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SUPPLEMENTARY ONLINE MATERIAL FOR

A new basal eusauropod from the Middle Jurassic of Yunnan Province, China, and faunal compositions and transitions of Asian sauropodomorph dinosaurs

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SOM_1. Character list for the maximum parsimony analysis.

SOM_2. Character matrix used for a maximum parsimony analysis in nexus format.

References

SOM_1

Character list for the maximum parsimony analysis. Characters 1-331 follow Harris (2006), except for characters 38 and 76 modified by the authors. Characters 332-344 are added by the authors. U followed by number indicates character originally derived from Upchurch et al. (2004). W followed by number indicates character originally derived from Wilson (2002).

- (1) Morphology of rostralmost ends of jaws in dorsal view (W65, U1): triangular, with acute tip (0); broadly rounded rostrally with linear, roughly parallel lateral margins (U-shaped or parabolic) (1); platelean (broadly rounded and convex rostrally but with lateral margins that are sinuous, convex rostrally but becoming concave, producing spoon-shape caudally) (2); rectangular, especially lower jaw (rostral margin linear and at abrupt angle to lateral margins) (3).
- (2) Configuration of caudolateral processes of premaxilla and lateral processes of maxilla (W1, U15): lacking midline contact (0); possessing midline contact and forming marked narial depression (1).
- (3) Angle between lateral and medial margins of premaxilla as seen in dorsal view (U12-14): $>20^\circ$ (0); $\leq 20^\circ$ (1).
- (4) Morphology of rostral margin of premaxilla (= region rostral to nasal process) in lateral view (W2, U10): without 'step' (0); with marked 'step,' rostral margin of skull thus sharply demarcated (= muzzle-like area present).
- (5) Free portion of nasal process of premaxilla in lateral view (U11): majority projects caudally and divides external nares into right and left halves (0); majority projects dorsally and divides external nares into right and left halves (1); is greatly reduced, reducing or eliminating internarial bar and creating single, confluent external narial opening (2).
- (6) Thin, plate-like process (flange) directed rostromedially from edge of maxillary ascending process (U17-18, C14): absent (0); present but lacking midline contact (1); present and contacting each other at midline (2).
- (7) Direction in which subnarial foramen faces (U6): lateral (0); dorsal (1).
- (8) Proportions and size of subnarial foramen (U7): small and subcircular (0); elongate (at least 2x longer than wide in direction of premaxilla-maxilla suture) (1).
- (9) Position of subnarial foramen with respect to narial fossa (U8): outside (0); within (1).8
- (10) Relative positions of subnarial foramen and rostral maxillary foramen (W5): well distanced from one another (0); separated only by narrow bony isthmus (1).
- (11) External nares face (U4): laterally or rostrolaterally (0); dorsally or rostr dorsally (1).
- (12) Shelf-like area or fossa (narial fossa) on premaxilla and maxilla lateral to external nares (W1, U19): absent (0); present (1).
- (13) Length of border of external naris formed by maxilla (W3): short (less than 1/4 narial perimeter) (0); long (more than 1/3 narial perimeter) (1).
- (14) Position of mid-point of osteological external nares (W8, U2-3, C7, S7): rostral to antorbital fenestra (0); dorsal to antorbital fenestra (1); caudal to antorbital fenestra (2).
- (15) Ratio of maximum diameter of osteological external nares:maximum diameter of orbit (W9, U5): <1.0 (nares shorter) (0); ≥ 1.0 (nares longer) (1).9
- (16) Preantorbital fenestra (W4, U20, S24): absent (0); present (1).
- (17) Antorbital fossa (W7, U21): present (0); absent (1).
- (18) Ratio of maximum diameter of antorbital fenestra:maximum diameter of orbit (W6): <0.85 (orbit significantly larger) (0); ≥ 0.85 (diameters subequal) (1).
- (19) Angle subtended by rostral and ventral margins of orbit (W10): obtuse or roughly 90 degrees (0); markedly acute (1).
- (20) Rostral extent of maxillary process of lacrimal (W11, U16): dorsal to midpoint of antorbital fenestra (0); caudodorsal to midpoint of antorbital fenestra but rostral to

- caudodorsal corner of antorbital fenestra (1); process absent; maxilla-lacrimal contact at caudodorsal corner of antorbital fenestra (2).
- (21) Element contacting ectopterygoid laterally (W12, U65): jugal (0); maxilla (1).
 - (22) Contribution by jugal to antorbital fenestra (W13, U22): reduced or absent (0); large (occupying most of caudoventral margin) (1).
 - (23) Size of frontal (= caudal) process of prefrontal (W14): small (does not project far beyond frontal-nasal suture) (0); elongate (approaches parietal) (1).
 - (24) Morphology of frontal process of prefrontal in dorsal view (W15, U33): flat, broadly rounded or square (0); hooked or acute and subtriangular (1).
 - (25) Morphology of jugal (= ventral) process of postorbital (W16, U28): mediolaterally narrow (0); broader mediolaterally than rostrocaudally (1). 10
 - (26) Jugal (= ventral) process of postorbital (U31): does not contact lacrimal (jugal intervenes) (0); contacts lacrimal (excludes jugal from margin of orbit) (1).
 - (27) Squamosal (= caudal) process of postorbital (W17): present (0); absent (1).
 - (28) Frontal-parietal suture in dorsal view (W18, U34): between supratemporal fenestrae/fossae (frontals contribute to rostral margin of fenestrae/fossae) (0); rostral to supratemporal fenestrae/fossae (frontals excluded from rostral margin of fenestrae/fossae) (1).
 - (29) Midline contact (symphysis) between frontals in adults (W19, U36, C13, S31): sutured (0); fused (1).
 - (30) Ratio of rostrocaudal length:minimum mediolateral width of frontal (W20, U35): ≥ 1.0 (equal or longer than wide) (0); <1.0 (wider than long) (1).
 - (31) Dorsoventral height of occipital process of parietal (W21): short (less than diameter of foramen magnum) (0); deep (nearly twice the diameter of the foramen magnum) (1)
 - (32) Contribution to posttemporal fenestra by parietal (W22, U42): present (0); absent (1).
 - (33) Postparietal foramen (W23, U43, S26): absent (0); present (1).
 - (34) Morphology of infratemporal fenestra (C9, S6): subrectangular (0); subtriangular (1); linear (slit-like, crescentic) (2).
 - (35) Position of rostralmost or rostroventralmost end of infratemporal fenestra (W30, U29-30, C8, S32): caudal to orbit (0); rostral to caudal margin of but caudal to or equal with midpoint of orbit (1); rostral to midpoint of orbit (2).
 - (36) Ratio of intraparietal distance separating supratemporal fenestrae:length of long axis of supratemporal fenestrae (W24): <2.0 (0); ≥ 2.0 (1).
 - (37) Supratemporal fossa surrounds supratemporal fenestra (U37): present (0); absent (1).
 - (38) Orientation of long axis of external supratemporal fenestra (W25-26, U40): rostrocaudal (0); mediolateral (1) (Modified after Harris 2006; the state 2 (axis dorsoventral) correlates with reduction in lateromedial width of the fenestra (character 36)).
 - (39) Contribution by squamosal to dorsal (dorsomedial) margin of supratemporal fenestra (U44): present (0); absent (excluded by parietal-postorbital contact) (1).
 - (40) Ratio of maximum diameter of supratemporal fenestra:diameter of foramen magnum (W27, U41, C10, S30): $\gg 1.0$ (0); ~ 1.0 (subequal) (1).
 - (41) Ratio of rostrocaudal:mediolateral dimension of temporal bar (supratemporal region) (W28): ≥ 1.0 (longer rostrocaudally) (0); <1.0 (longer mediolaterally) (1).
 - (42) Lateral visibility of supratemporal fenestra (W29, U38-39): not visible (obscured by temporal bar) (0); visible (temporal bar shifted ventrally) (1).
 - (43) Maxilla-quadratojugal contact (U24, C11, S2): absent (0); present (1).
 - (44) Squamosal-quadratojugal contact (W31, U45): present (0); absent (1).
 - (45) Ratio of length of rostral (= jugal or maxillary) process of quadratojugal:length of squamosal (= dorsal) process (W32, U23): ≤ 1.0 (0); ≥ 1.0 (1).
 - (46) Rostral process of quadratojugal (U25): tapers to acute tip (0); expands dorsoventrally at tip (0).

- (47) Orientation of rostral process of quadratojugal in lateral view (U26): straight or curves slightly dorsally at tip (0); angles ventrally at tip (1).
- (48) Angle between rostral and dorsal processes of the quadratojugal (U27): roughly 90° (0); >>90° (1).
- (49) Orientation of long axis of quadrate with respect to long axis of skull (U68, C5, S5): perpendicular (0); angled caudodorsally-rostroventrally (1).
- (50) Quadrate fossa (W33-34, U66-67, C1): absent (0); shallow (1); deeply invaginated (2).
- (51) Orientation of quadrate fossa (W35): caudal (0); caudolateral (1).
- (52) Rostral articulation of vomer (W42): with maxilla (0); with premaxilla (1).
- (53) Morphology of lateral ramus of palatine (W40): plate-like (long maxillary contact) (0); rod-like (narrow maxillary contact) (1).
- (54) Rostral end of maxillary process of palatine (U57): poorly developed and unexpanded (0); mediolaterally expanded (1).
- (55) Composition of palatine (= rostral) process of pterygoid (U61): formed from two sheets of bone that project laterally and ventrally (0); formed from single, flat plate (1).
- (56) Ratio of width of main body of pterygoid:overall length of pterygoid (U62): <0.20 (0); ≥ 0.20 (1).¹³
- (57) Morphology of contact surface on pterygoid for basiptyergoid articulation (W36, U63-64): small facet (0); dorsomedially-oriented hook (1); rocker-like surface (2).
- (58) Rostrocaudal position of ectopterygoid process of pterygoid (W37, U58-59): caudal or ventral to orbit (0); between orbit and antorbital fenestra or ventral to antorbital fenestra (1); rostral to antorbital fenestra (2).
- (59) Dorsoventral position of ectopterygoid process of pterygoid (U60): projects below ventral margin of skull (usually robust) (0); does not project below ventral margin of skull (usually slender) (1).
- (60) Size of quadrate flange of pterygoid (W38): large (palatobasal and quadrate articulations well separated) (0); small (palatobasal and quadrate articulations approach) (1).
- (61) Shape of palatine ramus of pterygoid (W39): straight (at level of dorsal margin of quadrate ramus) (0); stepped (raised above level of quadrate ramus) (1).
- (62) Epiptyergoid (W41): present (0); absent (1).
- (63) Ratio of dorsoventral height of supraoccipital:height of foramen magnum (W43): ≥ 2 (0); 1.01-1.99 (1); ≤ 1 (2).
- (64) Sagittal and transverse nuchal crests merge smoothly at dorsal end of supraoccipital forming low tetrahedral process (S29): absent (0); present (1).
- (65) Distal ends of paroccipital processes (U46): flat or slightly convex laterally (0); markedly convex laterally and expanded suddenly dorsally and ventrally ('tongue-like' process present) (1).
- (66) Ventral (nonarticular) process of paroccipital process (W44): absent (0); present (1). 14
- (67) Morphology of occipital region of skull (W54): concave caudally, with paroccipital processes oriented caudolaterally (0); flat with paroccipital processes oriented mediolaterally (1).
- (68) Morphology of crista prootica (W45, U49): simple, low crest, either lacking processes or with low, non prominent, craniocaudally compressed process (0); possessing prominent, craniocaudally compressed, 'leaf-shaped' dorsolateral process (1).
- (69) Ratio of length:maximum basal diameter of basiptyergoid processes (W46, U52-53, S27): ≤ 2 (0); 2.01-3.99 (1); ≥ 4.0 (2).
- (70) Angle of divergence between basiptyergoid processes (W47, U54, S28): ≥ 30° (0); <30° (1).
- (71) Ratio of rostrocaudal depth:dorsoventral height of basal tubercula (W48, U48): ≥ 0.25 (0); <0.25 (sheet-like) (1).

- (72) Ratio of mediolateral width of paired basal tubercula:mediolateral width of occipital condyle (W49): <1.0 (0); 1.0-1.2 (1); >1.2 (2).
- (73) (Note: craniopharyngeal foramen) Basisphenoid fossa/foramen between foramen magnum and basal tubercula (W50): absent (0); present (1).
- (74) Region between basiptyergoid processes (W51, U55): shallowly concave (0); deep pit (1).
- (75) Basisphenoid-quadrate contact (W52): absent (0); present (1).
- (76) Orientation of basiptyergoid processes: roughly perpendicular to skull roof (0), extending anteriorly (1), or extending posteriorly (2), forming markedly acute angle to skull roof. Unordered. Note: the last state is newly added to describe the morphology in *Atlasaurus*, *Jobaria*, and *Spinophorosaurus*.
- (77) Cross-sectional morphology of basiptyergoid processes (U51): elliptical or subtriangular (0); subcircular (1).
- (78) Morphology of parasphenoid rostrum (U56): broadly triangular in lateral view and with groove on dorsal margin (0); slender, spike-like, and lacking dorsal groove (1).
- (79) Depth of rostral end of dentary ramus (W55, U69): decreases or maintains dorsoventral height rostrally (0); increases in dorsoventral height and robustness rostrally (1).
- (80) Morphology of rostroventral margin of dentary (W56, U70): gently rounded (0); sharply projecting triangular process ('chin') (1).
- (81) Angle between dentary symphysis and long axis of jaw ramus (W57, U71): <75° (0); >75° (close to perpendicular) (1).
- (82) Ratio of length of external mandibular fenestra:length of mandible (W58, U76-77): ≥ 0.10 (0); <0.10 (1); absent (2).
- (83) Ratio of surangular dorsoventral depth:maximum depth of angular (W59, U75): <2.0 (0); ≥ 2.0 (1).
- (84) Ridge on surangular separating adductor and articular fossae (W60): absent (0); present (1).
- (85) Depth of medial wall of adductor fossa (W61): shallow (0); deep, with prearticular expanded dorsoventrally (1).
- (86) Position of rostral end of splenial relative to mandibular symphysis (U72): caudal to (0); participates in symphysis (1).
- (87) Position of caudal process of splenial (W62, U74): overlaps angular (0); separating rostral portions of prearticular and angular (1). 16
- (88) Caudodorsal process of splenial (W63, U73): present, approaching margin of adductor chamber (0); absent (1).
- (89) Size of coronoid (W64): extends to dorsal margin of jaw (0); reduced, does not extend to splenial (1); absent (2).
- (90) Plate of bone lying lateral to teeth on premaxilla, maxilla, and dentary (U9): absent (0); present (1).
- (91) Position in tooth row of largest teeth (U78): mid-length along maxilla (0); rostral end of jaws (1).
- (92) Number of dentary teeth (W73, U91): ≥ 18 (0); ≤ 17 (1).
- (93) Length of tooth rows (W66, U94-95): extends to orbit (0); rostral to orbit but caudal to subnarial foramen (1); restricted rostral to subnarial foramen (2).
- (94) Occlusal pattern (W67-68): absent (0); interlocking (creating V-shaped facets) (1); planar facets at markedly acute angle to long axis of tooth (high-angled) (2); planar facets at roughly 90° angle to long axis of tooth (low-angled) (3).
- (95) Orientation of tooth crowns (W69, U80): aligned along jaw axis (crowns do not overlap) (0); aligned slightly rostrolingually (tooth crowns overlap) (1).
- (96) Contact between adjacent tooth crowns (U81): present (0); absent (1).

- (97) Ratio of length of worn tooth crown:width of lingual face (= 'slenderness index') (U87-89): ≤ 3.0 (crowns expanded; teeth spatulate) (0); 3.01-3.99 (1); ≥ 4.0 (2).
- (98) Cross-sectional shape of worn tooth crowns at mid-crown (W70, U84-85, U92, C2, S1): elliptical (convex both labially and lingually) (0); D-shaped (convex labially, flat or concave lingually) (1); circular (spatulate crown wears away leaving facet on root = 'pencil-' or 'peg-like' tooth morphology) (2).
- (99) Enamel surface texture (W71, U79): smooth (0); wrinkled (1).
- (100) Marginal tooth denticles (W72, U82-83, C3): present (0); absent on distal margin only (1); absent on both mesial and distal margins (2).
- (101) Number of replacement teeth per alveolus (W74, U90): ≤ 2 (0); ≥ 3 (1).
- (102) Orientation of teeth (W75, U93): perpendicular to jaw margin (0); oriented rostrally with respect to jaw margin (procumbent) (1).
- (103) Longitudinal grooves on lingual face of tooth (W76): absent (0); present (1).
- (104) Prominent grooves near mesial and distal margins of labial surface of tooth crowns (U86): absent (0); present (1).
- (105) Number of cervical vertebrae (W80, U96-100, S25): ≤ 9 (0); 10 (1); 11 (2); 12 (3); 13 (4); 14 (5); ≥ 15 (6). 18
- (106) Shape of occipital facet of atlantal intercentrum (W79, U101): rectangular in lateral view (dorsal and ventral lengths subequal) (0); wedge-shaped (craniocaudal length of ventral margin greater than that of dorsal margin) (1).
- (107) Morphology of articular facets of cervical vertebral bodies (W82, U103): amphicoelous/amphiplatyan (0); opisthocoelous (1).
- (108) Morphology of cervical lateral pneumatic fossae (W78, W83, U110, C15, S33): absent (0); simple, undivided (1); simple and undivided in cranial cervicals but becoming complex (divided by bony septa) in caudal cervicals, producing numerous, laterally visible foramina (2); complex (with numerous, laterally visible foramina) in all (post-axial) cervicals (3).
- (109) Morphology of ventral surface of cervical vertebral bodies (U106-107): with prominent sagittal keels (0); flat or mildly convex ventrally (1); concave ventrally (longitudinal sulcus present) (2).
- (110) Fossae on dorsal surface of costolateral eminences of cervical vertebrae (U109): absent (0); present and confluent with lateral pneumatic fossa (1); present but separated from lateral pneumatic fossa by ridge (2).
- (111) Lamination (especially corporodiapophyseal) of cervical vertebral arches (W81, U115-116): well developed with well defined lamina and fossae (0); rudimentary; diapophyseal laminae only feebly developed or absent (1).
- (112) Ratio of caudal articular surface height:width of cranial cervical vertebral bodies (W84, U108): <1.25 (0); ≥ 1.25 (1).
- (113) Angulation of spinous process on cranial cervical vertebrae (C18): dorsal (vertical) or craniodorsal (0); caudodorsal (1). 19
- (114) Ratio of craniocaudal vertebral body length:dorsoventral height of caudal face of middle cervical vertebral bodies (W86, U102): <4.0 (0); ≥ 4.0 (1).
- (115) Ratio of dorsoventral height of middle cervical vertebral arches:dorsoventral height of caudal articular facet of vertebral body (W87, U111-112, C16): <1.0 (0); ≥ 1.0 (1).
- (116) Morphology of cranial corporozygapophyseal lamina on middle and caudal cervical vertebral arches (W88, U113): single (0); divided (= cranial infrazygapophyseal fossae present) (1); consists of two parallel laminae (2).
- (117) Morphology of articular surfaces of cranial zygapophyses on middle and caudal cervical vertebrae (U114): flat (0); transversely convex (1).

- (118) Cervical spinous process height (U117): low (height of vertebra subequal to or less than length of vertebral body) (0); high (height of vertebra greater than length of vertebral body) (1).
- (119) Bifurcation of cervical vertebral spines (W85, C17, S34): absent (0); present only on caudal cervicals (1); present on middle cervicals (to C6) (2); present on cranial cervicals (cranial to C6) (3).
- (120) Morphology of caudal cervical and cranial thoracic spinous processes (W89-90, U118, C17): single (0); bifid but lacking pseudospinous tuberculum (1); bifid with sagittal pseudospinous tuberculum (2). 20
- (121) Orientation of caudal margin of spinous processes on caudal cervical vertebrae with respect to craniocaudal axis of vertebral body (U119): nearly vertical (0); slopes craniodorsally-caudoventrally (1).
- (122) Number of thoracic vertebrae (W91, U122-125): 15 (0); 14 (1); 13 (2); 12 (3); 11 (4); ≤ 10 (5).
- (123) Lateral pneumatic fossae in majority of thoracic vertebral bodies (W78, U128-129, C22): absent (0); present as deep but simple pits (1); present as deep excavations that ramify into vertebral body and into base of vertebral arch (leaving only thin septum in body midline) (2).
- (124) Lateral position of lateral pneumatic foramina on thoracic vertebral bodies (U130): absent (0); flush with lateral surface (no lateral pneumatic fossa) (1); set within lateral pneumatic fossa (2).
- (125) Cranial face of thoracic vertebral arches (U136): flat or shallowly excavated (0); deeply excavated (1).
- (126) Hypantrum-hyposphene articulations on thoracic vertebrae (W106, U145, C23, S15): absent (0); present on middle and/or caudal thoracics only (1); present on cranial-caudal thoracics (2).
- (127) Single midline lamina extending ventrally from hyposphene in thoracic vertebrae (U146): absent (0); present (1).
- (128) Thoracic vertebrae with spinodiapophyseal lamina (W99, U156-157): none (0); on caudal thoracics only (1); on middle and caudal thoracics (2).
- (129) Accessory spinodiapophyseal lamina on thoracic vertebrae with non-bifid spinous processes (U151): absent (0); present (1). 21
- (130) Postspinal lamina on thoracic vertebrae with non-bifid spinous processes (U149, C27): absent (0); present (1).
- (131) Orientation of transverse processes on thoracic vertebrae (U138, S35): lateral or slightly dorsal (0); strongly dorsolateral (approximately 45° to horizontal) (1).
- (132) Morphology of articular face of cranial thoracic vertebral bodies (W94, U104): amphicoelous (0); opisthocoelous (1).
- (133) Morphology of caudal margins of lateral pneumatic fossae on cranial thoracic vertebrae (U127, C29): rounded (0); acute (1).
- (134) Morphology of ventral surfaces of cranial thoracic vertebral bodies (U126): ventrally convex (0); flat (1); with sagittal crest (creating two ventrolaterally-facing surfaces) (2); ventrally concave with sagittal crest in resultant sulcus (3).
- (135) Cranial corporozygapophyseal lamina on cranial thoracic vertebrae (U134): consists of single lamina (0); bifurcate toward upper end (= cranial infrazygapophyseal fossa present) (1).
- (136) Orientation of spinous processes of cranial thoracic vertebrae (U158): dorsal or caudodorsal (0); craniodorsal (1).
- (137) Ratio of dorsoventral height of vertebral arch:dorsoventral height of thoracic vertebral body (W93, U132, C20, C24, C28, S9): ≤ 1.0 (0); >1.0 (1).

- (138) Morphology of cranial corporozygapophyseal lamina on middle and caudal thoracic vertebral arches (U135): single (0); bifurcate toward upper end (= cranial infrazygapophyseal fossa present) (1).
- (139) Cranial corporoparapophyseal lamina on middle and caudal thoracic vertebral arches (W96, U133): absent (0); present (1).
- (140) Cranial zygaparapophyseal lamina on middle and caudal thoracic vertebral arches (W97): absent (0); present (1).
- (141) Caudal corporoparapophyseal lamina on middle and caudal thoracic vertebral arches (W98, U137): absent (0); present (1).
- (142) Morphology of the distal ends of the transverse processes in thoracic vertebrae (U140): transitions smoothly and uninterrupted onto dorsal surface of transverse process (0); possesses distinctive, elevated area with its own dorsally-facing surface that is connected to the dorsal surface of the remaining process only by a sloping region (1).
- (143) Lamination on cranial face of (non-bifid) spinous process of middle and caudal thoracic vertebrae (U148, C26): none (0); prespinal lamina present, cranial spinozygapophyseal laminae absent (1); prespinal lamina absent, cranial spinozygapophyseal laminae present (2); both prespinal and cranial spinozygapophyseal laminae present and connected to each other either directly (merging) or via accessory laminae (3); both prespinal and cranial spinozygapophyseal laminae present but unconnected to each other (4).
- (144) Caudal zygapophyses of middle and caudal thoracic vertebrae supported dorsally by (W100, W101, U147, U150): caudal margin of alaminar spinous process only or no dorsal support (0); separate caudal spinozygapophyseal laminae unconnected to postspinal lamina via accessory laminae (1); separate caudal spinozygapophyseal laminae connected to postspinal lamina at proximal end either directly or via accessory laminae (2).
- (145) Infradiapophyseal fossa on thoracic vertebral arches (W103, U144): absent (0); present (1).
- (146) Spinodiapophyseal and caudal spinozygapophyseal laminae on middle and caudal thoracic vertebrae contact each other (W101): absent (0); present (1).
- (147) Supraneural pneumatic cavity within some or all thoracic vertebral arches (U141): absent (0); present but not open externally (1); present and open externally via foramen (2).²⁵
- (148) Triangular, aliform processes projecting laterally from distal ends of middle and caudal (= non-bifurcate) thoracic spinous processes (W102, U153-154): absent (0); present but do not project far laterally (not as far as caudal zygapophyses) (1); present and project far laterally (as far as caudal zygapophyses) (2).
- (149) Orientation of middle and caudal thoracic spinous processes (W104): vertical (0); caudal (distal end approaches level of diapophyses) (1).
- (150) Morphology of articular face of caudal thoracic vertebral bodies (W105, U105, C25): amphicoelous/amphiplatyan (0); opisthocoelous (1).
- (151) Cross-sectional morphology of caudal thoracic vertebral bodies (U131): subcircular (0); dorsoventrally compressed (1).
- (152) Ventral end of caudal corporodiapophyseal lamina of caudal thoracic vertebrae (U142): unexpanded (0); expands and may bifurcate (1).
- (153) Position of transverse process on caudal thoracic vertebrae (U139): caudal or caudodorsal to costolateral eminence (0); dorsal to costolateral eminence (1).
- (154) Ratio of mediolateral width:craniocaudal length of caudal (non-bifid) thoracic spinous processes (W92, U152): ≤ 1.0 (longer than wide) (0); >1.0 (wider than long) (1).
- (155) Morphology of caudal thoracic spinous processes in cranial view (W107, U155): rectangular for most of its length with little or no lateral expansion (except at distal end)

- (0); progressively expanding mediolaterally through most or all of its length ('petal' or 'paddle' shaped) (1).
- (156) Number of sacral vertebrae (W108, U161-163): ≤ 3 (0); 4 (1); 5 (2); ≥ 6 (3). 26
- (157) Sacricostal yoke (W109): absent (0); present (1).
- (158) Ratio of maximum mediolateral width across sacral vertebrae and ribs: average length of sacral vertebral body (U164): <4.0 (0); ≥ 4.0 (1).
- (159) Lateral pneumatic fossae and/or foramina in sacral vertebral bodies (U165): absent (0); present (1).
- (160) Ratio of proximodistal length of sacral spinous processes: craniocaudal length of vertebral body (W111): <2.0 (0); 2.0-3.49 (1); ≥ 3.50 (2).
- (161) Dorsoventral length of sacral ribs (W112, U168): low (not projecting beyond dorsal margin of ilium) (0); high (extending to or beyond dorsal margin of ilium) (1).
- (162) Caudal vertebral bone internal construction (W113): solid (0); spongy (with large internal cells) (1).
- (163) Number of caudal vertebrae (W114, U170): ≤ 35 (0); 36-60 (1); ≥ 61 (2).
- (164) Ratio of height of spinous process: dorsoventral height of caudal articular facet of vertebral body in caudal thoracic, sacral and proximal caudal vertebrae (U166-167, C33, S19, S36): <2.0 (0); 2.0-3.0 (1); >3.0 (2).
- (165) Caudal vertebral transverse processes (ribs) (W115, U193): persist through caudal vertebra 20 or farther distally (0); disappear by caudal 15 (1); disappear by caudal 10 (2).
- (166) Morphology of articular face of first caudal vertebral body (W116, U171): flat (0); procoelous (1); opisthocoelous (2); biconvex (3). 27
- (167) Spinous process of first caudal vertebra (W117): simple and alaminar or single fossa on lateral aspect (0); complex system of laminae, resembling spines of thoracics ('dorsalized') (1).
- (168) Morphology of articular face of proximal caudal vertebral bodies (excluding first) (W118, U173-174, C30, S16): amphiplatyan or platycoelous (0); weakly procoelous (1); strongly procoelous (2); opisthocoelous (3).
- (169) Morphology of articular surfaces in proximal caudal vertebral bodies (U172): subcircular (0); dorsoventrally compressed (1); mediolaterally compressed (2).
- (170) Pneumatopores (lateral pneumatic fossae and/or foramina) on proximal caudal vertebral bodies (W119, U181, C31): absent (0); present (1).
- (171) Length of caudal vertebral bodies (W120, U178): ~same over first 20 (0); doubling over first 20 (1).
- (172) Ratio of proximodistal length: dorsoventral height of proximal caudal vertebral body (U177): ≥ 0.6 (0); <0.6 (1).
- (173) Cranial spinozygapophyseal lamina on proximal caudal vertebral arches (W121, U188): absent (0); present and extending onto lateral aspect of spinous process (1).
- (174) Cranial and caudal spinozygapophyseal laminae contact on proximal caudal vertebral arches (W122, U188): absent (0); present (1).
- (175) Prespinal lamina on proximal caudal vertebral arches (W123, U188): absent (0); present (1).
- (176) Postspinal lamina on proximal caudal vertebral arches (W124, U188): absent (0); present (1).
- (177) Postspinal fossa on proximal caudal vertebral arches (W125, U188): absent (0); present (1).
- (178) Hyposphenal ridge on proximal caudal vertebrae (U187): absent (0); present (1).
- (179) Transverse process morphology on proximal caudal vertebrae (W128, U190-192, C32, S11): simple, flattened processes (0); triangular or aliform process (connected via

- laminae to vertebral arch) on caudal 1 only (1); triangular or aliform processes through caudal 3 (2); triangular or aliform processes on or beyond caudal 4 (3).
- (180) Dorsoventral extent of proximal end of transverse processes on proximal caudal vertebrae (W127): shallow (on vertebral body only) (0); deep (extending from vertebral body to vertebral arch) (1).
- (181) Diapophyseal laminae (= proximal and distal corporodiapophyseal laminae and cranial and caudal zygadiapophyseal laminae) on proximal caudal transverse processes (W129): absent (0); present (1).
- (182) Morphology of proximal corporodiapophyseal lamina on proximal caudal transverse processes (W130): single (0); divided (1).
- (183) Ratio of mediolateral width:proximodistal length of proximal caudal spinous processes (W126, U189): ≤ 1.0 (longer than wide) (0); >1.0 (wider than long) (1). 29
- (184) Ratio of vertebral body length:height in middle caudal vertebrae (U179): <2.0 (0); ≥ 2.0 (1).
- (185) Sharp ridge on lateral surface of middle caudal vertebral bodies at arch-body junction (U186): absent (0); present (1).
- (186) Morphology of articular surfaces in middle caudal vertebral bodies (W131, U184): subcircular (0); flat dorsal and ventral surfaces (~ quadrangular) (1).
- (187) Ventral longitudinal sulcus on proximal and middle caudal vertebral bodies (W132, U182-183): absent (0); present (1).
- (188) Morphology of proximal articular face of middle and distal caudal vertebral bodies (W134, U175): amphicoelous/amphiplatyan (0); procoelous (conical) (1); opisthocoelous (2).
- (189) Position of vertebral arches over vertebral bodies on middle caudal vertebrae (U185, C35): straddles midpoint (significant portions located on either side of midpoint) (0); located mostly or entirely over proximal half of body (1).
- (190) Orientation of middle caudal spinous processes (W133): distodorsal (0); vertical (1).
- (191) Morphology of distal caudal vertebral bodies (W135): cylindrical (0); flattened dorsoventrally (at least 2x as wide mediolaterally as tall dorsoventrally) (1).
- (192) Number of anarcuate, distal caudal vertebrae (W136, W138, U176): ≤ 10 (0); ≥ 30 (1).
- (193) Morphology of articular surfaces of anarcuate ('whiplash') distal caudal vertebrae (W136, W138, U176): absent (0); amphiplatyan (1); proximo- or distoplatyan (2); biconvex (3). 30
- (194) Ratio of distalmost caudal vertebral body length:width (W137, U180, C36, S8): ≤ 4.0 (0); 4.01-4.99 (1); ≥ 5.0 (2). Ordered.
- (195) Angle between tuberculum and capitulum costae of cervical ribs (W139, U121): greater than 90° (0); less than 90° (rib ventrolateral to vertebral body) (1).
- (196) Length of cervical rib bodies (W140, U120): much longer than vertebral body (overlapping as many as three subsequent vertebrae) (0); slightly longer, equal to, or shorter than vertebral body (little or no overlap) (1).
- (197) Proximal pneumatopores on thoracic ribs (W141, U160): absent (0); present (1).
- (198) Morphology of proximal ends of cranial thoracic ribs (U159): shallowly concave on both cranial and caudal faces (0); strongly convex cranially and deeply concave caudally (1).
- (199) Cross-sectional shape of cranial thoracic ribs (W142): subcircular (0); 'plank'-like (craniocaudal dimension $>3x$ mediolateral dimension) (1).
- (200) Haemal arch persistence (W147): throughout at least 80% of tail (0); disappearing by caudal 30 (1).
- (201) Morphology of haemal arches on middle and distal caudal vertebrae (W143-144, U197-198, S17): simple or curve caudoventrally (forming caudal process) (0); develop small

- cranial process (1); cranial and caudal processes elongate so arch is proximodistally much longer than tall dorsoventrally ('skid-like') (2).
- (202) Ratio of haemal canal dorsoventral height:total haemal arch length (W146, U196): <0.30 (0); ≥ 0.30 (1). 31
- (203) 'Crus' bridging proximal margin of haemal canal (W145, U194-195, C34, S18): present in proximal through distal haemal arches (0); present in proximal arches but absent in middle and distal arches (1); absent in proximal through distal arches (2).
- (204) Distal ends of distal haemal arches (W148, U199, C37): fused (0); unfused (open) (1).
- (205) Ratio of forelimb:hindlimb length (W149, U214-215): ≤ 0.6 (0); 0.6-0.74 (1); ≥ 0.75 (2).
- (206) Ratio of humerus:femur proximodistal length (W172, U216, C48, S12): <0.60 (0); 0.60-0.89 (1); ≥ 0.90 (2).
- (207) Position of dorsalmost point of acromion process of scapula: closer to level of glenoid fossa than to level of midpoint of scapular body (0); equidistant between or closer to level of midpoint of scapular body than to level of glenoid fossa (1).
- (208) Size of scapular acromion (W150, U200): small and narrow (0); broad (dorsoventral width more than 150% minimum width of scapular body) (1).
- (209) Deltoid crest (= crest of acromion process) (U201): absent (0); present (1).
- (210) Morphology of portion of acromion caudal to deltoid crest (U202): flat or convex and decreases in mediolateral thickness toward caudal margin (0); forms distinct fossa (1).
- (211) Orientation of scapular body with respect to coracoid articulation (W151): roughly perpendicular (0); roughly 45° angle (1).
- (212) Morphology of scapular body (W152, U206, C38, S19): acromial (dorsal) edge not expanded (parallels long axis of body) (0); acromial edge with rounded dorsal expansion caudal to acromion but cranial to distal end (1); distal end racquet-shaped (dorsoventrally expanded) (2). 32
- (213) Orientation of scapular glenoid fossa (W153, U203): flat or facing laterally (0); strongly bevelled medially (1).
- (214) Cross-sectional shape of proximal end of scapular body (W154): flat or rectangular (0); D-shaped (1).
- (215) Dorsal ridge on medial surface of scapular body (U204): absent (0); present (1).
- (216) Ventral ridge on medial surface of scapular body (U205): absent (0); present (1).
- (217) Ratio of craniocaudal length of coracoid:maximum length of scapula-coracoid articulation (W155): <1.5 (articular surface longer) (0); ≥ 1.5 (craniocaudal length longer) (1).
- (218) Morphology of craniodorsal margin of coracoid (W156, U208): rounded (cranial and dorsal margins grade into one another) (0); rectangular (meet at abrupt angle) (1).
- (219) Position of dorsal margin of coracoid with respect to dorsal margin of scapula (U207): equal or dorsal to acromion (0); ventral to acromion and separated from it by V-shaped notch (1).
- (220) Infraglenoid lip of coracoid (W157): absent (0); present (1).
- (221) Morphology of sternal plate (W158, U210, C39): ovoid (0); triangular due to presence of acute cranial projection (1); elliptical with concave lateral margin (2).
- (222) Ratio of maximum length of sternal plate:length of humerus (U209): <0.75 (0); ≥ 0.75 (1).
- (223) Ridge on ventral surface of sternal plate (U213): absent (0); present (1). 33
- (224) Prominent caudolateral expansion of sternal plate producing reniform profile in dorsal view (U211): absent (0); present (1).
- (225) Prominent proximolateral process on humerus (W159, U218): present (proximal end of humerus markedly convex in cranial view) (0); absent (proximal end of humerus flat or gently sinusoidal in cranial view) (1).

- (226) Supracoracoideus tuberculum on proximolateral portion of humerus (U217): absent (0); present (1).
- (227) Development of humeral deltopectoral crest (W160, U219): prominent (0); reduced to low crest or ridge (1). 34
- (228) Position of deltopectoral crest (U220): restricted to lateral edge of humerus (0); expanded medially across cranial face of humerus (1).
- (229) Morphology of humeral deltopectoral crest (W161): relatively narrow throughout length (0); markedly expanded distally (1).
- (230) Cross-sectional shape of humerus at mid-shaft (W162): circular (0); elliptical with long axis oriented transversely (1).
- (231) Extent of distal articular surface of humerus (W163, U222): restricted to distal end (articular surface flat) (0); exposed on cranial and caudal portions of humeral shaft (forming convex articular surface) (1).
- (232) Distocaudal surface of humerus (U221): shallowly concave (0); deeply concave, bounded between prominent vertical ridges (1).
- (233) Morphology of distal humeral articular surface (W164): divided (0); flat (separate condyles indistinct) (1).
- (234) Morphology of proximal ulna (W165, U223): subtriangular (0); triradiate with deep radial fossa (1).
- (235) Morphology of articular surface of craniomedial process of ulna in cranial view (U224): flat (0); strongly concave on proximal surface (1).
- (236) Relative length of proximal ulnar condylar processes (W166): subequal (0); unequal (with cranial process longer) (1).
- (237) Development of ulnar olecranon process (W167): prominent (projecting beyond proximal articular surface) (0); rudimentary (level with proximal articular surface) (1).
- (238) Ratio of proximodistal length:proximal breadth of ulna (W168): gracile (0); stout (1). 35
- (239) Ratio of maximum diameter of proximal end of radius:radius length (U225): <0.30 (0); ≥ 0.30 (1).
- (240) Morphology of distal condyle of radius (W169, U226): round (0); subrectangular (flattened caudally and articulating on cranial side of ulna) (1).
- (241) Ratio of distal:midshaft breadth of radius (W170): <1.50 (0); 1.50-1.90 (1); >1.90 (2).
- (242) Orientation of distal radial condyle with respect to long axis of shaft (W171): perpendicular (0); bevelled approximately 20° proximolaterally (1).
- (243) Number of ossified carpal bones (W173, U228-230): ≥ 3 (0); 2 (1); 1 (2); none (3).
- (244) Morphology of carpal bones (W174, U227): round (0); blocky (with flattened proximal and distal articular surfaces) (1).
- (245) Morphology of metacarpus (W175, U235): spreading (0); bound (with subparallel shafts and articular surfaces extending half their length) (1).
- (246) Morphology of proximal surface of metacarpals in articulation (W176): gently curving to form 90° arc (0); U-shaped (subtending arc of 270°) (1).
- (247) Triangular, striated areas for ligament attachment on proximal parts of metacarpal shafts (U236): absent (0); present (1).
- (248) Ratio of length of longest metacarpal:length of radius (W177, U233, C49): <0.35 (0); 0.35-0.45 (1); >0.45 (2).
- (249) Ratio of length of metacarpal I:lengths of metacarpal II or III (whichever is longest) (U232): ≤ 1.0 (0); >1.0 (McI is longest metacarpal) (1).
- (250) Ratio of length of metacarpal I:length of metacarpal IV (W178, U231): <1.0 (0); ≥ 1.0 (1).
- (251) Morphology of distal condyle of metacarpal I (W179): divided (0); undivided (1). 36
- (252) Ratio of length of metacarpal V:length of longest metacarpal (U234): <0.90 (0); ≥ 0.90 (1).

- (253) Orientation of mediolateral axis of metacarpal I distal condyle with respect to axis of shaft (W180): bevelled $\sim 20^\circ$ proximodistally (0); perpendicular (1).
- (254) Manual phalangeal formula (W181, U238-239, U241): 2-3-4-3-2 or more (0); reduced to 2-2-2-2-2 or fewer (1); completely absent or unossified (2).
- (255) Morphology of manual phalanx I-1 (W182): rectangular (0); wedge-shaped (1).
- (256) Ratio of proximodistal length:mediolateral width of manual nonungual phalanges (W183, U237): >1.0 (longer than wide) (0); <1.0 (wider than long) (1).
- (257) Size of ungual on manual digit I (U240): large (at least 50% length of metacarpal I) (0); reduced ($<25\%$ length of metacarpal I) or absent (1).
- (258) Cranial mediolateral dimension of pelvis (W184): narrow (ilia longer craniocaudally than distance separating preacetabular processes) (0); wide (distance between preacetabular processes exceeds craniocaudal dimension of ilia) (1).
- (259) Morphology of dorsal margin of ilium body (in lateral view) (W186, U247): flat, sigmoid, or gently convex (0); semicircular (markedly convex) (1).
- (260) Position of dorsalmost point on ilium (U245): caudal or dorsal to base of pubic process (0); cranial to base of pubic process (1).
- (261) In lateral view, the cranioventralmost point on the iliac preacetabular process (W188, U244, C40): is also the cranialmost point (preacetabular process is pointed) (0); is caudal to the cranialmost part of process (process is semicircular with caudoventral excursion of cartilage cap) (1).
- (262) Orientation of preacetabular ala of ilium with respect to axis of body (W187, U242-243): cranial in vertical plane (0); craniolateral in vertical plane (1); craniolateral and cranial edge curls laterally into horizontal plane (2).
- (263) Size of ischiadic peduncle of ilium (W185, U248): large and prominent (long axis of ilium roughly horizontal) (0); low and rounded (long axis of ilium oriented craniodorsally-caudoventrally) (1).
- (264) Projected line (chord) connecting articular surfaces of ischiadic and pubic processes of ilium (U249): passes ventral to ventral margin of postacetabular portion of ilium (0); passes through or dorsal to ventral edge of postacetabular portion of ilium (1).
- (265) Brevis fossa on postacetabular ala of ilium (U246): present (0); absent (1).
- (266) Development of ambiens process of pubis (W189, U250, C42, S20): absent or small, striated area confluent with cranial margin of pubis (0); prominent and projecting cranial to cranial margin of pubis ('hook-like') (1).
- (267) Morphology of pubic 'apron' (W190, U252): flat (with straight symphysis, proximal end in parasagittal plane but middle and distal ends in mediolateral plane) (0); canted craniomedially (middle and distal ends in same plane as proximal end; gently sigmoid symphysis and V-shaped in cross section at body midlength) (1).
- (268) Ratio of length of puboischiadic contact:proximodistal length of pubis (W191, U253, C41): <0.40 (0); ≥ 0.40 (1).
- (269) Ratio of proximodistal length of ischium body:length of pubis body (W192, U251, C45): <0.90 (0); ≥ 0.90 (1). 38
- (270) Tuberosity on lateral surface of iliac process of ischium (U255): absent (0); present (1).
- (271) Projected line (chord) of long axis of ischium body in articulation with ilium (U259): passes through lower part of acetabulum or upper part of pubic articular surface (long axis of ischium $\sim 60^\circ$ to horizontal) (0); passes through upper part of acetabular margin or approaches rim of iliac articulation (long axis of ischium $\sim 80^\circ$ to horizontal) (1).
- (272) Morphology of ischium body distal to pubic process (W193, U254, C46): emarginate (sagittal notch) (0); not emarginated (1).
- (273) Morphology of distal shaft of ischium (W194, U260): craniocaudal depth increases medially but not laterally (0); blade-like (craniocaudal depths on both medial and lateral sides subequal) (1).

- (274) Ratio of mediolateral width of distal end of ischium:proximodistal length of ischium (U256): ≤ 0.15 (0); >0.15 (1).
- (275) Ratio of mediolateral width:craniocaudal thickness of distal end of ischium body (U260): <2.0 (0); ≥ 2.0 (1).
- (276) Cross-sectional morphology of articulated distal ischial bodies (W195, U258, C43, S22): V-shaped (forming marked angle to one another) (0); flat (nearly coplanar) (1).
- (277) Expansion of distal end of ischium body (U257, C44, S21): slight (0); strong dorsoventrally (1).
- (278) Morphology of cranial face of femoral body in lateral view (U266): convex (0); straight (1).
- (279) Orientation of femoral caput in cranial view (U263): medial or ventromedial (0); dorsomedial (1). 39
- (280) Position of fourth trochanter on femoral body (U268): on caudal surface, near midline (0); on caudomedial margin (1).
- (281) Development of fourth trochanter of femur (W196, U269): prominent and blade-like (0); reduced to low crest or ridge (1).
- (282) Position of distal tip of fourth trochanter (U267): lies above midshaft height (0); lies at or below midshaft height (1).
- (283) Morphology of lesser trochanter of femur (W197, U261-262): well-developed ridge or plate (0); weakly developed ridge or plate (1); absent (2).
- (284) Ratio of mediolateral:craniocaudal diameter of femur at midshaft (W198, U270): <1.25 (~ 1.0) (0); 1.25-1.50 (1); ≥ 1.85 (2).
- (285) Morphology of lateral margin of femoral shaft in cranial or caudal view (W199, U265, C47): straight (0); proximal 1/3 deflected medially (1).
- (286) Morphology of middle and distal portion of femoral body in cranial view (U264): sigmoid (0); straight (1).
- (287) Relative mediolateral breadth of distal femoral condyles (W200, U271): subequal (0); tibial condyle much broader than fibular condyle (1).
- (288) Orientation of femoral distal condyles with respect to femoral shaft (W201): perpendicular or slightly bevelled dorsolaterally (0); bevelled dorsomedially $\sim 10^\circ$ (1).
- (289) Morphology of articular surface of femoral distal condyles (W202, U272): restricted to distal portion of femur (0); expanded onto cranial and caudal portion of femoral shaft (surfaces visible in cranial and caudal views) (1).
- (290) Ratio of tibia:femur length (U273): ≥ 0.70 (0); <0.70 (1). 40
- (291) Morphology of tibial proximal condyle (W203, U274): longer craniocaudally than mediolaterally by at least 15% (0); expanded mediolaterally (craniocaudal and mediolateral dimensions $<15\%$ each other) (1).
- (292) Tibial cnemial crest (U275): prominent (0); reduced to low ridge (1).
- (293) Orientation of tibial cnemial crest (W204, U276): projects cranially (fibula entirely visible in cranial view) (0); projects craniolaterally or laterally (obscures part of fibula in cranial view) (1).
- (294) Ratio of distal mediolateral dimension of tibia:midshaft mediolateral dimension (W205): <2.0 (0); ≥ 2.0 (1).
- (295) Size of distal caudoventral process of tibia (W206, U278): broad mediolaterally (covering caudal fossa of astragalus) (0); shortened mediolaterally (caudal fossa of astragalus visible caudally) (1).
- (296) Distal end of tibia (U277): wider mediolaterally than craniocaudally (0); roughly equal mediolateral and craniocaudal dimensions (1).
- (297) Development of proximal tibial scar on fibula (W207, U279): not well marked (0); well marked and widening craniocaudally toward proximal end (1). 42

- (298) Morphology of *M. flexor digitorum longus* sulcus and tuberculum of fibula (W208, U281): absent (0); present and ovoid (tuberculum angled) (1); present, fossa bounded by two vertically elongate, parallel ridges (tuberculum linear) (2).
- (299) Size of distal condyle of fibula (W209): subequal to shaft (0); expanded mediolaterally (>2x midshaft mediolateral dimension) (1).
- (300) Morphology of astragalus (W210, U284): rectangular (0); wedge-shaped (with reduced craniomedial corner) (1).
- (301) Craniocaudal dimension of astragalus as seen in dorsal view (U285): widens medially (0); narrows medially (1).
- (302) Morphology of ventral surface of astragalus (U282): flat or slightly concave mediolaterally (0); convex mediolaterally (1).
- (303) Vascular foramina at base of ascending process of astragalus (W211, U286): present (0); absent (1).
- (304) Extent of ascending process of astragalus (W212, U283): terminates cranial to caudal edge (0); extending to caudal margin (1).
- (305) Morphology of caudal fossa of astragalus (W213, U287): undivided (0); divided by vertical, caudomedially-oriented crest (1).
- (306) Ratio of mediolateral width:maximum craniocaudal length of astragalus (W214): ≤ 1.25 (dimensions subequal) (0); >1.25 (1).
- (307) Ossified calcaneum (W215, U288): present (0); absent or unossified (1).
- (308) Ossified distal tarsals 3 and 4 (W216, U289): present (0); absent (1).
- (309) Posture of metatarsus (W217, U291): bound (0); spreading (1). 43
- (310) Angle between long axis of body of metatarsal I and plane of proximal articular surface as seen in cranial view (W218): perpendicular (0); angled ventromedially (1).
- (311) Angle between long axis of body of metatarsal I and plane of distal articular surface as seen in cranial view (W219): perpendicular (0); angled dorsomedially (1).
- (312) Caudolateral projection of distal condyle of metatarsal I (W220, U293, S23): absent (0); present (1).
- (313) Size of metatarsal I (W221, U292): slender, reduced, or absent (0); robust (ratio of length:mediolateral width of proximal end ≤ 1.5) (1).
- (314) Rugosities on distal parts of dorsolateral portions of bodies of metatarsals I-III (U294): absent (0); present (1).
- (315) Size of proximal condyles of metatarsals I and V compared to metatarsals II, III, and IV (W222, U296): smaller than (0); subequal to (1).
- (316) Ratio of length of metatarsal III:length of tibia (W223, U290, U295): ≥ 0.40 (0); 0.26-0.39 (1); ≤ 0.25 (2).
- (317) Ratio of minimum mediolateral shaft diameters of metatarsals III and IV:minimum mediolateral shaft diameters of metatarsals I or II (W224, U297): ≥ 0.65 (0); <0.65 (1).
- (318) Ratio of length of metatarsal V:length of metatarsal IV (W225, U298): <0.70 (usually $<<0.70$) (0); ≥ 0.70 (1).
- (319) Relationship of plantar to proximal surface of pedal phalanx I-1 (U301): meet at $\sim 90^\circ$ angle (0); meet at acute angle (area drawn into thin plate that projects caudal to distal condyles of metatarsal I) (1). 44
- (320) Collateral ligament foveae on non-ungual pedal phalanges (U302): present (0); absent (1).
- (321) Ratio of maximum proximodistal:mediolateral dimensions of pedal nonungual phalanges (W226, U304): >1.0 (longer than wide) (0); ≤ 1.0 (wider than long) (1).
- (322) Development of penultimate phalanges of pedal digits II-IV (W227, U305): subequal in size to more proximal phalanges (0); rudimentary or absent (1).
- (323) Morphology of pedal phalanx II-2 (U303): square or rectangular in dorsal view (0); reduced craniocaudally, irregular in shape, and semicircular in dorsal view (1).

- (324) Number of phalanges on pedal digit IV (U299-300): ≥ 4 (0); 3 (1); ≤ 2 (2).
- (325) Orientation of pedal unguals with respect to digit axis (W228, U306): aligned (point forward) (0); deflected ventrolaterally (1).
- (326) Length of pedal unguual I relative to pedal digit II unguual (W229): subequal (0); 25% larger than (1).
- (327) Ratio of length of pedal digit I unguual:length of metatarsal I (W230, U307): <1.0 (0); ≥ 1.0 (1).
- (328) Ratio of mediolateral width:dorsoventral height of pedal digit I unguual (W231): >1.0 (wider than tall) (0); ≤ 1.0 (sickle-shaped, much taller than wide) (1).
- (329) Morphology of pedal unguals II-III (W232, U308): broader mediolaterally than dorsoventrally (0); sickle-shaped (much deeper dorsoventrally than broad mediolaterally) (1).
- (330) Development of pedal digit IV unguual (W233): subequal in size to unguals of pedal digits II and III (0); rudimentary or absent (1).
- (331) Osteoderms (W234): absent (0); present (1).
- (332) Occipital condyle, an angle with respect to the supraoccipital plane: less than (0); more than (1) 100 degrees.
- (333) Foramen magnum: vertically taller than wide transversely (0); wider than tall (1).
- (334) A vertical ridge extending from the postorbital contact of the laterosphenoid along the frontal-parietal suture dorsally and eventually reaching the posterolateral corner of the frontal: absent (0); present (1).
- (335) Transverse distance between right and left laterosphenoid-postorbital contacts: nearly equal to (0); approximately 25% narrower than (1) transverse distance between the lateral tips of posterior lateral wings of the parietal.
- (336) Frontoparietal fenestra: enclosed within parietal (0); incorporates frontal (1).
- (337) Supraoccipital: vertically taller than transversely wide (0); wider than tall (1).
- (338) Contribution of supraoccipital to the margin of foramen magnum: more than 10% the entire margin or more than 50% the dorsal margin (0); less than 10% the entire margin; less than 50% the dorsal margin due to medially expanded exoccipitals (1).
- (339) Supraoccipital ridge: transversely narrow (0), transversely robust (1), robust with a knob near the skull roof (2). Unordered.
- (340) The height of parietal along the supraoccipital-parietal suture: more than (0), approximately equal to (1); or less than (2) the height of exoccipital along the supraoccipital-exoccipital suture. Unordered.
- (341) External foramen for trigeminal nerve (CN V): posterior to (0), or directly below or anterior to crista antotica (1).
- (342) Crista interfenestralis: absent (0); incipient (1); nearly or entirely separating the fenestra ovalis and the metotic fissure (2).
- (343) Craniopharyngeal foramen: posterior (0), or anterior (1) to basal tubera. This character is scored inapplicable for taxa lacking the foramen.
- (344) Craniopharyngeal foramen: does not (0), or does (1) form a notch that separates the basal tubera from each other. This character is scored inapplicable for taxa lacking the foramen.

SOM_2

Character matrix used for a maximum parsimony analysis in nexus format.

http://app.pan.pl/SOM/app60-Xing_etal_SOM/SOM_2.nex

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