., 2008).
75. Quadrate, head: 0, partially exposed laterally; 1, completely covered by the squamosal (Serenio and Novas, 1994; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt, 2011).
76. Quadrate shaft: 0, convex in lateral view; 1, reduced in anteroposterior width and straight in lateral view (Butler et al., 2008).
77. Quadrate, angled: 0, posteroventrally or vertical; 1, anteroventrally (Nesbitt, 2007, Nesbitt, 2011).
78. Paraquadratic foramen or notch, size: 0, absent or small; 1, large (Butler et al., 2008).
79. Paraquadratic foramen, orientation: 0, posterolateral aspect of quadrate shaft; 1, lateral aspect of quadrate or quadratojugal (Butler et al., 2008).
80. Paraquadratic foramen, position: 0, on quadrate-quadratojugal boundary; 1, located within quadratojugal; 2, located within the quadrate (modified from Butler et al., 2008).
81. Quadrate mandibular articulation: 0, quadrate condyles subequal in size; 1, medial condyle is larger than lateral condyle; 2, lateral condyle is larger than medial (Butler et al., 2008).
82. Paired frontals: 0, short and broad; 1, narrow and elongate (more than twice as long as wide) (Butler et al., 2008).
83. Supratemporal fenestrae, anteroposterior elongation: 0, absent, fenestrae are subcircular to oval in shape; 1, present (Butler et al., 2008).
84. Supratemporal fossa: 0, absent anterior to the supratemporal fenestra; 1, present anterior to the supratemporal fenestra, extends onto the dorsal surface of the frontal (Gauthier, 1986; Novas, 1996; Nesbitt, 2011).
85. Squamosal, ventral process: 0, wider than one-quarter of its length; 1, narrower than one-quarter of its length (Yates, 2003; Langer and Benton, 2006; Nesbitt, 2011).
86. Ventral ramus of squamosal form: 0, more than half of the caudal border of the lower temporal fenestra, 1, less than half of the caudal border of the lower temporal fenestra (Langer, 2004; Pol et al., 2011b).

87. Paroccipital process: 0, extends laterally or dorsolaterally; 1, extends ventrally or ventrolaterally (Rauhut, 2003; Ezcurra, 2010; Nesbitt, 2011).
88. Paroccipital process: 0, expanded distally; 1, distal end pendent (modified from Rauhut, 2003; Ezcurra, 2010; Nesbitt, 2011).
89. Paroccipital processes, proportions: 0, short and deep; 1, elongate and narrow (Butler et al., 2008).
90. Opisthotic, ventral ramus (crista interfenestralis): 0, extends further laterally than lateral-most edge of exoccipital in posterior view; 1, covered by the lateral-most edge of exoccipital in posterior view (Gower, 2002; Nesbitt, 2011).
91. Posttemporal foramen/fossa, position: 0, totally enclosed with the paroccipital process; 1, forms a notch or foramen in the dorsal margin of the paroccipital process, enclosed dorsally by the squamosal (Butler et al., 2008).
92. Exoccipital, relative positions of the exits of the hypoglossal nerve (XII): 0, aligned in a nearly anteroposterior plane; 1, aligned subvertically; 2, combined into single exit (modified from Nesbitt, 2011).
93. Exoccipital, lateral surface: 0, without subvertical crest (metotic strut); 1, with clear crest (metotic strut) lying anterior to both external foramina for hypoglossal nerve (XII); 2, with clear crest (metotic strut) present anterior to the more posterior external foramina for hypoglossal nerve (XII) (Gower, 2002; Nesbitt, 2011).
94. Exoccipitals: 0, meet along the midline on the floor of the endocranial cavity (basioccipital excluded from the ventral border of the foramen magnum); 1, do not meet along the midline on the floor of the endocranial cavity (Gower and Sennikov, 1996; Gower, 2002; Nesbitt, 2011).
95. Supraoccipital: 0, excluded from dorsal border of foramen magnum by mediodorsal midline contact between opposite exoccipitals; 1, contributes to border of foramen magnum (Gower, 2002, Nesbitt, 2011).
96. Supraoccipital, rugose ridge on the anterolateral edges: 0, absent; 1, present (Nesbitt, 2011).
97. Shape of the supraoccipital: 0, diamond shaped or triangular; 1, semi-lunate/crescentic (Yates, 2003; Ezcurra, 2010).
98. Supraoccipital, proportions: 0, taller than wide or as wide as tall; 1, wider than tall (new).
99. Perilymphatic foramen: 0, with an incompletely ossified border; 1, border entirely ossified such that the ventral ramus of the opisthotic forms a perilymphatic loop incorporating a loop closure suture with itself (Gower, 2002; Nesbitt, 2011).

100. Basisphenoid, relative to the basioccipital: 0, longer than, or subequal in length to, basioccipital; 1, shorter than basioccipital (Butler et al., 2008).
101. Parabasisphenoid, foramina for entrance of cerebral branches of internal carotid artery into the braincase positioned on the surface: 0, ventral; 1, lateral (Parrish, 1993; Gower and Sennikov, 1996; Gower, 2002; Nesbitt et al., 2009c; Nesbitt, 2011).
102. Parabasisphenoid, recess (median pharyngeal recess, hemispherical sulcus, hemispherical fontanelle): 0, absent; 1, present (Nesbitt and Norell, 2006; Nesbitt, 2011).
103. Parabasisphenoid, anterior tympanic recess on the lateral side of the braincase: 0, absent; 1, present (Makovicky and Sues, 1998; Rauhut, 2003; Nesbitt, 2011).
104. Parabasisphenoid, between basal tubera and basipterygoid processes: 0, approximately as wide as long or wider; 1, significantly elongated, at least 1.5 times longer than wide (Rauhut, 2003; Nesbitt, 2007; Nesbitt, 2011).
105. Basal tubera, shape: 0, knob-shaped; 1, plate-shaped (Butler et al., 2008).
106. Basipterygoid processes, orientation: 0, anterior as well as ventrolateral or anteroventral; 1, entirely ventral; 2, posteroventral (modified from Butler et al., 2008)
107. Basipterygoid processes and basal tubera: 0, basipterygoid processes ventrally offset relative to the basal tubera; 1, basipterygoid process and basal tubera are horizontally aligned to one another (new).
108. Dorsoventrally deep (deeper than 50% of snout depth) median palatal keel formed of the vomers, pterygoids and palatines: 0, absent; 1, present (Butler et al., 2008).
109. Ectopterygoid, ventral recess: 0, absent; 1, present (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011).
110. Ectopterygoid, direction of arc: 0, arcs anteriorly; 1, arcs anterodorsally (Nesbitt, 2011).
111. Ectopterygoid, jugal process: 0, broad; 1, slender (new).
112. Vestibule, medial wall: 0, incompletely ossified; 1, almost completely ossified (Gower, 2002; Nesbitt, 2011).
113. Lagenar/cochlea recess: 0, absent or short and strongly tapered; 1, present and elongated and tubular (Gower, 2002; Nesbitt, 2011).

114. Foramen for trigeminal nerve and middle cerebral vein: 0, combined and undivided; 1, at least partially subdivided by prootic; 2, fully divided (Gower and Sennikov, 1996; Gower, 2002; Nesbitt, 2011).
ORDERED

115. Auricular recess: 0, largely restricted to prootic; 1, extends onto internal surface of epiotic/supraoccipital (Gower, 2002; Nesbitt, 2011).

116. Cortical remodeling of surface of skull dermal bone: 0, absent; 1, present (Butler et al., 2008).

117. Predentary: 0, absent; 1, present (Sereno, 1986; Butler et al., 2007, 2008b; Nesbitt, 2011).

118. Predentary size: 0, short, posterior premaxillary teeth oppose anterior dentary teeth; 1, roughly equal in length to the premaxilla, premaxillary teeth only oppose predentary (Butler et al., 2008).

119. Predentary, ventral process: 0, well-developed; 1, very reduced or absent (Butler et al., 2008).

120. Dentary, anterior extremity: 0, rounded; 1, tapers to a sharp point (Nesbitt, 2011).

121. Dentary, anterior swelling: 0, absent; 1, present, anterior end is expanded dorsoventrally just posterior to the anterior tip (new).

122. Dentary symphysis: 0, restricted to the rostral margin of the dentary (V-shaped), or absent entirely; 1, expanded along the ventral border of the bone (spout shaped) (Sereno, 1999; Butler et al., 2008 Pol et al., 2011b).

123. Anterior half of the dentary, position of the Meckelian groove: 0, dorsoventral centre of the dentary; 1, restricted to the ventral border (Nesbitt, 2011).

124. Dentary, anterior extent of the Meckelian groove: 0, ends short of the dentary symphysis; 1, present through the dentary symphysis (Nesbitt, 2011).

125. Dentary tooth row (and edentulous anterior portion) in lateral view: 0, relatively straight; 1, anterior end downturned; 2, anterior end strongly upturned (dentary ventrally bowed) (modified from Butler et al., 2008 and Nesbitt, 2011).

126. Dorsal and ventral margins of the dentary along the posterior two thirds of the dentary tooth row: 0, converge anteriorly; 1, subparallel (modified from Butler et al., 2008).

127. Transverse groove (sulcus, external mandibular groove) running along the dentary beneath and parallel to tooth row: 0, absent; 1, present.

128. Articular, glenoid of the mandible located: 0, level with or marginally dorsal to the dorsal margin of the dentary; 1, well ventral of the dorsal margin of the dentary (Gauthier, 1986; Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011; Pol et al., 2011b).
129. Maximum depth of mandible: 0, less than 150% depth of mandible beneath tooth row; 1, roughly 160% or more of the depth of mandible beneath tooth row (Sereno, 1986, 1999; Butler, 2005; Irmis et al., 2007; Butler et al., 2008; Nesbitt, 2011).
130. Anterodorsal margin of coronoid process formed by posterodorsal process of dentary: 0, absent; 1, present (Butler et al., 2008).
131. Splenial, foramen in the ventral part: 0, absent; 1, present (Rauhut, 2003; Langer and Benton, 2006; Smith et al., 2007; Nesbitt, 2011).
132. External mandibular fenestra, situated on dentary-surangular-angular boundary: 0, present; 1, absent (Butler et al., 2008).
133. External mandibular fenestra between the surangular, angular and dentary, proportions: 0, small, rounded or elliptical with anteroposterior length is less than 4 times the dorsoventral depth; 1, fenestra is a greatly elongate ellipse, length is greater than 4 times the dorsoventral depth (new).
134. Foramen located on the dorsal (and sometimes lateral) face of the surangular (surangular foramen): 0, present; 1, absent (new).
135. Surangular foramen: 0, both foramen (anterior, dorsally positioned and posterior, laterally positioned) remain open; 1 only the foramen on the dorsal surface of the surangular, anterior to or at the point of maximum mandibular depth remains open; 2, only the foramen located laterally, posterior to the point of maximum mandibular depth remains open (new).
136. Ridge or process on lateral surface of surangular, anterior to jaw suture: 0, absent or very poorly developed; 1, present, strong anteroposteriorly extended ridge; 2, present, dorsally directed finger-like process (Butler et al., 2008).
137. Anteroposteriorly extending groove on the dorsal surface of the surangular (dorsal surface formed by medial inflection of the lateral surangular): 0, absent; 1, present (new).
138. Retroarticular process: 0, elongate; 1, rudimentary or absent (Butler et al., 2008).
139. Retroarticular process in lateral and dorsal view: 0, does not taper caudally, 1, tapers caudally (Yates, 2003; Pol et al., 2011b).

140. Retroarticular process, upturn: 0, present and strong, retroarticular forms nearly a right angle with the rest of the mandible; 1, present and subtle, retroarticular is slightly upturned at its distal end; 2, absent, retroarticular extends straight out from the caudal part of the mandible, or turns slightly downward (new). ORDERED
141. Dentary teeth: 0, present along almost entire length of the dentary; 1, absent in the anterior portion; 2, completely absent (Parrish, 1994; Parker, 2007; Nesbitt, 2011).
142. Number of dentary teeth: 0, 17 or fewer; 1, 18 or more (Wilson and Sereno, 1998; Pol et al., 2011b).
143. First dentary tooth: 0, lies at the extreme rostral end of the dentary; 1, is inset a short distance from the rostral tip of the dentary (Sereno, 1999; Pol et al., 2011b).
144. Premaxillary teeth: 0, present; 1, absent, premaxilla edentulous (Butler et al., 2008).
145. Premaxillary teeth, number: 0, six or more; 1, five; 2, four; 3, three; 4, two; 5, one or none (Butler et al., 2008).
146. Premaxillary teeth, crown expanded above root: 0, crown is unexpanded mesiodistally above root, no distinction between root and crown is observable; 1, crown is at least moderately expanded above root (Butler et al., 2008).
147. Premaxillary teeth increase in size posteriorly: 0, absent; 1, present, posterior premaxillary teeth are significantly larger in size than anterior teeth (Butler et al., 2008).
148. Premaxillary teeth size: 0, anterior premaxillary teeth are smaller than most maxillary teeth; 1, anterior premaxillary teeth are subequal to maxillary teeth; 2, anterior premaxillary teeth are enlarged relative to maxillary teeth (new).
149. Premaxillary caniniform tooth, distinct from anterior premaxillary teeth: 0, absent; 1, present, squat caniniform (greater in diameter than in apicobasal height); 2, present, long caniniform (greater in apicobasal height than in diameter) (new).
150. Maxillary and dentary crowns, shape: 0, blade-like, with continuous mesial and distal edges; 1, subtriangular or 'diamond shaped', with a distinct kink present in mesial and distal edges (modified from Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).
151. Maxillary and dentary crowns, dimensions: 0, apicobasally taller than they are mesiodistally wide; 1, apicobasally shorter than they are mesiodistally wide (new).
152. Enamel on maxillary/dentary teeth: 0, symmetrical; 1, asymmetrical (Butler et al., 2008).

153. Apicobasally extending ridges on maxillary/dentary teeth: 0, absent; 1, present (Butler et al., 2008).
154. Apicobasally extending ridges on lingual/labial surfaces of maxillary/dentary crowns confluent with marginal denticles: 0, absent; 1, present (Butler et al., 2008).
155. Tooth implantation, teeth ankylosed into the alveoli (ankylotheodont): 0, absent (free at the base of tooth); 1, present (Gauthier, 1984; Benton and Clark, 1988; Benton, 1990; Bennett, 1996; Nesbitt et al., 2009c; Nesbitt, 2011).
156. Primary ridge on labial side of maxillary teeth: 0, absent; 1, present (Butler et al., 2008).
157. Primary ridge on lingual side of dentary teeth: 0, absent; 1, present (Butler et al., 2008).
158. Position of maxillary/dentary primary ridge: 0, centre of the crown surface, giving the crown a relatively symmetrical shape in lingual/labial view; 1, offset, giving crown asymmetrical appearance (Butler et al., 2008).
159. Labial side of maxillary/dentary teeth, profile: 0, evenly convex in mesiodistal aspect (D-shaped profile), 1, with greater labiolingual expansion at the base of the tooth (new).
160. Moderately developed lingual expansion of crown (cingulum) on maxillary/ dentary teeth: 0, absent; 1, present (Seren, 1986; Butler et al., 2008; Nesbitt, 2011).
161. Dentition: 0, homodont; 1, slightly heterodont, with small observable changes across tooth rows; 2, markedly heterodont, clearly distinct types of teeth present (modified from Parrish, 1993; Nesbitt, 2011). ORDERED
162. Heterodont dentary dentition: 0, no substantial heterodonty is present in dentary dentition; 1, single, enlarged, caniniform anterior dentary tooth, crown is not mesiodistally expanded above root; 2, multiple anterior dentary teeth are recurved but are not enlarged relative to other non-recurved dentary teeth; 3, multiple anterior dentary teeth are recurved and are enlarged relative to other dentary teeth; 4, anterior dentary teeth are followed by a row of numerous minuscule teeth (modified from Butler et al., 2008).
163. Maxillary/dentary tooth, serrations: 0, absent; 1, present as small fine knifelike serrations; 2, present and enlarged and coarser (lower density) denticles. (Gauthier et al., 1988; Juul, 1994; Dilkes, 1998; Irmis et al., 2007; Butler et al., 2008; Nesbitt, 2011). ORDERED
164. Distribution of the serrations along the mesial and distal carinae of the teeth: 0, extended along most of the length of the crown; 1, restricted to the upper half of the crown (Yates, 2003; Ezcurra, 2010).
165. Peg-like tooth located anteriorly within dentary, lacks recurvature and denticles, strongly reduced in size: 0, absent; 1, present (Butler et al., 2008).

166. Alveolar foramina ('special foramina') medial to maxillary/ dentary tooth rows: 0, present; 1, absent (Butler et al., 2008).
167. Recurvature in premaxillary teeth: 0, present, 1, absent (new).
168. Recurvature in majority of maxillary and dentary teeth: 0, strong recurvature present; 1, weak recurvature present; 2, recurvature absent (modified from Butler et al., 2008) ORDERED
169. Maxillary teeth, posterior cutting edge of posterior maxillary teeth: 0, concave or straight; 1, convex; 2, concavo-convex or sinusoidal (modified from Sues et al., 2003; Clark et al., 2004; Nesbitt, 2011).
170. Medial or lateral overlap of adjacent crowns in maxillary and dentary teeth: 0, absent; 1, present (Serenio, 1986; Butler et al., 2008; Nesbitt, 2011).
171. Tooth crown, maxillary/dentary teeth: 0, not mesiodistally expanded; 1, mesiodistally expanded above root in cheek teeth (Serenio, 1986; Butler et al., 2008; Nesbitt, 2011).
172. Extensive planar wear facets across multiple maxillary/dentary teeth: 0, absent; 1, present (Weishampel and Witmer, 1990; Nesbitt, 2011; Han et al., 2012).
173. Position of maximum apicobasal crown height in dentary/maxillary tooth rows: 0, anterior portion of tooth row; 1, central portion of tooth rows; 2, posterior portion of tooth rows (Gauthier, 1986; Butler et al., 2008; Pol et al., 2011b).
174. Maxillary tooth row: 0, extends posteriorly to approximately half the length of the orbit; 1, ends at the anterior rim of the orbit; 2, completely antorbital, tooth row ends anterior to the vertical strut of the lacrimal (Gauthier, 1986; Smith et al., 2010).
175. Conical, often unserrated tooth crowns: 0, absent, 1, present together with serrated crowns, 2, encompasses all dental elements of maxilla and dentary (new). ORDERED
176. Palatal teeth present on palatal process of the pterygoid: 0, present; 1, absent (Juul, 1994; Gower and Sennikov, 1997; Nesbitt et al., 2009c; Nesbitt, 2011).
177. Close-packing and quicker replacement eliminates spaces between alveolar border and crowns of adjacent functional teeth: 0, absent; 1, present (Butler et al., 2008).
178. Anterior dentary teeth, orientation: 0, vertical or inclined posteriorly; 1, inclined anteriorly (procumbent).
179. Canted dentary teeth: 0, absent; 1, present in anterior dentary teeth; 2, present in all dentary teeth (modified from Kammerer et al., 2012). ORDERED

180. Length of the atlantal intercentrum: 0, greater than that of the axial intercentrum; 1, shorter than that of the axial intercentrum (Yates and Kitching, 2003; Pol et al., 2011b).
181. Axis, dorsal margin of the neural spine: 0, expanded posterodorsally; 1, arcs dorsally, where the anterior portion height is equivalent to the posterior height (Nesbitt, 2011).
182. Cervical vertebrae, deep recesses on the anterior face of the neural arch, lateral to the neural canal (prechonos of Welles, 1984): 0, absent; 1, present (Nesbitt, 2011).
183. Epiphyses on anterior (postaxial) cervicals: 0, absent; 1, present (Gauthier, 1986; Novas 1996; Langer and Benton, 2006; Butler et al., 2008; Nesbitt, 2011).
184. Epiphyses: 0, absent in posterior cervical vertebrae (6–9); 1, present in posterior cervical vertebrae (6–9) (Serenio et al., 1993; Langer and Benton, 2006; Nesbitt, 2011).
185. Epiphyses overhanging the rear margin of the postzygapophyses: 0, absent, epiphyses do not overhang the postzygapophyses in any postaxial cervical vertebrae; 1, present in at least some postaxial cervical vertebrae (Yates, 2003; Pol et al., 2011b).
186. Third cervical vertebra, centrum length: 0, subequal to the axis centrum; 1, longer than the axis centrum (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011).
187. Cervicals 4–9, form of central surfaces: 0, amphicoelous; 1, at least slightly opisthocoelous or heterocoelous (Butler et al., 2008).
188. Cervical number: 0, seven/eight; 1, nine; 2, ten or more (Butler et al., 2008).
189. Anterior to middle cervical vertebrae, diapophysis and parapophysis: 0, well separated; 1, nearly touching (Nesbitt, 2011).
190. Anterior cervical vertebrae, neural arch, posterior portion ventral to the postzygapophysis: 0, smooth posteriorly or has a shallow fossa; 1, with a deep excavation (Langer and Benton, 2006; Nesbitt, 2011).
191. Cervical vertebrae, pneumatic features (pleurocoels) in the anterior portion of the centrum: 0, absent; 1, present as fossae; 2, present as foramina (Holtz, 1994; Rauhut, 2003; Smith et al., 2007; Nesbitt, 2011).
ORDERED
192. Cervical vertebrae, rimmed depression on the posterior part of the centrum: 0, absent; 1, present (Gauthier, 1986; Rauhut, 2003; Nesbitt, 2011).

193. Elongation of cervical centrum (cervicals 3–5): 0, less than 3.0 times the centrum height, 1, 3.0–4.0 times the centrum height, 2, >4.0 times the centrum height (Upchurch, 1998; Pol et al., 2011b).
ORDERED

194. Cervical vertebrae, distal end of neural spines: 0, laterally expanded in the middle of the anteroposterior length; 1, expansion absent (new).

195. Posterior cervical and/or dorsal vertebrae, hyposphene-hypantrum accessory intervertebral articulations: 0, absent; 1, present (Gauthier, 1986; Juul, 1994; Benton, 1999; Rauhut, 2003; Langer and Benton, 2006; Weinbaum and Hungerbühler, 2007; Nesbitt, 2011).

196. Hyposphene in the cervical and/or dorsal vertebrae, height: 0, less than the height of the neural canal; 1, equal to or greater than the height of the neural canal (Gauthier, 1986; Yates, 2007; Ezcurra, 2010).

197. Prezygaodiapophyseal lamina on the cervical vertebrae: 0, absent; 1, present (new).

198. Postzygaodiapophyseal lamina on cervical neural arches 4 to 8: 0, absent; 1, present (Yates, 2003; Ezcurra, 2010; Pol et al., 2011b).

199. Laminae of the cervical neural arches 4–8: 0, well developed, tall laminae; 1, weakly developed, low ridges (Wilson and Sereno, 1998; Ezcurra, 2010).

200. Angle formed between pre- and postzygapophyses on anterior-to-middle cervical vertebrae: 0, very large, around 40 degrees, or over; 1, large, around 30 degrees; 2, small, around 20 degrees (new).
ORDERED

201. Ventral keels on cranial cervical centra: 0, present; 1, absent (Upchurch, 1998; Pol et al., 2011b).

202. Middle cervical vertebrae, hypapophyses: 0, absent; 1, present (Nesbitt, 2011).

203. Ventral keels on the vertebrae at the cervicodorsal transition: 0, absent; 1, present (Rauhut, 2003; Ezcurra, 2010).

204. Cervical ribs: 0, slender and elongated; 1, short and stout (Gauthier, 1986; Benton and Clark, 1988; Juul, 1994; Benton, 1999; Nesbitt, 2011).

205. Dorsal vertebrae, neural spine lateral expansion of the distal end: 0, absent; 1, present with a flat dorsal margin (spine table); 2, present with a rounded dorsal margin (Nesbitt, 2011).

206. Dorsal vertebrae (mid- to posterior dorsal), neural spine anteroposterior expansion of distal end: 0, absent; 1, present, distal end of neural spine is anteroposteriorly longer than base of neural spine (new).

207. Posterior dorsal vertebrae, neural spine inclination: 0, anteriorly inclined; 1, vertical or posteriorly inclined (new).
208. Parapophyses contact with the centrum in vertebrae caudal to the twelfth presacral element: 0, do not contact; 1, contact (Langer, 2004; Pol et al., 2011b).
209. Dorsals, number: 0, 12–14; 1, 15; 2, 16 or more (Butler et al., 2008). ORDERED
210. Sacrals, number: 0, two; 1, three; 2, four/five; 3, six or more (Butler et al., 2008). ORDERED
211. Sacral centra: 0, separate; 1, at least partially co-ossified (Nesbitt, 2011).
212. Sacral vertebrae, prezygapophyses and complimentary postzygapophyses: 0, separate; 1, co-ossified (Nesbitt, 2011).
213. Fusion of the sacral neural spines: 0, absent; 1, present (new).
214. Sacral vertebrae, centra articular rims: 0, present in sacrum; 1, absent or nearly obliterated (Nesbitt, 2007, 2011).
215. “Insertion” of a sacral vertebra between the first and second primordial sacral vertebrae: 0, absent; 1, present (Nesbitt, 2011).
216. Number of dorsosacral vertebrae: 0, none; 1, one; 2, two (Gauthier, 1986; Yates, 2007; Ezcurra, 2010). ORDERED
217. Sacral ribs: 0, almost entirely restricted to a single sacral vertebra; 1, shared between two sacral vertebrae (Nesbitt, 2011).
218. First primordial sacral, articular surface of sacral rib: 0, circular; 1, C-shaped in lateral view; 2, rectangular (modified from Langer and Benton, 2006; Nesbitt, 2011).
219. Possession of a caudosacral vertebra: 0, absent; 1, present (new).
220. Length of first caudal centrum: 0, greater than its height; 1, much less than its height (Yates, 2003; Ezcurra, 2010).
221. Anterior caudal vertebrae, neural spines: 0, up to 50% taller than the centrum; 1, more than 50% taller than the centrum (Butler et al., 2008).

- 222.Length of base of the proximal caudal neural spines: 0, greater than half the length of the neural arch, 1, less than half the length of the neural arch (Gauthier 1986, Yates and Kitching, 2003; Ezcurra, 2010).
- 223.Length of midcaudal centra: 0, greater than twice the height of their proximal faces; 1, less than twice the height of their proximal faces (Yates and Kitching, 2003; Pol et al., 2011b).
- 224.Distal caudal vertebrae, prezygapophyses: 0, not elongated; 1, elongated beyond the anterior face of the centrum (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2007; Nesbitt, 2011).
- 225.Elongated prezygapophyses of the distal caudals: 0, elongated less than $\frac{1}{4}$ of the length of the adjacent centrum; 1, elongated more than $\frac{1}{4}$ of the length of the adjacent centrum (modified from Gauthier, 1986; Rauhut, 2003; Nesbitt, 2007; Nesbitt, 2011).
- 226.Position of postzygapophyses in proximal caudal vertebra: 0, protruding with an interpostzygapophyseal notch visible in dorsal view; 1, placed on either side of the caudal end of the base of the neural spine without any interpostzygapophyseal notch (Yates and Kitching, 2003; Pol et al., 2011b).
- 227.Chevron shape: 0, rod-shaped, often with a slight distal expansion; 1, strongly expanded distally, triangular or 'boat' shaped (Butler et al., 2008).
- 228.Length of the longest chevron: 0, less than the length of the preceding centrum, 1, greater than the length of the preceding centrum (Yates and Kitching, 2003; Pol et al., 2011b).
- 229.Gastralia: 0, present; 1, absent (Butler et al., 2008).
- 230.Gastralia, form: 0, forming extensive ventral basket with closely packed elements; 1, elements well separated (Nesbitt, 2011).
- 231.Ossified clavicles: 0, absent; 1, present (Butler et al., 2008).
- 232.Clavicles: 0, unfused; 1, fused into a furcula (Gauthier, 1986; Sereno, 1991; Benton, 1999; Benton and Walker, 2002; Nesbitt, 2011).
- 233.Sternal plates: 0, absent; 1, present (modified from Butler et al., 2008).
- 234.Proportions of humerus and scapula: 0, scapula longer or subequal to the humerus; 1, humerus longer than the scapula (Butler et al., 2008).
- 235.Scapula, blade height versus distal width: 0, less than 3 times distal width; 1, more than 3 times distal width (Sereno, 1999).

236. Minimum width of scapula: 0, less than or equal to 20% of its length; 1, more than 20% of its length (Gauthier, 1986; Ezcurra, 2010).
237. Scapula, blade-shape: 0, strongly expanded distally; 1, weakly expanded, near parallel-sided; 2, scapula tapers distally (modified from Butler et al., 2008).
238. Scapula acromion shape: 0, weakly developed or absent; 1, well-developed spine-like (Butler et al., 2008).
239. Orientation of dorsal margin of the acromion process of the scapula: 0, posteroventrally, forming an acute angle with the dorsoventral axis of the scapula, 1, posteriorly or subhorizontally, forming an obtuse or right angle with the dorsoventral axis of the scapula (Novas, 1996; Pol et al., 2011b).
240. Scapulocoracoid, anterior margin: 0, distinct notch between the two elements; 1, uninterrupted edge between the two elements (Parrish, 1993; Benton, 1999; Nesbitt, 2011).
241. Coracoid: 0, subcircular in lateral view; 1, with postglenoid process (notch ventral to glenoid) (Nesbitt, 2011).
242. Coracoid, elongation: 0, absent, coracoid is roughly subcircular; 1, coracoid is massively elongated and strap-like (new).
243. Coracoid, posteroventral portion: 0, smooth; 1, possesses a “swollen” tuber (biceps tubercle, posteroventral process) (Nesbitt, 2011).
244. Glenoid, orientation: 0, posterolaterally; 1, directed posteroventrally (Fraser et al., 2002; Nesbitt, 2011).
245. Humerus/femur ratio: 0, roughly equal to or less than 0.6; 1, greater than 0.6 but less than 0.8; 2, greater than 0.8; 3, humerus is longer (Gauthier, 1986). ORDERED
246. Deltopectoral crest: 0, less than 30% the length of the humerus; 1, more than 30% the length of the humerus (Bakker and Galton, 1974; Benton, 1990; Juul, 1994; Novas, 1996; Benton, 1999).
247. Humerus, apex of deltopectoral crest situated at a point corresponding to: 0, less than 30% down the length of the humerus; 1, more than or equal to 30% down the length of the humerus but less than 50% down the length of the humerus; 2, more than 50% down the length of the humerus (Bakker and Galton, 1974; Benton, 1990; Juul, 1994; Novas, 1996; Benton, 1999, Nesbitt, 2011).
248. Deltopectoral crest orientation: 0, slants at <60 to the transverse axis of the distal condyles, 1, perpendicular to the transverse axis of the distal condyles (Sereno, 1999; Pol et al., 2011b).

- 249.Deltopectoral crest form/development: 0, rudimentary, is at most a thickening of the humerus; 1, well-developed, projects as a distinct flange (Butler et al., 2008).
- 250.Deltopectoral crest, shape (if well developed): 0, rounded or subtriangular; 1, square or rectangular, proximal and distal margins are straight and oriented perpendicular to the shaft (Gauthier, 1986; Yates, 2007; Cabreira et al. 2016).
- 251.Humeral shaft in anterior/posterior view: 0, relatively straight; 1, bowed ventrally (new).
- 252.Head of humerus is separated from prominent medial tubercle on proximal surface by a groove: 0, absent; 1, present (Han et al., 2012).
- 253.Humerus, proximal articular surface: 0, continuous with the deltopectoral crest; 1, separated by a gap from the deltopectoral crest (Nesbitt, 2011).
- 254.Humerus, distinct fossa on posterodorsal surface, just below the proximal edge: 0, absent; 1, present (new).
- 255.Humerus, distal end width: 0, narrower or equal to 30% of humerus length; 1, greater than 30% of humerus length (Langer and Benton, 2006).
- 256.Maximum transverse expansion of the distal end of the humerus: 0, greater than 50% of the maximum transverse expansion of the proximal humerus; 1, less than or equal to 50% of the maximum transverse expansion of the proximal humerus (new).
- 257.Olecranon process on proximal ulna: 0, absent; 1, present (modified from Wilson and Sereno, 1998; Ezcurra, 2010).
- 258.Olecranon process: 0, not greatly enlarged; 1, greatly enlarged as a single ossification; 2, greatly enlarged with a separate ossification forming a strongly striated proximoanterior portion (modified from Wilson and Sereno, 1998; Ezcurra, 2010).
- 259.Radial fossa, bounded by an anterolateral process, on proximal ulna: 0, absent; 1, present (Wilson and Sereno, 1998; Ezcurra, 2010).
- 260.Form of radial fossa: 0, shallow; 1, deep (new).
- 261.Radius, length: 0, longer than 80% of humerus length; 1, shorter than 80% of humerus length (Langer and Benton, 2006).

262. Proximal width of the first metacarpal respect to its length: 0, less than 65% of its length, 1, 65%-80% of its length, 2, greater than 80% of its length, 3: broader proximally than long (Sereno, 1999; Pol et al., 2011b). ORDERED
263. First distal carpal: 0, is narrower transversely than metacarpal I; 1, is subequal, or greater, in transverse width compared to metacarpal one (Sereno, 1999; Pol et al., 2011b).
264. Second distal carpal: 0, completely covers the proximal end of metacarpal II; 1, does not completely cover the proximal end of metacarpal II (Yates and Kitching, 2003; Ezcurra, 2010).
265. Manual length (measured as the average length of digits I–III): 0, accounts for less than 0.3 of the total length of humerus plus radius; 1, more than 0.3 but less than 0.4 of the total length of humerus plus radius; 2, more than 0.4 of the total length of humerus plus radius (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011). ORDERED
266. Metacarpals, proximal ends: 0, overlap; 1, abut one another without overlapping (Sereno and Wild, 1992; Clark et al., 2000; Olsen et al., 2000; Benton and Walker, 2002; Sues et al., 2003; Clark et al., 2004; Butler et al., 2008; Nesbitt, 2011).
267. Metacarpals I and V: 0, both substantially shorter in length than metacarpal III; 1, only metacarpal I longer than or subequal to metacarpal III; 2, only metacarpal V longer than or subequal to metacarpal III; 3, both are longer than or subequal to metacarpal III (modified from Butler et al., 2008).
268. Distal carpal V: 0, present; 1, absent (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).
269. Penultimate phalanx of the second and third fingers: 0, shorter than or equal to the first phalanx; 1, longer than the first phalanx (Butler et al., 2008).
270. Metacarpal V: 0, present; 1, absent (new).
271. Manual digit V: 0, possesses one or more phalanges; 1, phalanges absent (Bakker and Galton, 1974; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
272. Extensor pits on the dorsal surface of the distal end of metacarpals and manual phalanges: 0, absent or poorly developed; 1, deep, well-developed (Sereno et al., 1993; Langer and Benton, 2006; Butler et al., 2008; Nesbitt, 2011).
273. All manual unguals blunted distally in to rounded hooves: 0, absent; 1, present (new).
274. Metacarpal I, width at the middle of the shaft accounts for: 0, less than 0.35 of the total length of the bone; 1, more than 0.35 of the total length of the bone (Bakker and Galton, 1974; Langer and Benton, 2006; Nesbitt, 2011).

275. Digit I with metacarpal: 0, longer than the ungual; 1, subequal or shorter than the ungual (Serenó, 1999; Langer and Benton, 2006; Nesbitt, 2011).
276. Manual digit I, first phalanx: 0, is not the longest non-ungual phalanx of the manus; 1, is the longest non-ungual phalanx of the manus (Gauthier, 1986; Langer and Benton, 2006; Nesbitt, 2011).
277. Metacarpal I, distal condyles: 0, approximately aligned or slightly offset; 1, lateral condyle strongly distally expanded relative to medial condyle (Bakker and Galton, 1974, Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
278. Ventrolateral twisting of the transverse axis of the distal end of the first phalanx of manual digit one relative to its proximal end: 0, absent, 1, present proximodorsal lip aligned with dorsal margin of medial distal condyle, 2, present proximodorsal lip aligned with central region of medial ligament pit of the distal condyle (Serenó, 1999; Pol et al., 2011b; Otero et al., 2015). ORDERED
279. Metacarpal II: 0, shorter than metacarpal III; 1, equal to or longer than metacarpal III (Gauthier, 1986; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
280. Manual unguals of digits 2 and 3: 0, gently recurved or flat; 1, trenchant, unguals are extremely recurved and appear semi-lunate in shape in lateral view (Gauthier, 1986; Juul, 1994; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011).
281. Manual digit IV: 0, five or four phalanges; 1, three or two phalanges; 2, one phalanx; 3, phalanges absent (Gauthier, 1986; Benton and Clark, 1988; Serenó et al., 1993; Novas, 1996; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011). ORDERED
282. Metacarpal IV, shaft width: 0, about the same width as that of metacarpals I–III; 1, significantly narrower than that of metacarpals I–III (Serenó et al., 1993; Langer and Benton, 2006; Nesbitt, 2011).
283. Metacarpals IV and V, position: 0, level with metacarpals I–III; 1, ventral to metacarpals I–III (Serenó, 1993; Ezcurra, 2010).
284. Acetabulum: 0, completely closed; 1, open to at least some degree (Butler et al., 2008).
285. Ilium, preacetabular (= anterior, cranial process) process: 0, short and does not extend anterior to the pubic peduncle; 1, long and extends anterior to the pubic peduncle (Galton, 1976; Benton, 1985; Serenó, 1986; Juul, 1994; Gower, 2000; Hutchinson, 2001a; Langer and Benton, 2006; Nesbitt and Norell, 2006; Butler et al., 2008b; Nesbitt, 2011).
286. Ilium, relative lengths of preacetabular (= anterior, cranial process) and postacetabular (= posterior processes): 0, anterior process much shorter than the posterior process of the ilium; 1, anterior process subequal or longer than the posterior process of the ilium (Galton, 1976; Benton, 1985; Serenó, 1986; Juul, 1994; Gower, 2000; Hutchinson, 2001a; Langer and Benton, 2006; Nesbitt and Norell, 2006; Butler et al., 2008b; Nesbitt, 2011).

287. Shape of preacetabular process: 0, rounded/rectangular, blunt profile, 1, triangular and pointed; 2, elongated, thin and strap-like; 3, elongated, expanded dorsoventrally towards its anterior end producing a hatchet-shaped profile (i.e. possesses an anteroventral lobe); 4, elongated and dorsoventrally deep along its entire length, essentially continuous with the arched dorsal margin of the iliac body (modified from Sereno, 1999; Butler et al., 2008; Pol et al., 2011b).
288. Preacetabular process, length: 0, less than 50% of the length of the ilium; 1, more than 50% of the length of the ilium (Butler et al., 2008).
289. Length of the preacetabular process of the ilium: 0, less than twice its depth, 1, greater than twice its depth (Yates and Kitching, 2003; Pol et al., 2011b).
290. Dorsal margin of preacetabular process and dorsal margin of ilium above acetabulum: 0, narrow, not transversely expanded; 1, dorsal margin is transversely expanded to form a narrow shelf (Butler et al., 2008).
291. Ilium, dorsal portion: 0, height about the same or shorter than the distance from the dorsal portion of the supraacetabular rim to the pubis-ischium contact; 1, expanded dorsally, height markedly taller than the dorsal portion of the supraacetabular rim to the pubis-ischium contact (Nesbitt, 2011).
292. In dorsal view preacetabular process of the ilium expands mediolaterally towards its distal end: 0, absent; 1, present (Butler et al., 2008).
293. Dorsal margin of the ilium in lateral view: 0, relatively straight or convex; 1, concave (saddle-shaped), postacetabular process is upturned (Butler et al., 2008).
294. Shape of the caudal margin of the postacetabular process of the ilium: 0, bluntly pointed and dorsoventrally narrow; 1, rounded or squared and dorsoventrally deep; 2, trapezoidal, with a clearly demarcated trapezoidal area for muscle attachment; 3, elongate and rectangular; 4, partly ballooned distally (modified from Yates, 2003; Pol et al., 2011b).
295. Distal end of the postacetabular process, dorsal and ventral borders: 0, dorsal and ventral borders extend roughly equal distances posteriorly in lateral view; 1, ventral border extends farther posteriorly in lateral view, creating a posteroventrally sloping posterior margin (new).
296. Distal end of the postacetabular process, incision: 0, absent; 1, present, small groove or notch present on posterior margin of the postacetabular process (new).
297. Ilium, distinct fossa present for the attachment of the caudifemoralis brevis muscle (brevis shelf): 0, absent; 1, present as an embankment on the lateral side of the posterior portion of the ilium; 2, present, not visible in lateral view and is in the form of a fossa on the dorsal margin of the ilium and/or the ventral surface of postacetabular process (Gauthier and Padian, 1985; Gauthier, 1986; Juul, 1994; Novas, 1996; Benton, 1999; Hutchinson, 2001a; Butler et al., 2008; Nesbitt, 2011). ORDERED
298. Ilium, ridge connecting the posterior portion of the supraacetabular rim to the posterior portion of the ilium: 0, absent; 1, present (Langer and Benton, 2006; Nesbitt, 2011).

299. Ilium, ridge (or buttress) extending from the middle of the supraacetabular crest to the lateral edge of the preacetabular process: 0, absent; 1, present, low and rounded swelling; 2, present, pronounced and sharp (buttress) (new). ORDERED
300. Ilium, ventral margin of the acetabulum: 0, convex; 1, straight; 2, concave (Bakker and Galton, 1974; Gauthier and Padian, 1985; Gauthier, 1986; Juul, 1994; Novas, 1996; Benton, 1999; Fraser et al., 2002; Langer and Benton, 2006; Nesbitt, 2011).
301. Length of the postacetabular process as a percentage of the total length of the ilium: 0, more than 35%; 1, 35%-25%; 2, 20% or less (Butler et al., 2008). ORDERED
302. Medioventral acetabular flange of ilium, closes the acetabulum: 0, present, partially or fully closes the acetabulum; 1, absent (Butler et al., 2008).
303. Ilium, ischiadic peduncle: 0, part of the main body of ilium, continuous with distal portion of the acetabular wall; 1, posterior portion is distinct from the main body of the ilium and the acetabular wall, is a ventrally/posteroventrally extending body (new).
304. Ilium, ischiadic peduncle orientation: 0, mainly vertical in lateral aspect; 1, well expanded posteriorly to the anterior margin of the postacetabular embayment (Langer and Benton, 2006; Butler et al., 2008; Nesbitt, 2011).
305. Supra-acetabular 'crest' or 'flange': 0, present; 1, absent (Butler et al., 2008).
306. Ilium, supraacetabular crest (supraacetabular rim): 0, projects laterally or ventrolaterally; 1, projects ventrally, hood-like (Gauthier, 1986; Nesbitt, 2011).
307. Supraacetabular crest of ilium: 0, not extended along (only at the base of) the pubic peduncle; 1, extended along the pubic peduncle as a faint ridge; 2, extended along the full length of the pubic peduncle and contacts the distal end as a well-developed crest (Ezcurra, 2010). ORDERED
308. Pubic peduncle of ilium: 0, longer in length than ischiadic peduncle; 1, shorter in length than ischiadic peduncle (Butler et al., 2008).
309. Length of the pubic peduncle of ilium: 0, greater than twice the craniocaudal width of its distal end, 1, less than twice the craniocaudal width of its distal end (when excluding contribution of medioventral acetabular wall to craniocaudal width) (Serenó, 1999; Ezcurra, 2010; Pol et al., 2011b).
310. Heavy reduction in dorsoventral depth of the ischiadic peduncle of the ilium, peduncle is almost completely lost: 0, absent; 1, present (new).

311. Ilium, acetabular antitrochanter: 0, absent; 1, present (Serenio and Arcucci, 1994; Novas, 1996; Benton, 1999; Fraser et al., 2002; Irmis et al., 2007; Nesbitt, 2011; Nesbitt, 2011).
312. Ilium, extensive, rugose areas on the dorsal and lateral surfaces of the pre- and postacetabular processes: 0, absent; 1, present, limited mainly to the lateral surfaces of the pre- and postacetabular processes, often as bounded ovoid patches; 2, present and highly extensive on both the pre- and postacetabular processes (NEW). ORDERED
313. Ischium, shape of shaft: 0, relatively straight; 1, curved along length (Butler et al., 2008).
314. Ischium-pubis, contact: 0, present and extended ventrally; 1, present and reduced to a thin proximal contact; 2, absent (Benton and Clark, 1988; Novas, 1996; Nesbitt, 2011).
315. Ischial shaft, cross-section: 0, compressed mediolaterally into thin sheet (rectangular); 1, subcircular/ovoid and bar-like (rod-like); 2, triangular or D-shaped (new).
316. Ischial shaft: 0, tapers distally; 1, expands weakly, or is parallel-sided, distally; 2, distally expanded into a distinct 'foot' or 'boot' (modified from Butler et al., 2008). ORDERED
317. Ischium, obturator process: 0, absent; 1, confluent with the pubic peduncle (obturator plate); 2, offset from the pubic peduncle (Gauthier, 1986; Novas, 1993; Rauhut, 2003; Nesbitt, 2011).
318. Ischium, proximal portion of the ventral margin: 0, continuous ventral margin; 1, notch present; 2, abrupt change in angle between the proximal end and the shaft (Serenio et al., 1996; Rauhut, 2003; Nesbitt, 2011).
319. Ischium, proximal articular surfaces: 0, articular surfaces with the ilium and the pubis continuous; 1, articular surfaces with the ilium and the pubis continuous but separated by a fossa; 2, articular surfaces with the ilium and the pubis separated by a large, nonarticulating concave surface (Irmis et al., 2007; Nesbitt, 2011). ORDERED
320. Ischium length: 0, about the same length or shorter than the dorsal margin of iliac blade; 1, longer than the dorsal margin of iliac blade (Juul, 1994; Nesbitt et al., 2009c; Nesbitt, 2011).
321. Groove on the dorsal margin of the ischium: 0, absent; 1, present (Butler et al., 2008).
322. Distinct obturator process of ischium (when separated from the pubic process of the ischium), form: 0, present as a rounded expansion of ventral margin; 1, present as distinct tab ('tab-shaped') (modified from Butler et al., 2008).
323. Ischium, medial contact with antimere: 0, restricted to the medial edge; 1, extensive contact but the dorsal margins are separated; 2, extensive contact and the dorsal margins contact each other (Nesbitt, 2011).

324. Ischium, cross section of the distal portion: 0, platelike; 1, rounded; 2, subtriangular or D-shaped (Sereno, 1999; Langer and Benton, 2006; Irmis et al., 2007; Yates, 2007; Ezcurra, 2010; Nesbitt, 2011).
325. Ischial symphysis, length: 0, ischium forms a median symphysis with the opposing blade along at least 50% of its length; 1, ischial symphysis present distally only (elongate interischial fenestra) (Yates, 2003; Butler et al., 2008; Pol et al., 2011b).
326. Pubis, orientation: 0, anteroventral; 1, rotated posteroventrally (= opisthopubic) (Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).
327. Shaft of pubis (postpubis), shape in cross-section: 0, blade-shaped; 1, comma shaped, rod like body with a tapering medial margin; 2, rod-like (modified from Butler et al., 2008). ORDERED
328. Shaft of pubis (postpubis), length: 0, longer than or approximately equal in length to the ischium; 1, reduced, extends two-thirds to one-half of the length of the ischium (Butler et al., 2008). ORDERED
329. Pubic plate length: 0, less than 40% of the pubic shaft length; 1, more than 40% of the pubic shaft length (Pol and Powell, 2007).
330. Pubic shaft, shape: 0, posteriorly bowed; 1, relatively straight; 2, anteriorly bowed (modified from Sereno, 1999; Ezcurra and Novas, 2007; Ezcurra, 2010).
331. Body of pubis, size: 0, relatively large, makes substantial contribution to the margin of the acetabulum; 1, reduced in size, rudimentary, nearly excluded from the acetabulum (Butler et al., 2008).
332. Openings in the body of the pubis (obturator foramen): 0, absent, no obturator process or notch; 1, one, single obturator foramen or obturator notch present; 2, two, distinct second opening in the main body ("ceratosaur" foramen) (new)., ORDERED
333. Combined transverse width of both pubes: 0, less than 75% of their length; 1, more than 75% of their length (Cooper, 1984; Ezcurra, 2010).
334. Pubis/femur length: 0, less than or equal to 0.5; 1, more than 0.5 but less than 0.7; 2, equal to or more than 0.7 (Novas, 1996; Pol et al., 2011b).
335. Body of the pubis, dorsolaterally rotated so that obturator foramen is obscured in lateral view: 0, absent; 1, present (Butler et al., 2008).
336. Prepubic process: 0, absent; 1, present (Sereno, 1986; Butler et al., 2008; Nesbitt, 2011).

337. Prepubic process: 0, compressed mediolaterally, dorsoventral height exceeds mediolateral width; 1, rod-like, mediolateral width exceeds dorsoventral height (Butler et al., 2008).
338. Prepubic process, length: 0, stub-like and poorly developed, extends only a short distance anterior to the pubic peduncle of the ilium; 1, elongated into distinct anterior process (Butler et al., 2008).
339. Extent of pubic symphysis: 0, elongate; 1, restricted to distal end of pubic blade, or absent (Butler et al., 2008).
340. Pubis, pubic apron: 0, present; 1, absent (new).
341. Pubis, median gap below the pubic apron: 0, present; 1, absent, distal pubes swollen mediolaterally and contact along their medial surfaces (new).
342. Pubis, anteroposterior expansion of the distal portion: 0, present; 1, absent (new).
343. Pubis, level of anteroposterior expansion of the distal portion: 0, large, distal portion is expanded more than 2 times the width of the mid-shaft forming a distinct 'boot'; 1, reduced, distal portion is expanded up to 2 times the width of the mid-shaft (knob-like swelling) (new).
344. At least some fusion of the pelvic elements around the acetabular region (ilium, ischium pubis fused at their points of contact): 0, absent; 1, present (new).
345. Tibia (or fibula)-femur length: 0, femur longer or about the same length as the tibia; 1, tibia longer (Gauthier, 1986; Sereno, 1991; Juul, 1994; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011).
346. Femur, proximal portion, anteromedial tuber: 0, absent; 1, small and rounded; 2, offset medially (or posteriorly) relative to the posteromedial tuber (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, 2011). ORDERED
347. Femur, proximal portion, posteromedial tuber: 0, present and small; 1, present and largest of the proximal tubera; 2, absent (Novas, 1996; Nesbitt, 2005a; Irmis et al., 2007; Nesbitt, 2011).
348. Femur, proximal portion, anterolateral tuber: 0, present as an expansion; 1, absent, the anterolateral face is flat (Sereno and Arcucci, 1994; Irmis et al., 2007; Nesbitt, 2011).
349. Femur, medial articular surface of the head in dorsal view: 0, rounded; 1, flat/ straight (Nesbitt, 2011).
350. Femoral head, narrowness (maximum anteroposterior breadth of femoral head < 30% of transverse width of the proximal surface of the femur): 0, absent, maximum anteroposterior breadth of femoral head is greater than 30% of transverse width of the proximal surface of the femur; 1, present, maximum

anteroposterior breadth of femoral head is less than 30% of mediolateral width of the proximal surface of the femur (new).

351. Femur, ventral to the proximal head: 0, smooth transition from the femoral shaft to the head; 1, notch; 2, concave emargination (Serenio and Arcucci, 1994a; Novas, 1996; Nesbitt, 2011).
352. Femoral shape in medial/lateral view: 0, bowed anteriorly along length; 1, relatively straight (Butler et al., 2008).
353. Medial bowing of the femur: 0, present, strong sigmoidal profile in anterior/posterior view; 1, present, small medial bowing forming gentle continuous curve; 2, absent, femur is straight in anterior/posterior view (new). ORDERED
354. Cross section of the mid-shaft of the femur: 0, roughly circular or elliptical, with the long axis running anteroposteriorly; 1, elliptical, with the long axis oriented mediolaterally (Wilson and Sereno, 1998; Ezcurra, 2010).
355. Femur, femoral head orientation (long axis of the femoral head angle with respect to the transverse axis through the femoral condyles: 0, anterior; 1, anteromedial; 2, medial/posteromedial (Benton and Clark, 1988; Hutchinson, 2001b; Nesbitt, 2011).
356. Femur, femoral head in medial and lateral views: 0, rounded; 1, hook shaped (Serenio and Arcucci, 1994a; Irmis et al., 2007; Nesbitt, 2011).
357. Femur, dorsolateral margin of the proximal portion: 0, smooth; 1, dorsolateral trochanter (modified from Nesbitt, 2011).
358. Dorsolateral trochanter, form: 0, sharp ridge; 1, rounded ridge (modified from Nesbitt, 2011).
359. Dorsolateral trochanter, fusion to the anterior trochanter: 0, absent, anterior trochanter and dorsolateral trochanter are separated by a gap; 1, present (new).
360. Femur, anterior trochanter (lesser trochanter, M. iliofemoralis cranialis insertion): 0, absent; 1, present (Bakker and Galton, 1974; Gauthier, 1986; Novas, 1992; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt et al., 2009c; Nesbitt, 2011).
361. Femur, anterolateral side of the femoral head: 0, featureless; 1, ventral emargination present (Serenio and Arcucci, 1994a; Irmis et al., 2007; Nesbitt, 2011).
362. Femur, anterior trochanteric shelf proximal to the attachment site of the M. caudifemoralis (insertion site for the M. iliofemoralis externus): 0, present; 1, absent (Gauthier, 1986; Rowe and Gauthier, 1990; Novas, 1992, 1996; Langer and Benton, 2006; Nesbitt, 2011).

363. Anterior trochanter (lesser trochanter), morphology: 0, a very small, round tubercle; 1, elongate ridge that is oriented proximodistally (finger-like or spike-like); 2, broadened, prominent, 'wing' or 'blade' shaped (Bakker and Galton, 1974; Gauthier, 1986; Novas, 1992; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt et al., 2009c; Nesbitt, 2011).
364. Broadened (wing or blade shaped) anterior trochanter, broadness in comparison with the greater trochanter: 0, as broad as the greater trochanter; 1, greater trochanter is broader (new).
365. Anterior trochanter, completely connected to the shaft of the femur: 0, present; 1, absent, anterior trochanter is separated from the shaft by a marked cleft (modified from Bakker and Galton, 1974; Gauthier, 1986; Novas, 1992; Juul, 1994; Novas, 1996; Benton, 1999; Langer and Benton, 2006; Nesbitt et al., 2009c).
366. Level of most proximal point of anterior trochanter (lesser trochanter) relative to level of proximal femoral head: 0, anterior trochanter is positioned distally on the shaft; 1, anterior trochanter positioned proximally, approaches level of proximal surface of femoral head (Butler et al., 2008).
367. Position of the anterior trochanter (lesser trochanter) in anterior view: 0, near the centre of the anterior face of the femoral shaft; 1, close to the lateral margin of the femoral shaft (Yates, 2007; Ezcurra, 2010).
368. Femur, proximal surface: 0, rounded and smooth; 1, transverse groove present (modified from Ezcurra, 2006; Nesbitt, 2011).
369. Transverse groove on femur, form: 0, transverse groove is shallow, poorly developed and is straight; 1, transverse groove is deep and well developed and is straight; 2, transverse groove is deep and well developed and is curved (modified from Ezcurra, 2006; Nesbitt, 2011). ORDERED
370. Fourth trochanter of femur: 0, absent; 1, present (modified from Butler et al., 2008).
371. Fourth trochanter of femur, shape: 0, low, mound-like and rounded; 1, raised, prominent ridge (aliform, linguiform); 2, raised and pendant or rod-like (modified from Butler et al., 2008; Nesbitt, 2011). ORDERED
372. Fourth trochanter, position: 0, located entirely on proximal half of femur; 1, positioned at midlength, or distal to midlength (Butler et al., 2008).
373. Fourth trochanter: 0, symmetrical, with distal and proximal margins forming similar low-angle slopes to the shaft; 1, asymmetrical (Langer and Benton, 2006; Nesbitt, 2011).
374. Transverse expansion of distal femur, ratio of the transverse width of the distal femur to the anteroposterior depth of the medial condyle: 0, greater than 1.5; 1, less than 1.5 (new).

375. Femur, distal condyles of the femur divided posteriorly: 0, less than 1/4 the length of the shaft; 1, between 1/4 and 1/3 the length of the shaft (Nesbitt, 2011).
376. Femur, anterior surface of the distal portion: 0, smooth; 1, distinct scar orientated mediolaterally; 2, scar oriented proximodistally (modified from Nesbitt et al., 2009a; Nesbitt, 2011).
377. Femur, crista tibiofibularis (fibular condyle, tibiofibular crest): 0, smaller or equal in size to the medial condyle; 1, larger than the medial condyle (Serenio and Arcucci, 1994a; Irmis et al., 2007; Butler et al., 2008; Nesbitt, 2011).
378. Femur, surface between the lateral condyle and crista tibiofibularis on the distal surface: 0, smooth or bears a shallow groove; 1, deep groove (Nesbitt, 2011).
379. Flange projecting from the mediocranial corner of the distal end of the femur: 0, absent; 1, present (new).
380. Form of mediocranial flange: 0, rounded, poorly developed; 1, sharp, distinct (new).
381. Medial border of medial condyle of the femur in distal view: 0, straight or convex; 1, concave (new).
382. Medial condyle of the distal end of the femur in anterior/posterior view: 0, as distally extensive as the lateral (fibular) condyle; 1, much more extensive distally than the lateral condyle (new).
383. Tibia, proximal portion, cnemial crest: 0, absent; 1, present and anteriorly straight; 2, present and curved anterolaterally (Benton and Clark, 1988; Juul, 1994; Novas, 1996; Benton, 1999; Irmis et al., 2007; Nesbitt, 2011). ORDERED
384. Cnemial crest, anteroposterior length in proximal view: 0, between 0.25 and 0.4 times the anteroposterior width of the proximal tibia; 1, over 0.5 times the anteroposterior width of the proximal tibia (new).
385. Tibia, proximal surface: 0, flat or convex; 1, concave, the posterior condyles of the tibia are separated from the cnemial crest by a concave surface (Nesbitt, 2011).
386. Tibia, lateral (fibular) condyle of the proximal portion: 0, offset anteriorly from the medial condyle; 1, level with the medial condyle at its posterior border (Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011).
387. Tibia, lateral margin of the lateral condyle of the proximal portion: 0, rounded; 1, squared off (Nesbitt, 2011).
388. Tibia, lateral side of the proximal portion: 0, smooth; 1, dorsoventrally oriented crest present (fibular crest) (Gauthier, 1986; Rauhut, 2003; Nesbitt, 2011).
389. Tibia, posterolateral flange (posterolateral process, descending process) of the distal portion: 0, absent; 1, present and contacts fibula; 2, present and extends well posterior to the fibula (Novas, 1992; Juul, 1994; Benton, 1999; Langer and Benton, 2006; Irmis et al., 2007; Nesbitt, 2011). ORDERED

390. Tibia, posterolateral margin of the distal end: 0, straight or convex; 1, concave (Irmis et al., 2007; Nesbitt, 2011).
391. Mediocranial corner of distal tibia forms: 0, rounded, obtuse or near right angle, 1, sharp, acute angle (Langer, 2004; Pol et al., 2011b).
392. Notch in distal tibia (with respective bump in the proximal astragalus): 0, absent, 1, present (Novas, 1996; Langer, 2004; Nesbitt, 2011; Pol et al., 2011b).
393. Lateral migration of the proximodistally oriented groove on the distal tibia: 0, absent; 1, present (new).
394. Tibia, anterior diagonal tuberosity (anteromedial sheet of Galton, 2014) located proximomedial to the anterior ascending process: 0, absent; 1, present (Ezcurra and Brusatte, 2011).
395. Tibia, proximodistally oriented ridge on the posterior face of the distal end: 0, absent; 1, present (new).
396. Maximum expansion of distal tibia relative to proximal: 0, distal tibia is considerably less expanded than proximal tibia; 1, maximum expansion of distal tibia is roughly equal to that of proximal tibia, or greater (Han et al., 2012).
397. Transverse width of the distal tibia: 0, subequal to or less than the anteroposterior width (distal tibia is square/circular); 1, greater than the anteroposterior width (around 1.25 times or more) (Gauthier, 1986; Ezcurra, 2010).
398. Distal articular surface of tibia, forms an oblique angle with the long axis of the tibia in anterior and posterior views: 0, absent, inner and outer malleoli are roughly level with one another distally, forming a near right angle between the articular surface the condyles form and the long axis; 1, present, outer malleolus extends further distally than the inner malleolus creating an oblique between the articular surface and the long axis; 2, present, inner malleolus extends further distally (new).
399. Fibula, attachment site for the M. iliofibularis, form: 0, knob shaped, robust; 1, crest shaped, low (modified from Sereno, 1991; Nesbitt, 2011).
400. Fibula, attachment site for the M. iliofibularis, location: 0, near the proximal portion; 1, near the mid-point between the proximal and distal ends (Sereno, 1991; Nesbitt, 2011).
401. Fibula, anterior edge of the proximal portion: 0, rounded; 1, tapers to a point and arched anteromedially (Nesbitt, 2011).
402. Fibula respect to tibia at the middle of their shafts: 0, wider than half the width of the tibia, 1, subequal or narrower than half the width of the tibia (Langer, 2004; Pol et al., 2011b).

403. Fibula, distal end is strongly reduced and splint-like: 0, absent; 1, present (Han et al., 2012).
404. Tibia, fibula and proximal tarsals, fused (or partly fused) as a tibiotarsus (tibiofibulatarsus): 0, absent; 1, present (new).
405. Astragalus and calcaneum, relative sizes: 0, astragalus and calcaneum roughly equal in size; 1, calcaneum greatly reduced in comparison to astragalus (Serenio and Arcucci, 1994).
406. Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus: 0, present, 1, absent with a largely vertical fibular facet (Serenio, 1999).
407. Fibular facet on the lateral margin of the proximal surface of the astragalus: 0, large; 1, reduced to small articulation (Butler et al., 2008).
408. Astragalus, dorsally expanded process on the posterolateral portion of the tibial facet: 0, absent or poorly expanded; 1, expanded into a distinct, raised process (posterior ascending process of Serenio and Arcucci, 1994, pyramidal process of Nesbitt and Ezcurra, 2015) (modified from Serenio and Arcucci, 1994; Nesbitt, 2011).
409. Astragalus, anterior ascending flange (anterior process, ascending process): 0, absent; 1, present (modified from Gauthier, 1986; Novas, 1992, 1996; Benton, 1999; Rauhut, 2003; Nesbitt, 2011).
410. Anterior ascending flange of the astragalus: 0, less than or equal to the height of the dorsoventral extent of the posterior side of the astragalus; 1, greater in height than the dorsoventral height of the posterior side astragalus (modified from Gauthier, 1986; Novas, 1992, 1996; Benton, 1999; Rauhut, 2003; Nesbitt, 2011).
411. Astragalus, anterior hollow: 0, shallow depression; 1, reduced to a foramen (extensor canal) (Nesbitt, 2011).
412. Astragalus, proximal surface: 0, lacks a marked rimmed and elliptical fossa posterior to the anterior ascending process; 1, possesses a marked rimmed and elliptical fossa posterior to the anterior ascending process (Langer and Benton, 2006; Nesbitt, 2011).
413. Astragalus, posterior groove: 0, present; 1, absent (Serenio, 1991; Nesbitt et al., 2009c; Nesbitt, 2011).
414. Astragalus in distal view, symmetry: 0, astragalar body is fairly symmetric, medial and lateral margins are about equal in depth; 1, astragalar body is strongly asymmetric, medial margin is at least 1.4 times as deep as lateral margin (new).
415. Distal articular surface of astragalus: 0, relatively flat or weakly convex; 1, extremely convex and 'roller shaped' (Smith and Pol, 2007; Ezcurra, 2010).

416. Astragalus-calcaneum, articulation: 0, free; 1, coossified (Serenio and Arcucci, 1994; Irmis et al., 2007; Nesbitt, 2011; Han et al., 2012).
417. Calcaneum, proximal surface: 0, facet for tibia absent; 1, well-developed facet for tibia present (Butler et al., 2008).
418. Calcaneum, calcaneal tuber: 0, present; 1, absent (Gauthier, 1986; Sereno, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2011).
419. Calcaneum, shape: 0, proximodistally compressed with a short posterior projection and medial process; 1, transversely compressed, with the reduction of these projections (Langer and Benton, 2006; Nesbitt, 2011).
420. Calcaneum, fossa on the lateral surface: 0, absent; 1, present (Yates, 2007; Ezcurra, 2010).
421. Distal tarsals: 0, ossified; 1, not ossified (new).
422. Distal tarsal 4, posterior prong: 0, blunt; 1, pointed (Langer and Benton, 2006; Nesbitt, 2011).
423. Distal tarsal 4, medial side: 0, without a distinct medial process present in the anteroposterior middle of the element; 1, with a distinct medial process present in the anteroposterior middle of the element (Nesbitt, 2011).
424. Distal tarsal 4, proximal surface: 0, flat; 1, distinct, proximally raised region on the posterior portion (heel of Sereno and Arcucci, 1994, 1994) (Nesbitt, 2011).
425. Medial distal tarsal: 0, articulates distally with metatarsal 3 only; 1, articulates distally with metatarsals 2 and 3 (Butler et al., 2008).
426. Medial distal tarsal: 0, not enlarged; 1, enlarged (new).
427. Metatarsal III: 0, roughly equal to or shorter than 50% of tibial length; 1, longer than 50% of tibial length (Serenio, 1991; Juul, 1994; Benton, 1999; Nesbitt, 2011).
428. Longest metatarsal: 0, metatarsal III is the longest; 1, metatarsal IV is the longest (new).
429. Metatarsals, midshaft diameters: 0, both I and V subequal or greater than II–IV in diameter; 1, only diameter of metatarsal I greater than or equal to diameter of metatarsals II–IV; 2, only diameter of metatarsal V greater than or subequal to the diameters of metatarsal II–IV; 3, both I and V have

diameters less than metatarsals II-IV (modified from Sereno, 1991; Juul, 1994; Novas, 1996; Benton, 1999; Nesbitt, 2011).

430. Metatarsal I: 0, reaches the proximal surface of metatarsal II; 1, does not contact the ankle joint and attaches onto the medial side of metatarsal II (Gauthier, 1986; Rauhut, 2003; Nesbitt, 2011).

431. Metatarsal I: 0, subequal or greater in length than metatarsal II; 1, significantly shorter in length than metatarsal II (new).

432. Metatarsal II, proximal articular surface: 0, subrectangular; 1, hour-glass shaped (Sereno, 1991; Pol and Powell, 2007).

433. Fusion of distal tarsals to proximal ends of metatarsals: 0, absent; 1, present (new).

434. Metatarsal IV, distal articulation surface: 0, broader than deep and nearly symmetrical; 1, deeper than broad (or as broad as it is deep) and asymmetrical (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).

435. Metatarsal IV, proximal portion, possesses an elongated lateral expansion that overlaps the anterior surface of metatarsal V: 0, absent; 1, present (Sereno, 1999; Langer and Benton, 2006; Nesbitt, 2011).

436. Metatarsal V, phalanges: 0, present and “fully” developed first phalanx; 1, present and “poorly” developed first phalanx; 2, without phalanges (Gauthier, 1984; Parrish, 1993; Nesbitt, 2011).
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437. Metatarsal V shape: 0, proximal and distal ends subequal in breadth, 1, proximal end is wider than the distal end, metatarsal V is triangular or y-shaped, with wide proximal surface and pointed distal end (Galton and Upchurch, 2004; Pol et al., 2011b).

438. Metatarsal V, length: 0, longer than 50% of metatarsal III; 1, shorter than 50% of metatarsal III (Butler et al., 2008).

439. Metatarsals fused or partly fused into tarsometatarsus: 0, absent; 1, present (new).

440. Digit 1: 0, metatarsal I robust and well-developed, distal end of phalanx 1–1 projects beyond the distal end of metatarsal II; 1, metatarsal I reduced, end of phalanx 1–1 does not extend much beyond the end of metatarsal II if at all; 2, metatarsal I reduced to a vestigial splint or absent, does not bear digits (Butler et al., 2008). ORDERED

441. Non-terminal phalanges, shape: 0, elongate; 1, subquadrangular (Pol and Powell, 2007).

442. Pedal digit 4 phalangeal number: 0, five or more; 1, four or fewer (Butler et al., 2008).

443. Majority of pedal unguals, shape: 0, claw-like; 1, hoof-like (Butler et al., 2008).
444. Shape of the ungual of pedal digit I: 0, shallow, pointed, with convex sides and a broad ventral surface; 1, deep, abruptly tapering, with flattened sides and a narrow ventral surface. (McPhee et al. 2015).
445. Unguals of digits II-IV: 0, deeper than broad, with curved ventral surfaces; 1, broader than deep, with flat plantar surfaces (new).
446. Epaxial ossified tendons present along vertebral column: 0, absent; 1, present (Butler et al., 2008).
447. Ossified hypaxial tendons, present on caudal vertebrae: 0, absent; 1, present (Butler et al., 2008).
448. Parasagittal row of dermal osteoderms on the dorsum of the body: 0, absent; 1, present (Butler et al., 2008).
449. Lateral row of keeled dermal osteoderms on the dorsum of the body: 0, absent; 1, present (Butler et al., 2008).
450. 'Weaponised' dermal spikes on the tail: 0, absent; 1, present (McPhee et al., 2015).
451. Singular and unbranched filamentous integumentary structures covering, or partially covering, the outer body: 0, absent; 1, present (new).

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001010000000100000000??111?11?00001101110010001011000?0010??010???0101??0010011?1?11011111
11?001100-1000011000101101011113101000?001?001112?1110020101001220021?-2200?001010?00---
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100002?????0?01????1???00011101?10?1000??1011?1?103110?1?02110?00000000000

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Euparkeria_capensis 000000000000-000-0-00100-000000-00000010000110000----
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0000011011100?000???000?000??0?0?10?0?00?0000010000000000000001--00?00000000000-
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Postosuchus_kirkpatricki 0000000000020-010-0-10000-10?000-00200020001100000----
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Yunnanosaurus_huangi 00?101?001?01???0-1?01?1?0?000???1?0?02000?110?00----
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10000200000110010000101000011111?1?0000101???????1011001011100000000000?
Riojasaurus_incertus 0000010?11?0????0-110?011??0000??1001?20?011?100----
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Vulcanodon_karibaensis
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Coloradisaurus_brevis 00??010011201-?10-11011110?01000-01001?2???0???00----
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Lufengosaurus_huenei 0001????????????1?1?1?2?00???100?020?011?00---1?10?????01001101-
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Gongxianosaurus_shibeiensis

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Zupaysaurus_rougieri 00??1??????????11????????000001000100120001100110----
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Dromomeron_gigas

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Dimorphodon_macronyx

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3.2 Taxon scores from Chapter 7

Euparkeria

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Postosuchus

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0?0111000?100???01?000010?????0?0?110001?0110100000000?????????????1?????????00000?

[illegible]

Tianyulong 000010110001?0?011?1000000?0?100-
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Heterodontosaurus 0000101100011010110100000010111100111020000111000100000100?120001011200110001000200101100
1001110?01010110000?1???0?011101010010111000020000200003011210111011001212?110201111011100?
001?10010000010-00-0011?211?03100012001?0??10?01010-1010011?1?11111?10111?00110-
10002110100100000011101112010000400201211101--00010010100210-1111200101?010011-
??01?0??120?0??101100201110-
1211?000???021000110???1?1110111111??1?1?1?1?11100100110?110110???1100000100000

Eocursor 0????????????????????????????????1??0?????????????????
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02012?110001000?00101002?1-20012?0101?2010011-??0110001202010101100201010-1201110000-
0020?00120111?11110?100????????????????????1????0????0?0?0??1?00?0

Laquintasaura 0???101????????????????????100-
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0???1?120101??12010??0?01?????201110??11?????1?1???????11????????????????????????0???????

Lesothosaurus 00??10101?0011100-
01000?0?10?101?00201120000111000100000100?00??0011?100210001000000111000?0???11000?010100000
01??10?01000011001000100002110020??0010?01100-000-1110200002011110010?0?001?00???000010-00-
0????011??211101101?01111?0?????01001101?111110101000110-
10??100?00?0000?0000?1?111201000031010122010002000100101202111101120010102010011-1-
0110000202020100101201010-
120100000???02000012011100111??110011101110100?111?0?100100?110110-??010?0?0100000

Scelidosaurus 000?1??0100?????????0?0?0?0100-
0?21101100?101?0011?2?0010?010310010100100000000100110000?????????1????01?1??????1?????????1
0111?1-??10002???0110??1001101?01010200002011110?0?0???1???00??????0-
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??00011????1?11110001?10????????????????????????11201100031010112010002001?0010100210-
?01120010102110011-1-
0?1000?00212010010120101??12010?00????0?????2??110?112??11001?1?1?????01???0???0?00101???021
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Emausaurus 00??1??00?0??100-1?000000?0?100-
00010020?011100010100001??000300010100?00?0?000?00110????????????0????00?????????1?0?0011010
0111?0002100020??01101011011000-
11002000120110000?000??10-
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Agilisaurus 00011000000010100-01000000?01100-
00211020000111000101110100?00030001010??10?01000100?011?0?0??1?00?0????0?00?????010001110
010111?1-
??000020010110101001101?0111220000201111001000?0?????11?????????0?????????121?10120?0?0?????0
?1-0-?10001101??1000?1?1010000-
100????????????????????11201010031010121010002100?00101202111100120010102010111-1-

0110???10?0??1011??20101??12011001????01????20?1??01?110?100101011?????1???0???00003110?0021
100000?0100000

Hexinlusaurus 0?0?1??0????????????????????1100-
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??0?1-0-?1?01?????1??0-?0????????????00?0?0?????????1120101003002?1210101--
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0110????0?????1??2010???1201???00???0????????????????0???1?????????1??????1????????????1?1?
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Jeholosaurus 00?01011000010110-01000000101100-
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10001111010?11100?02??1000?0??000? ???????01100011?01011101-
020?01200?00101011?1101?01110200002011?100100000?1??001000001??01100?10211??300101212110011
10011-???11?101????111111?1?1?00??0-????????????????????112010100300201201101--
100?0011120211120012001?????1??11-?011?001202020101101211110-1201100000-
00211?1?20111001111011001010110010001?110???1100311010021101000001?0000

Dracoraptor 00??100011??1?1??1100?00?10?00??11?0?12????10110?0---
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110-?0?????????00?1????????????????????????????????0102112??????1?010?0?0--
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2110?0?0???000?0

Massospondylus carinatus 0001010011200-010-01101111-12?00-0100002111001-1000---
01010000010011000001000???111110001010?0100???11?01010??1??2?00--
01010110110?0000100020110211200000-000-
00202100120110011010????11??01?00011100112?0?0?11?0100001?0100?0???001??10?0010110?011012111
101100100-13?1100?00000111211?001001000000100?012111000?000?001?20????-???0?001010200--
???0100???0?00010????????????110100????????0????1?110000?0?0000111?111????0???0????00100?00
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Massospondylus kaalae 0????10011100-?10-01101111-1??0??01000021?0001-1000---
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Leyesaurus 00?0?0?011?010?10-0111??1?11??0??0100?02???001-1000---
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002021?002101????10?0?0?1101??000021?01?200?0?????????????????1??0?????????????1??1?????????
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Guaibasaurus
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10110000002000100122002?1-220000010?01?0--00?1-0?????020001?1001?01-
000??1101?000???02???11??100000010?000111011110?0001010100?00010100112110000000000000

Plateosaurus 0000000011100-000-01000111-12010-1111102111001-1000----

00010000301010100000100??0111101010?011?011?0101000001?012?00--

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01000010200002111010110000001101020000111?111000?0011111000000011000110?01????000001000110

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1201201?0001010111111001011000100110001221110020101001021221102??00001010200--

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Herrerasaurus 000000000000?000-01110000?11010-000000200001101000----
0000?10030001000000000000010010100101??11001?111000000010????00--
000??010010?0101000000000200100000-000-
00001001000000000100010?11110?0000011011000?21101000000001010011100??????00111????1???1010
0110?01110?000?10110110001010121110000001101100012101000100012012110210022000001010200--
0000000101002000101101001-000101101101010-
002001001001000000101000110010110100010?0110001030100111100000010000000

Chindesaurus
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001001?0100110?010?????0?10?1?11??0??

Staurikosaurus
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000100?00110?????????1??101000?1?01100012?010001000
1211?1???21???1?000010?02?0--0000001?000020001011?1001-0001?110110?0?0-
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Sanjuansaurus
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00??10???00000?0000???1110100000?10110011?1110100?0000010100???0???????1011101011???????
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001101001001000000?10001?01111000?010?????????????0?????????????00????

Eodromaeus
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?0?11?000?????????00--00???00?0?0?0?????0110000201000000-
00??0?010000000000?00000?001111021010111010?100???01?01????01?00???10?0101???010011010?101?
?1???????110-1000?10010?1000010102?01?????????????1?????1?002???0?1???????????01?02010210--
00001?1???0?200010???1?01-
000??????000????02?11?????1???0???1000101?1???1?0?0011????0?????????0?????0???000000

Coelophysis_bauri 00101000012210??111101101110?00-00100?20?011001000----
01?10101300010100000001???0111111?1?011100???1111????01???0?00--
0000?001010?0002000010100201000000-000-
001010000000001001000?11111102111111010?010?0011?02111111011010011?010111?100011?101111111
0111001110-100010111110000101021011030001?0301211201110120101001121121?-10101002020200--
00101112000?20202011?11020101121???100010-
00211111111111011011011???1101010110111?010?10311?1102110100000000000

Syntarsus 00?01000012210??1111011011100?01?11100120?011?01110----
01?1?10030001010000000?????1111110?10??1100?????????????????00--
000??00101?00??100020100200000000-000-
001?10?000000010?000?????????1???1?1???10?0?????1????????????????????000?1?1011?????????
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02011011020101121100100010-
002011011?1110001?1011011???1?1?111?11?0???0???311?1??21?1?0?0?0?00??

Eoraptor 00001000100010?01011010000100?00-001000201001111000----
01?1010030001011020000001101?11???0?0?????0???1?010?0011????00--
0001?01111010002000120110210000000-000-
00101000000010000000?111?11?00001101110001000101100?0010???010???0101?0010011?1?11011110
111?00100-1000110010110101111031011?0?00100???1112?1110020101001220021?-2200?001010?00--00?1-

01??00??010101001?010000??11011000???02?????0?1????????00011101?11?1000??1011?1?1030100102
110?000000000?0

Procompsognathus

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10??1?0-0??21?01111000110012101????00?01101112?11100?010?0?1???2??????0?20?0?00--
?0?00012000?20102010010?10000121100100010-
002001101001000000001?001110111100001101100010301?0102110??0?0000??

Dilophosaurus

0010100011?211?11110110110000010101001201011001110----

110100013000111001010000001?110110010011?0001?1110??????0?2?00--
00000011010100??1?0020000200100000-000-
001010100000000111010?011110?112011011100?00010?21?001101100101000101??000011010111111
0101000110-10??212?01110000101021110300010031121221110120101011?11121?00?021020102?0--
?0?0110200002010101010120?0112110100?010-
0020111121?1110110101?00111?11101??0?11?00100010211?1102??010000000000

Tazoudasaurus

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00??21?0?210110??000?0????1?010?1???11????201????????????1000??0????????????????
??1?????????00?1?010100--
001?0?0?????121?????1?????1?????????????1?????????????1?00?11111?1?0?0?????????????0??
??0?1?11100???

Yunnanosaurus

00?101?001?01???0-01?01?1?0??00???1?0?02?01?01-?000----

01??120?000?000010?000????10?100000??00001????????????????00--
01???1?0?10?0?????????0????0000-000-0?2?0-
?0?21000001?0??1??1?010??000111?0112?0?0?01??1000010010100????01????10000?????1010110101?101
00-?2?1?0?00?001011210?00100100?0?01101012011000200000112200201-2??00001010200--
0010100??00201010??1011-000??11011000?0-
002000001101000010101000111111?1?1000101???????10110011110000000000??

Riojasaurus

0000010?11?0????0-0110?111???00???1001?1???0?1?1000----

0001?200?1001110000?001????11110?????????????1?????????????00--
01????0010?00??1?0020?101????000?0?0??0??2????21010?01?0?0?0?110?0??00?110010200??1110?1??
??0??00??0????????????101111110101110100-1201?001001?0111111?3101001000000110201201101--
000?001?2022??-???00001010200--0011-0010000102110??1011-
00110110110001???02000011101000010??1000111?1?????00???10??0?0101?0012?1000???0000??

Vulcanodon

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1101--001??010?012?1-1?000?11010000--001000?100001121201?01011-
001101111????????10000???10?????101000111110?00100?011----?000011001?10001?0100000??

Coloradisaurus

00??010011201-?10-011011110?0100-01001?2???0????00----

0??10?003?011?0000100001011011010?11001?01100120?????2?00--
010??1?011010?01?0011011?????00010000-
002?21?0?210110??0?0??1?0?0?00001???01120?1?0111?????????00????0?????00001101010111110
1100????????0????????????????1????????????012?010001000000122012???22000001010200--

Lufengosaurus 0001????????????0???1???1??2?0???110?021??001-?100----
01?10????00001101-
01000???11011000?0???11001?0?1?0000?011????0???????1?010?0?????001?????????0000-000-
00??20?0?21010?0110?00??10010200001???0111001?0111010000100101001100010?0-
100000101001011110101100100-1211100100??01011211?00100100010011020?211101--00000?12200201-
22000001010200--0000000100002020101??10?1-000??11011000?0-
0020000?110100001010100011111?111?0110?010?10101011001111000000000000?

Cryolophosaurus 00?01?????????????????????0?0????10?1?010?1001120----
1??1010?3?1?1?0?0?0100000?011??100100100000????1?0?????0?0?0?????????????0???10002??????????
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Ignotosaurus
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Panguraptor 00?01?????????111?????????001010100?20??110?1100----
0??1?1013000?0100200001?????110????????????????????????????00--
00???001??0?00??1????000?????000??0??0?0?1?00?00000?0??000?????1?21?111??1??0?0?0?01?0?????
?????????????????10011????1????????????????????????11??0?0?0?101??1?????????????2??1?0?0?0?????
02??????10?????????????????1????2??0?0??1?0??01?????????????2????1??11?????????1?01?????????
?10??10??01?????1?0?1?0?0????0?00??

[illegible]

Pampadromaeus 00?010001120?0?00-11??1011?1?010-1100002010?1101000----

00?0?100300010?0?0???000?000?0?10????????????????????????????00--

000??001010?0?0?0?0010100210100000-000-

0?1320000100100110010?0????????????1???????0????????????????????????0011????1?????????1?

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0101001001-000111101000010-001?0?0??0?00?0

Gongxianosaurus
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??0?????0?01?0???00???0-
????1??1?0????1????????00110?010???100?0?01???111111010????0-
??1??0?0????????????????0????????????00???00?000?0121?0?
??00?-----????????????????????1??100???0???100111?1??????00???0?????00101?0???1000100000000?

Zupaysaurus 00??1??????????11????????000010?01001202011001100----
11010001300010100200001????11100100????1010???????????1????00--
00???011010?00???00010?0?????000??000-
????1?0?00000010?000?0??1?11????????????
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[illegible]

Chilesaurus
0????1?1????????????????????0????????????????????0?????????1?????????????
??1????????????0--0101?1?0????????????0?0????00?0-000-
00??11???20?00??1?10??????0?0100???00-
1?1?0????????????????????01????0101010000111110101?10110-
00?????0??1010111????111300?1?0300201211101--1100001020100?-10012001010?00--10-1-
01???0?0020?0111?120111??1101?0??????2010001????0011?10?100111011?0?1??11????????0??10?00??
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[illegible][illegible]

[illegible]

Blikanasaurus
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Megalosaurus
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????????????????0???0?10?1????0?0????????????0000?000?00?10?0?00000?2?0?0?11?1????11???11
10?0???1001??2111002101?101?0????????1011101001?111101?1?0110????????????????????????11030001
0030120120111001000001112102?1?100010011?0????00?010?1000020202010111020101??1101102010-
00201111111100111????0????????????????????????????00????0????00????

Segisaurus
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??????01?????1?010?0????10001?02?20?00?00001?????????????????1?0???1??????????????2?????????????
??10???0??????????1?011100?0???311??1?211?0?0?00000?0

Tachiraptor
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[illegible]

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101?01????????????????????????????????????01011????1?10110101?101011?3????????0011?11????100100?0?0?0?
?012101000201000??2???????2?00?0?010?00--
00???0?0?0?112120?????????????111100?00???01000001?100?0?0?????0?1111?1000????????????10?10
?1?110?1?0?000???
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001000020000202020???110201011?11001120???0211???2??11?101110?10?1??111???111110???000?11
0110???1???????010?

Melanorosaurus 00???010011?000?10-0111?111-1200??0100?0311?011?1000----
00011201?10011000201001????01110001?0??11?01????????????????00--
0?0????????????????020?100000-000-0?2?10?0011000001?0?????1?01???0002?1100-
2????21???2???????1?????????????1?0???????111101?01?01010?3??00??0?011?1?1?1?1???????1?
??0?1-
?0?0?0?1121?0???1??1?????111000?01???0?0???1??10???????0001?????????00??10?1010?0101?0?11?0
010?0?0000??

Shunosaurus 000111002122???0-01111022?1013--?1000?3-00001-0000----
00010?013010120002001?11020011100110?0?110011011100100??1?12?00--
01011010010000????001010010??0000-000-
002?1?0?0?101100?11?0????????????????????201??2?????????????????1?11????????????11????00
????3?????00?0???????1?111400?1?110???22010???001?01?20020?-???0?01101??00--
????0????????????????????1??
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Scutellosaurus 0????1?????1?1???0100?0?1???????11????????????????10?00?3000?0?????????110?0?????????
?????????????????1???0111010?0?????1???01100?0??110110?1011??20?0?201102??0?0?0???01000?0
?0?????0?10????120?0?00?00?10-?0?1-?0???0110001111110101000100-
????0?0?0?0?????01??112??00003001??2???0???0?00101002?0-?012000010?010?11-1-
0110000202010101101201010-
12010020???02?0000201110011210?100?1111101000?11?????????????0?0???0?0?0001?1100

Anchisaurus 00??1???1???????011???1???00???001?22??001-
?0?????00???20???0?1??1????0???????1?0?1?????11???11?????1????00--
000??110?10???0?1000?0?10?1???00?1?0????2???002101????1010?1???1???0021????2?????1?????0?
?0?????????????100111010?111110101?0011??12??100?0001011121?0011?2?1?0?0???012?110???0?
0?0?1????2?????00?01010200--000?0010000201010???1011-0001111010021?0-
002010001??1?0110?00001???1????00???0???1010101?00??1100000?000000?

Sarhsaurus 0????0?1?010?10-011????01??1??1?0000???1?01-?000----
0?0?000??10?1??100??100010?011?011??0?11011001110020?0011???00--
00???110?10?????0020110200100000-
00??0?2?20?002101????1010?1?110102000010?0111?0?1101101?????????01?0?0???10101001101011011
11010110010??1311101?00010111210?00100100?0?0110?01211100010000001?201211-???0000?0202?0--
00???001000?2121201001011-001??11010020?0-
00???????1???0????00?1101110100????????????1???1?0?????00000?

Eustreptospondylus 0????0?1??2110?11?11???1?1???101?000?20???1011?????1???1?????1?1?001?0000???01110?100??01?
???????1100???????0?00--
010010?1?????????0?0?020???????0?????????00?????????0111101201110?1?11001?0?0010?20000?
????0?11?0?0?????0101?????1011110111000?0????????????????????110300010020121120111002010
10110?102?1-??101000110200--
0000000200002020201011?201001111001000???02110111?110111101100?1111101100?????????00??
?0011???0?0?00000??

Coelophysis_rhodesiensis 0010101011?2????111101?011?000011?010?12000110???00----
010?0101?100?0001-00?01????111?1???0???????0111000001?1?10?00--
010??00?010?00???002010020010000?0????10?0?0000000?01000?0????????????10???????0?????1??1
????????11???0?????????????11110111?0011???0?0?10111-
?0100101?210110300?1?03012112011101?0101011?21221?-???0?012020?00--
???011??0?011?0311?11021
1110000000000?

Psittacosaurus 01101011000010010-011100001001---102100--0--01--00101000-
010120300011201-10001000201101100?00111000?011100010?11?10?01100010100011100000000021011----
-11111001011002000-201111001000?1011000?00000?0-00-000110010?3111?110210111?0011-
10100001101011211110101000100-11???0?0?011011010?1?112010000300200201101--10000110100210-

101121000102012111-1-0110000202020???101201110-1211000000-
002000012???110011110110?11101110100011110???11010101112111000000100001

Stegosaurus 000110100000111011110000011001---00210120100100-0011?2?0-
100100101010201-11101000100101000?10211001011?100001???1211100011??10111100002000021111----
11011011011002000-201101201000?0010000200000?0-111000?11110021110?11?1?011100011-0-
0010010000111111010111011101???003100?01?0???1010011121110003012012201001?0??00110000200-
101120010101010111-1-00100012121201011011-1110-101?002000-
002100012???110011210110111111???100111101-----00???00002??021110100111?

Adeopapposaurus 00010100112011?10-01111111012100-0100012010001-1000----
01010000000011100101001000211110001010?1100110110011000?1?1?100--
0101011001010000?0010110211100000-000-
0?13200002111100110100??1101020000211?01120110011101000001000011?10001??10101101101011?1111
1101?10100-1301100?00010101111010110010100001101012011000100010112101211-22000001010200--
00?000010000200010???1011-001121101100010-
00200001110100001010110011111111010??1?101???00010110?1110000000000000?

PVSJ_883
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Eucemesaurus fortis
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00001????????????21?1011?010?0110????0????????????????????????????????????

Camelotia
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001??11110?0???0????????????0??

Cetiosaurus
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????????????????????1114?0?101100012?1101--0010011?002?1-???00?1001?00--
???000?1?00?012120???001-----
??1011?0?0???1100???101100?01010?00????????????????????????????????????0000??

Barapasaurus_
0??
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012?21???21?11????0?0?0???1?000001111100001?101??21?00011?110011?000??0-
101101100011?101101010000-1110???0???0?0000?0?????1114001100100?01221101--00100012200201-
02100011010000--101000011000112120???0?1-----0-
110100201???010000011010000001010001111110?0?10010?1-----000011011?00001?010000000

Jingshanosaurus 0001110021?0100?0-01111121010000-01000?3-??0?1??000----
0?01020?10???1?0?000010002011??101????11?00?0???0100?1????00--
010??110010000??11000011020010000?000-00220-00000010001100000????1?????11?00-
10?1?01?021100011?1100111001???1001011010110121110111010101301100?00000101111010?100100?
0?0110101201101--0000001?200201-2?000001010100--000000011?002010101101??1-
0011?110110?0???02000?11?10?010101000111111?1?100???0?01100101?0011100110000000000

Merosaurus

Austriadactylus

Perfect_Taxon

[illegible]