

Supplementary Information

A new Early Jurassic dinosaur represents the earliest-diverging and oldest sauropodomorph of East Asia

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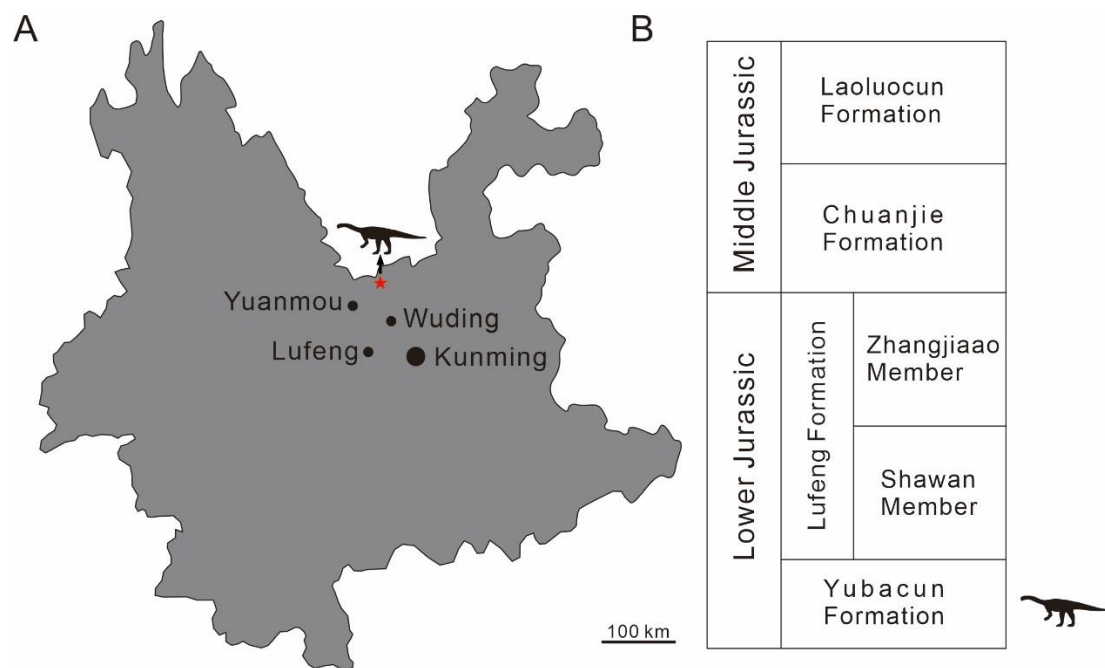


Figure S1. Geographic position and stratigraphic provenance of *Wudingloong wui* (from Wang et al. 2017 and Zhang et al. 2024). A. Location of the fossil site in Wande, Wuding County of Yunnan Province. B. Generalized lithostratigraphy of the Lower and Middle Jurassic of Kunming subregion.



Figure S2. Strict consensus tree of the phylogenetic analysis conducted with 79 taxa and 398 characters. The consensus tree of 168 MPTs of 1647 steps each (CI = 0.286, RI = 0.658). Numbers above the nodes represent bootstrap frequencies > 50%, numbers below the nodes represent Bremer support values >1.

Table S1. Measurements (in mm) of the vertebrae of *Wudingloong wui*. Abbreviations: AntH, anterior height of the centrum; AntW, anterior width of the centrum; CL, maximum anteroposterior centrum length; Cv, cervical vertebra; Dv, dorsal vertebra; NSL, neural spine length (at the bottom); NSH, neural spine width; NSW, neural spine width (at the top); PosH, posterior height of the centrum; PosW, posterior width of the centrum; TH, total height.

*represents estimated value.

Element	TH	CL	AntH	AntW	PosH	PosW	NSL	NSH	NSW
Axis		65.5	26.0	31.0	26.6	25.5*	44.0		
Cv3		90.4	25.8	25.7*	30.4	29.0	49.8		
Cv4		98.9	27.8	27.6	31.4	34.4	49.9		
Cv5		105.5	31.4	36.0	35.2	33.9*	49.0		
Cv6		99.7	35.5	34.2	37.8	38.9	38.9		
Cv7	83.1	99.2	39.6	40.1	45.7*	38.8*	37.3		
Cv8		98.9	47.6*	40.5*	45.1	41.9*	37.0		
Cv9		87.5	45.5*	45.0	49.2	45.9*	36.0		
Cv10		81.3*	56.0	50.6		56.5*	23.7		
Dv1		75.2	54.4	55.7	55.4	49.9	21.1		
Dv2		64.0	60.8	50.0	50.4	49.0	18.8		
Dv3	104.8	61.7	59.8	46.7	53.5	47.9	19.5	26.3	23
Dv4	100.7	63.7	53.8	48.8	45.5*	40.0*	24.1	29.3	21.5
Dv5	102.5	69.6	55.5	42.8	49.5	42.9*	29.0	29.5	19.4
Dv6	113.1	69.0	49.0*	40.6	51.5	43.0*	35.4	29.2	
Dv7	112.0	70.3	52.0*	47.6*	49.4	48.2	42.0*	31.4	

Table S2. Measurements (in mm) of the pectoral girdle of *Wudingloong wui*. Abbreviations: APLV, anteroposterior length of the ventral end; APLD, anteroposterior length of the dorsal end; L, length; MAPL, minimum anteroposterior length of scapula blade.

Element	L	APLV	MAPL	APLD
Right scapula	365		61.7	131.0
Right coracoid		138.6		

Table S3. Measurements (in mm) of the humerus, ulna, and radius of *Wudingloong wui*.

*represents estimated value.

Element	Dimension	Measurement
Right humerus	Total length	315
	Deltopectoral crest length	154.5
	Proximal mediolateral width	140.0
	Humeral shaft minimum width	38.7
	Distal (condyles) mediolateral width	107.0*
Right ulna	Total length	200.3
	Proximal maximum anteroposterior length	79.8
	Proximal maximum mediolateral width	46.9
	Mid-shaft minimum transverse width	19.9
	Mid-shaft anteroposterior length	29.2
	Distal maximum mediolateral width	22.8
	Distal anteroposterior length	55.2*
Right radius	Total length	192.3*
	Proximal maximum anteroposterior length	57.5
	Proximal maximum mediolateral width	21.6*
	Mid-shaft minimum transverse width	13.9*
	Mid-shaft anteroposterior length	28.0
	Distal maximum mediolateral width	21.6*
	Distal anteroposterior length	47.9*

Table S4. Measurements (in mm) of the right manus of *Wudingloong wui*. Abbreviations: L, length; DH, distal dorsoventral height; DW, distal mediolateral width; PH, proximal dorsoventral height; PW, proximal mediolateral width. *represents estimated value.

Element	L	PW	PH	DW	DH
Metacarpal II				33*	
Metacarpa III				21.6	17.0
Metacarpa IV	52.9	22.4*	20.0	19.0	11.7
Metacarpa V	33.2	19.4	17.6*	19.6	16.9*
phalanx I-1	67.4	49*	27.5*	35.0	34.1
phalanx I-2 (ungual)	94.7*	35.3	55.2		
phalanx II-1	37.7	28.0	27.8	25.9	20.4
phalanx II-2	32.9	23.2	26.3	25.5	18.0
phalanx II-3 (ungual)		20.0	27.8		
phalanx III-1	23.0	19.6	15.9	16.9	11.7
phalanx III-2	24.3	16.5	17.9	16.6	14.8
phalanx III-3	18.8	14.8	17	16.5	10.0
phalanx III-4 (ungual)	33.0	10.6	17.1		
phalanx IV-1		12.3	15.0		
phalanx V-1	21.8	13.5	12.0	11.4	7.6

Character List

1. Skull to femur ratio (Gauthier 1986):
 - (0) greater than 0.6
 - (1) less than 0.6
2. Premaxilla, ventrolateral margin of alveolar region extends further ventrally than ventromedial margin in anterior/posterior view (Upchurch 1995):
 - (0) absent
 - (1) present
3. Relative height of the rostrum at the posterior margin of the external naris (Langer 2004):
 - (0) more than 0.6 the height of the skull at the middle of the orbit
 - (1) less than 0.6 the height of the skull at the middle of the orbit
4. Foramen on the lateral surface of the premaxillary body (Yates 2004):
 - (0) absent
 - (1) present
5. Distal end of the dorsal premaxillary process (Serenio, 1999):
 - (0) tapered
 - (1) transversely expanded
6. Profile of premaxilla (Upchurch, 1995):
 - (0) convex
 - (1) with an inflection at the base of the dorsal process
7. Size and position of the posterolateral process of premaxilla (Yates 2007):
 - (0) large and lateral to the anterior process of the maxilla
 - (1) small and medial to the anterior process of the maxilla
8. Relationship between the maxillary ramus of the premaxilla and the maxillary ramus of the nasal (modified from Gauthier 1986 and Yates 2007): (ORDERED)
 - (0) broad sutured
 - (1) point contact
 - (2) separated by maxilla
 - (3) maxillary ramus of nasal much reduced to absent
9. Posteromedial process of the premaxilla (Rauhut 2003):
 - (0) absent
 - (1) present
10. Shape of the anteromedial process of the maxilla (Yates 2007):
 - (0) narrow, elongated and projecting anterior to lateral premaxilla-maxilla suture
 - (1) short, broad and level with lateral premaxilla-maxilla suture
11. Development of external narial fossa (Yates 2007):
 - (0) absent to weak
 - (1) well developed with sharp posterior and anteroventral rims
12. Development of narial fossa on the anterior ramus of the maxilla (modified from Upchurch 1995):
 - (0) weak and orientated laterally to dorsolaterally
 - (1) well developed and forming a horizontal shelf
13. Subnarial foramen, size and position (modified from Sereno et al. 1993): (ORDERED)

- (0) absent
 - (1) small (no larger than adjacent maxillary neurovascular foramina) and positioned outside of narial fossa
 - (2) large and on the rim, or inside, the narial fossa
14. Shape of subnarial foramen (Yates 2007):
- (0) rounded
 - (1) slot-shaped
15. Maxillary contribution to the margin of the narial fossa (Yates 2007):
- (0) absent
 - (1) present
16. Diameter of external naris (Wilson and Sereno 1998):
- (0) less than 0.5 of the orbital diameter
 - (1) greater than 0.5 of the orbital diameter
17. Shape of the external naris (in mature individuals) (Galton and Upchurch 2004):
- (0) rounded
 - (1) subtriangular with an acute posteroventral corner
18. Level of the anterior margin of the external naris (Rauhut 2003):
- (0) anterior to the midlength of the premaxillary body
 - (1) posterior to the midlength of the premaxillary body
19. Level of the posterior margin of the external naris (modified from Wilson and Sereno 1998): (ORDERED)
- (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
20. Dorsal profile of the snout (Yates 2007):
- (0) straight to gently convex
 - (1) with a depression behind the naris
21. Elongate median nasal depression (Sereno 1999):
- (0) absent
 - (1) present
22. Width of anteroventral process of nasal at its base (modified from Sereno 1999):
- (0) less than the width of the anterodorsal process at its base
 - (1) greater than the width of the anterodorsal process at its base
23. Nasal relationship with dorsal margin of antorbital fossa (modified from Sereno 1999): (ORDERED)
- (0) not contributing to the margin of the antorbital fossa
 - (1) lateral margin overhangs the antorbital fossa and forms its dorsal margin
 - (2) overhang extensive, obscuring the dorsal lachrymal-maxilla contact in lateral view
24. Pointed posterolateral process of the nasal overlapping the lachrymal (Sereno 1999):
- (0) absent
 - (1) present
25. Anterior profile of the maxilla (Sereno et al. 1996):

- (0) slopes continuously towards the rostral tip
 - (1) with a strong inflection at the base, creating a rostral ramus with parallel dorsal and ventral margins
26. Length of rostral ramus of the maxilla (Serenio et al. 1996):
- (0) less than its dorsoventral depth
 - (1) greater than its dorsoventral depth
27. Shape of the main body of the maxilla (Yates 2007):
- (0) tapering posteriorly
 - (1) dorsal and ventral margins parallel for most of their length
28. Shape of the ascending ramus of the maxilla in lateral view (Yates 2007):
- (0) tapering dorsally
 - (1) with an anteroposterior expansion at the dorsal end
29. Anteroposterior length of the antorbital fossa (Yates 2003a):
- (0) greater than that of the orbit
 - (1) less than that of the orbit
30. Posteroventral extent of medial wall of antorbital fossa (modified from Galton and Upchurch 2004):
- (0) reaching the anterior tip of the jugal
 - (1) terminating anterior to the anterior tip of the jugal
31. Posteroventral extent of the antorbital fenestra (Chapelle and Choiniere 2018):
- (0) reaching the anterior tip of the jugal
 - (1) terminating anterior to the anterior tip of the jugal
32. Development of the antorbital fossa on the ascending ramus of the maxilla (Yates 2007):
- (0) deeply impressed and delimited by a sharp, scarp-like rim
 - (1) weakly impressed and delimited by a rounded rim or a change in slope
33. Antorbital fossa (Chapelle and Choiniere 2018):
- (0) absent
 - (1) present
34. Shape of the antorbital fossa (i.e., the anteromedial wall of the external fenestra) (modified from Galton 1985):
- (0) crescentic with a strongly concave posterior margin that is roughly parallel to the anterior margin of the antorbital fossa
 - (1) subtriangular with a straight to gently concave posterior margin
35. Size of the neurovascular foramen at the posterior end of the lateral maxillary row (Yates 2003a):
- (0) not larger than the others
 - (1) distinctly larger than the others in the row
36. Direction that the neurovascular foramen at the posterior end of the lateral maxillary row opens (modified from Sereno 1999):
- (0) posteriorly
 - (1) rostrally, ventrally or laterally
37. Arrangement of lateral maxillary neurovascular foramina (modified from Sereno 1999):

- (0) linear
- (1) irregular
- 38. Longitudinal ridge on the posterior lateral surface of the maxilla (Barrett et al. 2005):
 - (0) absent
 - (1) present
- 39. Dorsal exposure of the lachrymal (Gauthier 1986):
 - (0) present
 - (1) absent
- 40. Shape of the lachrymal (Rauhut 2003):
 - (0) dorsoventrally short and block-shaped
 - (1) dorsoventrally elongate and shaped like an inverted L
- 41. Orientation of the lachrymal orbital margin (Yates 2007):
 - (0) strongly sloping anterodorsally
 - (1) erect and close to vertical
- 42. Length of the anterior ramus of the lachrymal (modified from Galton 1990):
 - (ORDERED)
 - (0) greater than half the length of the ventral ramus
 - (1) less than half the length of the ventral ramus
 - (2) absent altogether
- 43. Sheet/flange of bone spanning junction between anterior and ventral rami of lachrymal (Yates 2007):
 - (0) absent and antorbital fossa laterally exposed
 - (1) present, obscuring posterodorsal corner of antorbital fossa
- 44. Extension of the antorbital fossa onto the ventral end of the lachrymal (modified from Wilson and Sereno 1998):
 - (0) present
 - (1) absent
- 45. Length of the posterior process of the prefrontal (Galton 1985):
 - (0) short
 - (1) elongated, so that total prefrontal length is equal to the anteroposterior diameter of the orbit
- 46. Prefrontal, dorsoventral height of the lacrimal ramus (ventral process) of the prefrontal (Chapelle and Choiniere 2018):
 - (0) more than 0.5 times that of the jugal ramus (ventral ramus) of lacrimal
 - (1) less than 0.5 times that of the jugal ramus (ventral ramus) of the lacrimal
- 47. Ventral process of prefrontal extending down the posteromedial side of the lachrymal (Wilson and Sereno 1998):
 - (0) present
 - (1) absent
- 48. Maximum transverse width of the prefrontal (modified from Galton 1990):
 - (0) less than 0.25 of the skull width at that level
 - (1) more than 0.25 of the skull width at that level
- 49. Shape of the orbit (Wilson and Sereno 1998):
 - (0) subcircular

- (1) ventrally constricted making the orbit subtriangular
- 50. Slender anterior process of the frontal intruding between the prefrontal and the nasal (modified from Sereno 1999):
 - (0) absent
 - (1) present
- 51. Jugal-lachrymal relationship (Sereno et al. 1993):
 - (0) lachrymal overlapping lateral surface of jugal or abutting it dorsally
 - (1) jugal overlapping lachrymal laterally
- 52. Shape of the suborbital region of the jugal (Yates 2007):
 - (0) an anteroposteriorly elongate bar
 - (1) an anteroposteriorly shortened plate
- 53. Dorsally extending process of the anterior jugal (Rauhut 2003):
 - (0) present
 - (1) absent
- 54. Ratio of the minimum depth of the jugal below the orbit to the distance between the anterior end of the jugal and the anteroventral corner of the infratemporal fenestra (modified from Galton 1985):
 - (0) less than 0.2
 - (1) greater than 0.2
- 55. Transverse width of the ventral ramus of the postorbital (Wilson and Sereno 1998):
 - (0) less than its anteroposterior width at midshaft
 - (1) greater than its anteroposterior width at midshaft
- 56. Shape of the dorsal margin of postorbital in lateral view (Yates 2007):
 - (0) straight to gently curved
 - (1) with a distinct embayment between the anterior and posterior dorsal processes
- 57. Postorbital, distal end of frontal process, distinct concave notch between parietal and frontal facets (Chapelle and Choiniere 2018):
 - (0) absent
 - (1) present
- 58. Relationship of postorbital rim to squamosal rim of postorbital (Yates 2007):
 - (0) postorbital level with lateral surface of the squamosal ramus
 - (1) raised so that it projects laterally to the lateral surface of the squamosal ramus
- 59. Postfrontal bone (Sereno et al. 1993):
 - (0) present
 - (1) absent
- 60. Position of the anterior margin of the infratemporal fenestra (modified from Upchurch 1995): (ORDERED)
 - (0) behind the orbit
 - (1) extends under the rear half of the orbit
 - (2) extends as far forward as the midlength of the orbit
- 61. Frontal contribution to the supratemporal fenestra (modified from Gauthier 1986):
 - (0) present
 - (1) absent

62. Presence of anterior portion of supratemporal fossa on posterior end of dorsal surface of frontal (Chapelle and Choiniere 2018):
 - (0) weak
 - (1) deeply excavated, forming a scarp- like margin
63. Orientation of the long axis of the supratemporal fenestra (Wilson and Sereno 1998):
 - (0) longitudinal
 - (1) transverse
64. Length of the quadratojugal ramus of the squamosal relative to the width at its base (Sereno 1999):
 - (0) less than four times its width
 - (1) greater than four times its width
65. Proportion of infratemporal fenestra bordered by squamosal (Yates 2007):
 - (0) more than 0.5 of the depth of the infratemporal fenestra
 - (1) less than 0.5 of the depth of the infratemporal fenestra
66. Squamosal-quadratojugal contact (Gauthier 1986):
 - (0) present
 - (1) absent
67. Angle of divergence between jugal and squamosal rami of quadratojugal (Yates 2007):
 - (0) close to 90 degrees
 - (1) close to parallel
68. Length of jugal ramus of quadratojugal (Wilson and Sereno 1998):
 - (0) no longer than the squamosal ramus
 - (1) longer than the squamosal ramus
69. Shape of the anterior end of the jugal ramus of the quadratojugal (Wilson and Sereno 1998):
 - (0) tapered
 - (1) dorsoventrally expanded
70. Relationship of quadratojugal to jugal (Yates 2007):
 - (0) jugal overlaps the lateral surface of the quadratojugal
 - (1) quadratojugal overlaps the lateral surface of the jugal
 - (2) quadratojugal sutures along the ventrolateral margin of the jugal
71. Position of the quadrate foramen (modified from Rauhut 2003):
 - (0) on the quadrate-quadratojugal suture
 - (1) deeply incised into, and partly encircled by, the quadrate
 - (2) on the quadrate-squamosal suture, just below the quadrate head
72. Shape of posterolateral margin of quadrate (Wilson and Sereno 1998): (ORDERED)
 - (0) sloping anterolaterally from posteromedial ridge
 - (1) everted posteriorly creating a posteriorly facing fossa
 - (2) posterior fossa deeply excavated, invading quadrate body
73. Exposure of the lateral surface of the quadrate head (Sereno et al. 1993):
 - (0) absent, covered by lateral sheet of the squamosal
 - (1) present
74. Proportion of the length of the quadrate that is occupied by the pterygoid wing (Yates 2003a):

- (0) at least 70 percent
 - (1) greater than 70 percent
75. Angle between quadratojugal and pterygoid rami of the quadrate (Chapelle and Choiniere 2018):
- (0) between 0 and 30 degrees, near parallel
 - (1) between 30 degrees and 90 degrees
 - (2) greater than 90 degrees
76. Ventral extent of condyles of the quadrate (Chapelle and Choiniere 2018):
- (0) both condyles extend to the same ventral level
 - (1) medial condyle extends farther ventrally
 - (2) lateral condyle extends farther ventrally
77. Depth of the occipital wing of the parietal (Wilson and Sereno 1998):
- (0) less than 1.5 times the depth of the foramen magnum
 - (1) more than 1.5 times the depth of the foramen magnum
78. Position of foramina for mid-cerebral vein on occiput (modified from Yates 2003a):
- (0) between supraoccipital and parietal
 - (1) on the supraoccipital
79. Postparietal fenestra between supraoccipital and parietals (Yates 2007):
- (0) absent
 - (1) present
80. Shape of the supraoccipital (Yates 2003b):
- (0) diamond-shaped, at least as high as wide
 - (1) semilunate and wider than high
81. Orientation of the supraoccipital plate (Galton and Upchurch 2004):
- (0) erect to gently sloping
 - (1) strongly sloping forward so that the dorsal tip lies level with the basiptyergoid processes
82. Orientation of the paroccipital processes in occipital view (Rauhut 2003):
- (0) slightly dorsolaterally directed to horizontal
 - (1) ventrolaterally directed
83. Orientation of the paroccipital processes in dorsal view (Wilson 2002):
- (0) posterolateral forming a V-shaped occiput
 - (1) lateral forming a flat occiput
84. Size of the post-temporal fenestra (Yates 2007):
- (0) large fenestra
 - (1) a small hole that is much less than half the depth of the paroccipital process
85. Exit of the mid-cerebral vein (Rauhut 2003):
- (0) through trigeminal foramen
 - (1) through a separate foramen anterodorsal to trigeminal foramen
86. Ventral margin of the basal tubera of the basisphenoid (Chapelle and Choiniere 2018):
- (0) basal tubera ventral margins extends as far ventrally as basiptyergoid processes ventral margins
 - (1) basiptyergoid processes ventral margins extend further ventrally than that of basal tubera

87. Ventral margin of the basal tubera of the basisphenoid (Chapelle and Choiniere 2018):
 - (0) level or dorsal to proximal base of basiptyergoid processes
 - (1) ventral to proximal base of basiptyergoid processes
88. Ventral margin of basioccipital condyle of the basioccipital (Chapelle and Choiniere 2018):
 - (0) aligned with or ventral to proximal base of basiptyergoid processes
 - (1) dorsal to proximal base of basiptyergoid processes
89. Ridge between the basal tubera of the basioccipital (modified from Yates 2007):
 - (0) absent with the basal tuberae being separated by a well-developed, deep notch/fossa
 - (1) present
90. Length of the basiptyergoid processes (from the top of the parasphenoid to the tip of the process) (Benton et al. 2000):
 - (0) less than the height of the braincase (from the top of the parasphenoid to the top of the supraoccipital)
 - (1) greater than the height of the braincase (from the top of the parasphenoid to the top of the supraoccipital)
91. Angle separating the long axes of the basiptyergoid processes of the basisphenoid in anterior view (Chapelle and Choiniere 2018):
 - (0) 60 degrees or less
 - (1) More than 60 degrees
92. Angle between basiptyergoid process and cultriform process of the parabasisphenoid (Bronzati and Rauhut 2017, modified from Butler et al., 2008):
 - (0) < 90 degrees
 - (1) ~90 degrees
 - (2) > 90 degrees
93. Basisphenoid recess (ventral surface of the main body of basisphenoid posterior to the basiptyergoid processes (Chapelle and Choiniere 2018):
 - (0) absent to weak
 - (1) present and deeply excavated
94. Subsellar recess (fossa located on ventral surface of the base of the cultriform process) (Bronzati and Rauhut 2017):
 - (0) maximum width equal or greater than the dorsoventral height
 - (1) maximum width smaller than the dorsoventral height
95. Laminae/ridges extending from the basiptyergoid process onto the parasphenoid rostrum (Bronzati and Rauhut 2017):
 - (0) extend parallel until they fade into the ventral margin of the cultriform process
 - (1) converge anteromedially on the ventral surface of the cultriform process
96. Length of the basisphenoid (from the basiptyergoid process to the basisphenoidal component of the basal tubera) in relation to the length of the basioccipital (from the basioccipital component of the basal tubera to posterior limit of the condyle) (Bronzati and Rauhut 2017, modified from Butler et al., 2008):
 - (0) longer or equal

- (1) shorter
- 97. Otosphenoidal crest (Bronzati et al. 2018):
 - (0) low and not projecting posterolaterally (i.e. does not cover the fenestra ovalis with the braincase in lateral view)
 - (1) developed as a lamina projecting posterolaterally (i.e. cover the fenestra ovalis with the braincase in lateral view)
- 98. Dorsoventral depth of the parasphenoid rostrum (Yates 2003a):
 - (0) much less than the transverse width
 - (1) about equal to the transverse width
- 99. Shape of jugal process of ectopterygoid (Yates 2003a):
 - (0) gently curved
 - (1) strongly recurved and hook-like
- 100. Pneumatic fossa on the ventral surface of the ectopterygoid (Serenio et al. 1996):
 - (0) present
 - (1) absent
- 101. Relationship of the ectopterygoid to the pterygoid (Serenio et al. 1993):
 - (0) ectopterygoid overlapping the ventral surface of the pterygoid
 - (1) ectopterygoid overlapping the dorsal surface of the pterygoid
- 102. Position of the maxillary articular surface of the palatine (Wilson and Sereno 1998):
 - (0) along the lateral margin of the bone
 - (1) at the end of a narrow anterolateral process due to the absence of the posterolateral process
- 103. Centrally located tubercle on the ventral surface of palatine (Yates 2007):
 - (0) absent
 - (1) present
- 104. Medial process of the pterygoid forming a hook around the basipterygoid process (modified from Wilson and Sereno 1998): (ORDERED)
 - (0) absent
 - (1) flat and blunt-ended
 - (2) bent upward and pointed
- 105. Length of the vomers (Yates 2007):
 - (0) less than 0.25 of the total skull length
 - (1) more than 0.25 of the total skull length
- 106. Position of jaw joint (Serenio 1999):
 - (0) no lower than the level of the dorsal margin of the dentary
 - (1) depressed well below this level
- 107. Shape of upper jaws in ventral view (Wilson and Sereno 1998):
 - (0) narrow with an acute rostral apex
 - (1) broad and U-shaped
- 108. Length of the external mandibular fenestra (modified from Upchurch 1995):
 - (0) more than 0.1 of the length of the mandible
 - (1) less than 0.1 of the length of the mandible
- 109. Posterior end of dentary tooth row medially inset with a thick lateral ridge on the dentary forming a buccal emargination (Gauthier 1986):

- (0) absent
- (1) present
- 110. Height: length ratio of the dentary (modified from Benton et al. 2000):
 - (0) less than 0.2
 - (1) greater than 0.2
- 111. Orientation of the symphyseal end of the dentary (Serenio 1999):
 - (0) in line with the long axis of the dentary
 - (1) strongly curved ventrally
- 112. Position of first dentary tooth (Serenio 1999):
 - (0) adjacent to symphysis
 - (1) inset one tooth's width from the symphysis
- 113. Dorsoventral expansion at the symphyseal end of the dentary (Wilson and Sereno 1998):
 - (0) absent
 - (1) present
- 114. Splenial foramen (Rauhut 2003): (ORDERED)
 - (0) absent
 - (1) present and enclosed
 - (2) present and open anteriorly
- 115. Splenial-angular joint (Serenio et al. 1993):
 - (0) flattened sutured contact
 - (1) synovial joint surface between tongue-like process of angular fitting in groove of the splenial
- 116. A stout, triangular, medial process of the articular, behind the glenoid (Yates 2003a):
 - (0) present
 - (1) absent
- 117. Length of the retroarticular process (Yates 2003a):
 - (0) less than the depth of the mandible below the glenoid
 - (1) greater than the depth of the mandible below the glenoid
- 118. Strong medial embayment behind glenoid of the articular in dorsal view (Yates and Kitching 2003):
 - (0) absent
 - (1) present
- 119. Number of premaxillary teeth (Galton 1990):
 - (0) four or less
 - (1) more than four
- 120. Premaxilla, crown height of the first tooth (Pretto et al. 2018):
 - (0) significantly lower than most teeth in the row
 - (1) at least as high as the tallest maxillary tooth
- 121. Number of maxillary teeth (McPhee et al. 2020):
 - (0) twenty or less
 - (1) more than twenty
- 122. Number of dentary teeth (in mature individuals) (modified from Wilson and Sereno 1998):

- (0) less than 18
- (1) 18 or more
- 123. Arrangement of teeth within the jaws (Yates 2007):
 - (0) linearly placed, crowns not overlapping
 - (1) imbricated with distal side of tooth overlapping mesial side of the succeeding tooth
- 124. Orientation of the maxillary tooth crowns (modified from Gauthier 1986):
 - (0) erect
 - (1) procumbent
- 125. Orientation of the dentary tooth crowns (modified from Gauthier 1986):
 - (0) erect
 - (1) procumbent
- 126. Teeth with basally constricted crowns (Gauthier 1986):
 - (0) absent
 - (1) present
- 127. Tooth-tooth occlusal wear facets (Wilson and Sereno 1998):
 - (0) absent
 - (1) present
- 128. Mesial and distal serrations of the teeth (Benton et al. 2000):
 - (0) fine and set at right angles to the margin of the tooth
 - (1) coarse and angled upwards at an angle of 45 degrees to the margin of the tooth
- 129. Distribution of serrations on the maxillary and dentary teeth (Wilson 2002):
 - (0) present on both the mesial and distal carinae
 - (1) absent on the posterior carinae
 - (2) absent on both carinae
- 130. Long axis of the tooth crowns distally recurved (Gauthier 1986):
 - (0) present
 - (1) absent
- 131. Texture of the enamel surface (modified from Wilson and Sereno 1998):
(ORDERED)
 - (0) entirely smooth
 - (1) finely wrinkled in some patches
 - (2) extensively and coarsely wrinkled
- 132. Lingual concavities of the teeth (Upchurch 1995):
 - (0) absent
 - (1) present
- 133. Longitudinal labial grooves on the teeth (Upchurch 1998):
 - (0) absent
 - (1) present
- 134. Distribution of the serrations along the mesial and distal carinae of the tooth (Yates 2003a)
 - (0) extend along most of the length of the crown
 - (1) restricted to the upper half of the crown

135. Number of cervical vertebrae (modified from Wilson and Sereno 1998): (ORDERED)
- (0) eight or fewer
 - (1) 9-10
 - (2) 12-13
 - (3) more than 13
136. Shallow, dorsally facing fossa on the atlantal neurapophysis bordered by a dorsally everted lateral margin (Yates and Kitching 2003):
- (0) absent
 - (1) present
137. Width of axial intercentrum (Sereno 1999):
- (0) less than width of axial centrum
 - (1) greater than width of axial centrum
138. Position of axial prezygapophyses (Yates 2007):
- (0) on the anterolateral surface of the neural arch
 - (1) mounted on anteriorly projecting pedicels
139. Posterior margin of the axial postzygapophyses (Sereno 1999):
- (0) extend well beyond the posterior margin of the axial centrum
 - (1) flush with (or only marginally posterior to) the posterior margin of the axial centrum
140. Length of the axial centrum (Yates 2007):
- (0) less than three times the height of the centrum
 - (1) at least three times the height of the centrum
141. Length of the anterior cervical centra (cervicals 3-5) (Yates 2007):
- (0) no more than the length of the axial centrum
 - (1) greater than the length of the axial centrum
142. Length of middle to posterior cervical centra (cervical 6-8) (Yates 2007):
- (0) no more than the length of the axial centrum
 - (1) greater than the length of the axial centrum
143. Dorsal excavation of the cervical parapophyses (Upchurch 1998):
- (0) absent
 - (1) present
144. Lateral compression of the anterior cervical vertebrae (Upchurch 1998):
- (0) centra are no higher than they are wide
 - (1) are approximately 1.25 times higher than wide
145. Relative elongation of the anterior cervical centra (cervical 3-5) (modified from Sereno 1999): (ORDERED)
- (0) lengths of the centra are less than 2.5 times the height of their anterior faces
 - (1) lengths are 2.5-4 times the height of their anterior faces
 - (2) the length of at least cervical 4 or 5 exceeds 4 times the anterior centrum height
146. Ventral keels on anterior cervical centra (modified from Upchurch 1998):
- (0) present
 - (1) absent
147. Height of the mid cervical neural arches (Yates 2007):

- (0) no more than the height of the posterior centrum face
 - (1) greater than the height of the posterior centrum face
148. Orientation of the anterior-to-middle cervical postzygapophyses (McPhee et al. 2015b): (ORDERED)
- (0) planar (minimally offset) with respect to the prezygapophyses
 - (1) dorsally raised roughly 20 degrees relative to the coronal plane
 - (2) dorsally raised at least 30 degrees or more relative to the coronal plane
149. Cervical epipophyses on the dorsal surface of the postzygapophyses (Yates 2007):
- (0) absent
 - (1) present on at least some cervical vertebrae
150. Posterior ends of anterior, postaxial epipophyses (Yates 2007):
- (0) with a free pointed tip
 - (1) joined to the postzygapophysis along their entire length
151. Shape of the epipophyses (Yates 2003a):
- (0) tall ridges
 - (1) flattened, horizontal plates
152. Epipophyses overhanging the rear margin of the postzygapophyses (Serenio et al. 1993):
- (0) present in at least some postaxial cervical vertebrae
 - (1) absent
153. Anterior spur-like projections on mid-cervical neural spines (Yates 2007):
- (0) absent
 - (1) present
154. Shape of mid-cervical neural spines (Yates 2007):
- (0) less than twice as long as high
 - (1) at least twice as long as high
155. Shape of cervical rib shafts (Serenio 1999):
- (0) short and posteroventrally directed
 - (1) longer than the length of their centra and extending parallel to cervical column
156. Position of the base of the cervical rib shaft (Wilson and Serenio 1998):
- (0) level with, or higher than the ventral margin of the cervical centrum
 - (1) located below the ventral margin due to a ventrally extended parapophysis
157. Postzygodiapophyseal lamina in cervical neural arches 4-8 (Yates 2003a):
- (0) present
 - (1) absent
158. Laminae of the cervical neural arches 4-8 (Wilson and Serenio 1998):
- (0) well-developed tall laminae
 - (1) weakly developed low ridges
159. Shape of anterior centrum face in cervical centra (modified from Gauthier 1986): (ORDERED)
- (0) concave
 - (1) flat
 - (2) convex

160. Ventral surface of the centra in the cervicodorsal transition (Rauhut 2003):
- (0) transversely rounded
 - (1) with longitudinal keels
161. Number of vertebrae between cervicodorsal transition and primordial sacral vertebrae (modified from Wilson and Sereno 1998):
- (0) 15-16
 - (1) no more than 14
162. Lateral surfaces of the dorsal centra (Gauthier 1986): (ORDERED)
- (0) with at most vague, shallow depressions
 - (1) with deep fossae that approach the midline
 - (2) with invasive, sharp-rimmed pleurocoels
163. Oblique ridge dividing pleural fossa of cervical vertebrae (Wilson and Sereno 1998):
- (0) absent
 - (1) present
164. Laterally expanded tables at the midlength of the dorsal surface of the neural spines (Yates and Kitching 2003): (ORDERED)
- (0) absent in all vertebrae
 - (1) present on the pectoral vertebrae
 - (2) present on the pectoral and cervical vertebrae
165. Dorsal centra (Wilson and Sereno 1998): (ORDERED)
- (0) entirely amphicoelous to amphiplatyan
 - (1) first two dorsals are opisthocoelous
 - (2) anterior half of dorsal column is opisthocoelous
166. Shape of the posterior dorsal centra (Yates 2007):
- (0) relatively elongated for their size
 - (1) strongly axially compressed for their size
167. Laminae bounding triangular infradiapophyseal fossae (chonae) on dorsal neural arches (Wilson 1999):
- (0) absent
 - (1) present
168. Location of parapophysis in first two dorsals (Yates 2007):
- (0) at the anterior end of the centrum
 - (1) Set back from the anterior margin, within lateral surface of centrum
169. Parapophyses of the dorsal column completely shift from the centrum to the neural arch (Langer 2004):
- (0) anterior to the thirteenth presacral vertebra
 - (1) posterior to the thirteenth presacral vertebra
170. Orientation of the transverse processes of the dorsal vertebrae (Upchurch 1998):
- (0) most horizontally directed
 - (1) all upwardly directed
171. Contribution of the paradiapophyseal lamina to the margin of the anterior chonos in mid-dorsal vertebrae (Yates 2007):
- (0) present
 - (1) prevented by high placement of parapophysis

172. Hyposphenes in the dorsal vertebrae (modified from Gauthier 1986): (ORDERED)
- (0) absent
 - (1) present but less than the height of the neural canal
 - (2) present and equal to the height of the neural canal
173. Prezygodiapophyseal lamina and associated anterior triangular fossa (Yates 2003a):
- (0) present on all dorsals
 - (1) absent in mid-dorsals
174. Anterior centroparapophyseal lamina in dorsal vertebrae (Wilson 2002):
- (0) absent
 - (1) present
175. Prezygoparapophyseal lamina in dorsal vertebrae (Yates 2007):
- (0) absent
 - (1) present
176. Accessory lamina dividing posterior chonos from postzygapophysis (Yates 2007):
- (0) absent
 - (1) present
177. Pneumatic excavation of the dorsal neural arches (McPhee et al. 2014): (ORDERED)
- (0) absent
 - (1) equivocal (e.g., no more than depressions within the infradiapophyseal chambers)
 - (2) sharp-rimmed fossae or foramina clearly invading bone surface
178. Separation of lateral surfaces of anterior dorsal neural arches under transverse processes (Upchurch et al. 2004):
- (0) widely spaced
 - (1) only separated by a thin midline septum
179. Height of dorsal neural arches, from neurocentral suture to level of zygapophyseal facets (Yates 2007):
- (0) much less than height of centrum
 - (1) subequal to or greater than height of centrum
180. Form of anterior surface of neural arch (Bonaparte 1999):
- (0) simple centroprezygopophyseal ridge
 - (1) broad anteriorly facing surface bounded laterally by centroprezygopophyseal lamina
181. Shape of posterior dorsal neural canal (Wilson and Sereno 1998):
- (0) subcircular
 - (1) slit-shaped
182. Height of middle dorsal neural spines (modified from Bonaparte 1986): (ORDERED)
- (0) less than the length of the base
 - (1) higher than the length of the base but less than 1.5 times the length of the base
 - (2) greater than 1.5 times the length of the base
183. Shape of anterior dorsal neural spines (Yates 2007):
- (0) lateral margins subparallel in anterior view
 - (1) transversely expanding towards dorsal end

184. Cross-sectional shape of dorsal neural spines (modified from Bonaparte 1986):
- (0) transversely compressed
 - (1) broad and triangular
 - (2) square-shaped in posterior vertebrae
185. Spinodiapophyseal lamina on dorsal vertebrae (Wilson and Sereno 1998):
(ORDERED)
- (0) absent
 - (1) present and separated from spinopostzygapophyseal lamina
 - (2) present and joining spinopostzygapophyseal lamina to create a composite posterolateral spinal lamina
186. Well-developed, sheet-like suprapostzygapophyseal laminae (Bonaparte 1986):
- (0) absent
 - (1) present on at least the posterior dorsal vertebrae
187. Shape of the spinopostzygapophyseal lamina in middle and posterior dorsal vertebrae (Wilson 2002):
- (0) singular
 - (1) bifurcated at its distal end
188. Shape of posterior margin of middle dorsal neural spines in lateral view (Yates 2003b):
- (0) approximately straight
 - (1) concave with a projecting posterodorsal corner
189. Transversely expanded plate-like summits of posterior dorsal neural spines (Novas 1993):
- (0) absent
 - (1) present
190. Last presacral rib (Yates 2007):
- (0) free
 - (1) fused to vertebra
191. Number of dorsosacral vertebrae (modified from Gauthier 1986): (ORDERED)
- (0) none
 - (1) one
 - (2) two
192. Caudosacral vertebra (Galton and Upchurch 2004):
- (0) absent
 - (1) present
193. Shape of the iliac articular facets of the first primordial sacral rib (S1 in a two-sacral pelvis, typically S2 in a three-sacral pelvis) (Yates 2007):
- (0) singular
 - (1) divided into dorsal and ventral facets separated by a non-articulating gap
194. Deep, medially-directed pit excavating the surface of the non-articulating gap of the first primordial sacral rib (McPhee et al. 2015a):
- (0) absent
 - (1) present

195. Depth of the iliac articular surface of the primordial sacral (modified from Novas 1992):
- (0) less than 0.75 of the depth of the ilium
 - (1) greater than 0.75 of the depth of the ilium
196. Sacral ribs contributing to the rim of the acetabulum (Wilson 2002):
- (0) absent
 - (1) present
197. Posterior and anterior expansion of the transverse processes of the first and second primordial sacral vertebrae, respectively, partly roofing the intercostal space (Langer 2004):
- (0) absent
 - (1) present
198. Length of first caudal centrum (modified from Yates 2003a): (ORDERED)
- (0) longer anteroposteriorly than dorsoventrally tall
 - (1) taller than long
 - (2) highly compressed (dorsoventral height at least twice anteroposterior length)
199. Position of postzygapophyses in proximal caudal vertebrae (Yates 2003a):
- (0) protruding with an interpostzygapophyseal notch visible in dorsal view
 - (1) placed on either side of the posterior end of the base of the neural spine without any interpostzygapophyseal notch
200. A hyposphenal ridge on caudal vertebrae (Upchurch 1995):
- (0) absent
 - (1) present
201. Prezygodiapophyseal laminae on anterior caudal vertebrae (McPhee et al. 2015b):
- (0) absent
 - (1) present
202. Depth of the bases of the anterior caudal transverse processes (modified from Upchurch 1998):
- (0) dorsoventrally shallow and directed mainly anteroposteriorly, with only a minimal incursion onto the centrum
 - (1) dorsoventrally deep, with a strong ventral cant extending from the neural arch to the centrum
203. Position of last caudal vertebra with a protruding transverse process (Wilson 2002):
- (0) distal to caudal 16
 - (1) proximal to caudal 16
204. Orientation of posterior margin of proximal caudal neural spines (Novas 1992):
- (0) sloping posterodorsally
 - (1) vertical
205. Longitudinal ventral sulcus on proximal and middle caudal vertebrae (modified from Upchurch 1995):
- (0) present
 - (1) absent
206. Length of midcaudal centra (Yates 2003a):
- (0) greater than twice the height of their anterior faces

- (1) less than twice the height of their anterior faces
- 207. Cross-sectional shape of the distal caudal centra (Yates 2007):
 - (0) oval with rounded lateral and ventral sides
 - (1) square-shaped with flattened lateral and ventral sides
- 208. Length of distal caudal prezygapophyses (Gauthier 1986):
 - (0) short, not overlapping the preceding centrum by more than a quarter
 - (1) long and overlapping the preceding the centrum by more than a quarter
- 209. Shape of the terminal caudal vertebrae (Upchurch 1995):
 - (0) unfused, size decreasing toward tip
 - (1) expanded and fused to form a club-shaped tail
- 210. 'Weaponized' dermal spikes on tail (McPhee et al. 2015b):
 - (0) absent
 - (1) present
- 211. Length of the longest chevron (modified from Yates 2003a):
 - (0) less than twice the length of the preceding centrum
 - (1) greater than twice the length of the preceding centrum
- 212. Anteroventral process on distal chevrons (Upchurch 1995):
 - (0) absent
 - (1) present
- 213. Mid-caudal chevrons with a ventral slit (Upchurch 1995):
 - (0) absent
 - (1) present
- 214. Longitudinal ridge on the dorsal surface of the sternal plate (Upchurch 1995):
 - (0) absent
 - (1) present
- 215. Dorsoventral length of the acromion process of the scapula (when long axis of scapula is oriented vertically) (Wilson and Sereno 1998):
 - (0) less than 1.5 times the minimum width of the scapula blade
 - (1) greater than 1.5 times the minimum width of the scapula blade
- 216. Minimum width of the scapula (Gauthier 1986):
 - (0) less than 20 per cent of its length
 - (1) greater than 20 per cent of its length
- 217. Dorsal margin of the acromion process of the scapula (modified from Novas 1992):
 - (0) rises from the blade at angle that is less than 65 degrees from the long axis of the scapula, at its steepest point
 - (1) rises from the blade at angle that is greater than 65 degrees from the long axis of the scapula, at its steepest point
- 218. Width of dorsal expansion of the scapula (Pol and Powell 2007):
 - (0) less than the width of the ventral end of the scapula
 - (1) equal to the width of the ventral end of the scapula
- 219. Ventromedial ridge of scapula (Otero and Pol, 2013, 2021):
 - (0) absent
 - (1) present, extending until mid-blade
 - (2) present, extending until last third of the blade

220. Scapula, proximal expansion, acromial ridge and associated scapular fossa (osteological correlate of *M. Supracoracoideus*) (Otero and Pol, 2021): (ORDERED)
- (0) tenuous acromial ridge not delimiting a fossa
 - (1) acromial ridge delimiting a shallow fossa
 - (2) acromial ridge well-developed, delimiting a deep fossa
221. Flat caudoventrally facing surface on the coracoids between glenoid and coracoid tubercle (Yates and Kitching 2003):
- (0) absent
 - (1) present
222. Coracoid tubercle (modified from Pérez-Moreno et al. 1994):
- (0) absent
 - (1) present
223. Coracoid, anteroventral margin, biceps scar (Otero and Pol, 2022):
- (0) absent
 - (1) present
224. Length of the humerus (modified from Gauthier 1986): (ORDERED)
- (0) less than 55 per cent of the length of the femur
 - (1) 55-65 per cent of the length of the femur
 - (2) 65-70 per cent of the length of the femur
 - (3) more than 70 per cent of the length of the femur
225. Shape of the humeral head (McPhee et al 2015a, modified from Remes 2008):
- (0) slightly-developed, rounded in anteroposterior view
 - (1) flat in anteroposterior view with a minimally expanded lateral component
 - (2) domed, being convex/hemispherical in anteroposterior view with a strong lateral incursion onto the humeral shaft
226. Shape of the deltopectoral crest (Gauthier 1986; Wilson and Sereno 1998):
- (0) subtriangular
 - (1) subrectangular
 - (2) reduced to low ridge
227. Length of the deltopectoral crest of the humerus (modified from Sereno et al. 1993): (ORDERED)
- (0) less than 30 per cent of the length of the humerus
 - (1) 30-50 per cent of the length of the humerus
 - (2) greater than 50 per cent of the length of the humerus
228. Shape of the anterolateral margin of the deltopectoral crest of the humerus (Yates 2003a):
- (0) straight
 - (1) strongly sinuous
229. Rugose pit centrally located on the lateral surface of the deltopectoral crest (Yates 2007):
- (0) absent
 - (1) present
230. Well-defined fossa on the distal flexor surface of the humerus (Yates and Kitching 2003):

- (0) present
 - (1) absent
231. Transverse width of the distal humerus (modified from Langer 2004):
- (0) is less than 33 per cent of the length of the humerus
 - (1) 33 per cent and over, but less than 40 percent, of the length of the humerus
 - (2) 40 percent or more the length of the humerus
232. Shape of the entepicondyle of the distal humerus (Yates 2007):
- (0) rounded process
 - (1) with a flat distomedially facing surface bounded by a sharp proximal margin
233. Length of the radius (Langer 2004):
- (0) greater than 80 per cent of the humerus
 - (1) less than 80 per cent of the humerus
234. Radius, distal end, posterior tubercle (Otero et al. 2015):
- (0) absent
 - (1) present
235. Radius, biceps tubercle (Otero et al. 2015):
- (0) absent
 - (1) present
236. Radial fossa on anterolateral corner of proximal ulna (modified from Wilson and Sereno 1998): (ORDERED)
- (0) absent
 - (1) present, but only shallowly defined
 - (2) a well-defined recess, deeper than the transverse width of the anterior end of the anterior process
237. Anterior tip of anterior process of proximal ulna (McPhee et al. 2018):
- (0) no deflection or continues lateral curvature
 - (1) medially deflected
238. Olecranon process on proximal ulna (modified from Wilson and Sereno 1998):
- (0) present
 - (1) absent
 - (2) greatly enlarged olecranon
239. Ulna, radial face, longitudinal ridge (osteological correlate of M. pronator quadratus) (Otero and Pol 2021):
- (0) absent
 - (1) present
240. Carpus, ulnare and radiale (Otero and Pol 2021):
- (0) present
 - (1) absent
241. Maximum linear dimensions of the ulnare and radiale (Yates 2003a):
- (0) exceed that of at least one of the first three distal carpals
 - (1) less than any of the distal carpals
242. Transverse width of the first distal carpal (Sereno 1999):
- (0) less than 120 per cent of the transverse width of the second distal carpal
 - (1) greater than 120 per cent of the transverse width of the second distal carpal

243. Sulcus across the medial end of the first distal carpal (Yates 2007):
(0) absent
(1) present
244. Lateral end of first distal carpal (Yates 2003a):
(0) abuts second distal carpal
(1) overlaps second distal carpal
245. Second distal carpal (Yates and Kitching 2003):
(0) completely covers the proximal end of the second metacarpal
(1) does not completely cover the proximal end of the second metacarpal
246. Ossification of the fifth distal carpal (Yates 2007):
(0) present
(1) absent
247. Length of the manus (modified from Sereno et al. 1993): (ORDERED)
(0) less than 38 per cent of the humerus + radius
(1) 38-45 per cent of the humerus + radius
(2) greater than 45 per cent of the humerus + radius
248. Shape of metacarpus (Wilson and Sereno 1998):
(0) flattened to gently curved and spreading
(1) a colonnade of subparallel metacarpals tightly curved into a U-shape
249. Proximal width of first metacarpal (modified from Gauthier 1986):
(0) less than the proximal width of the second metacarpal
(1) greater than the proximal width of the second metacarpal
250. Minimum transverse shaft width of first metacarpal (Yates 2007):
(0) less than twice the minimum transverse shaft width of second metacarpal
(1) greater than twice the minimum transverse shaft width of second metacarpal
251. Proximal end of first metacarpal (Sereno 1999):
(0) flush with other metacarpals
(1) inset into the carpus
252. Shape of the first metacarpal (modified from Sereno 1999): (ORDERED)
(0) proximal width less than 65 per cent of its length
(1) proximal width 65-80 per cent of its length
(2) proximal width 80-100 per cent of its length
(3) greater than 100 per cent of its length
253. First metacarpal, width (at the middle of the shaft)/length ratio (Langer et al. in press):
(0) less than 0.35
(1) equal or more than 0.35
254. Ventromedial margin of first metacarpal (Otero et al. 2015):
(0) poorly concave
(1) deeply concave
255. Strong asymmetry in the lateral and medial distal condyles of the first metacarpal (Gauthier 1986):
(0) absent
(1) present

256. Pronounced tubercle on the ventrolateral corner of shaft of the second (and possibly third) metacarpal, just below the proximal surface (McPhee et al. 2018):
- (0) absent
 - (1) present
257. Deep distal extensor pits on the second and third metacarpals (Novas 1993):
- (0) absent
 - (1) present
258. Shape of the distal ends of second and third metacarpals (Yates 2007):
- (0) subrectangular in distal view
 - (1) trapezoidal with flexor rims of distal collateral ligament pits flaring beyond extensor rims
259. Shape of the fifth metacarpal (Yates 2003a):
- (0) longer than wide at the proximal end with a flat proximal surface
 - (1) almost as wide as it is long with a strongly convex proximal articulation surface
260. Length of the fifth metacarpal (Upchurch 1998):
- (0) less than 75 per cent of the length of the third metacarpal
 - (1) greater than 75 per cent of the length of the third metacarpal
261. Length of manual digit one (Yates 2003a):
- (0) less than the length of manual digit two
 - (1) greater than the length of manual digit two
262. Ventrolateral twisting of the transverse axis of the distal end of the first phalanx of manual digit one relative to its proximal end (Serenio 1999): (ORDERED)
- (0) absent
 - (1) present but much less than 60 degrees
 - (2) 60 degrees
263. Length of the first phalanx of manual digit one (Gauthier 1986):
- (0) less than the length of the first metacarpal
 - (1) greater than the length of the first metacarpal
264. Length of first phalanx of manual digit 1 (Otero et al. 2015):
- (0) much greater than its mediolateral width at proximal end
 - (1) subequal or equal to its mediolateral width at proximal end
 - (2) much less than its mediolateral width at proximal end
265. Shape of the proximal articular surface of the first phalanx of manual digit one (modified from Serenio 1999):
- (0) rounded
 - (1) with an embayment on the medial side
266. Shape of the first phalanx of manual digit one (Wilson 2002):
- (0) elongate and subcylindrical
 - (1) strongly proximodistally compressed and wedge-shaped
267. Length of the penultimate phalanx of manual digit two (Rauhut 2003):
- (0) less than the length of the second metacarpal
 - (1) greater than the length of the second metacarpal
268. Length of the penultimate phalanx of manual digit three (Rauhut 2003):

- (0) less than the length of the third metacarpal
- (1) greater than the length of the third metacarpal
- 269. Shape of non-terminal phalanges of manual digits two and three (Yates 2003a):
 - (0) longer than wide
 - (1) as long as wide
- 270. Shape of the unguals of manual digits two and three (Serenio et al. 1993):
 - (0) straight
 - (1) strongly curved with tips projecting well below flexor margin of proximal articular surface
- 271. Length of the ungual of manual digit two (modified from Gauthier 1986): (ORDERED)
 - (0) greater than the length of the ungual of manual digit one
 - (1) 75-100 per cent of the ungual of manual digit one
 - (2) less than 75 per cent of the ungual of manual digit one
 - (3) the ungual of manual digit two is absent
- 272. Phalangeal formula of manual digits two and three (modified from Wilson and Sereno 1998):
 - (0) three and four, respectively
 - (1) with at least one phalanx missing from each digit
- 273. Phalangeal formula of manual digits four and five (Gauthier 1986):
 - (0) greater than 2-0, respectively
 - (1) less than 2-0, respectively
- 274. Strongly convex dorsal margin of the ilium (Gauthier 1986):
 - (0) absent
 - (1) present
- 275. Anterior extent of preacetabular process of ilium (Yates 2003a):
 - (0) does not project further anterior than the anterior margin of the pubic peduncle
 - (1) projects anterior to the anterior margin of the pubic peduncle
- 276. Shape of the preacetabular process (modified from Sereno 1999):
 - (0) blunt and rectangular
 - (1) with a pointed, projecting cranioventral corner and a rounded dorsum
- 277. Depth of the preacetabular process of the ilium (modified from Gauthier 1986):
 - (0) much less than the depth of the ilium above the acetabulum
 - (1) subequal to the depth of the ilium above the acetabulum
- 278. Length of preacetabular process of the ilium (Yates 2007):
 - (0) less than twice its depth
 - (1) greater than twice its depth
- 279. Medial wall of acetabulum (modified from Gauthier 1986): (ORDERED)
 - (0) fully closing acetabulum with a triangular ventral process between the pubic and ischial peduncles
 - (1) partially open acetabulum with a straight ventral margin between the peduncles
 - (2) partially open acetabulum with a concave ventral margin between the

- peduncles
- (3) fully open acetabulum with medial ventral margin closely approximating lateral rim of acetabulum
- 280. Length of the pubic peduncle of the ilium (Serenio 1999):
 - (0) less than twice the anteroposterior width of its distal end
 - (1) greater than twice the anteroposterior width of its distal end
- 281. Posteriorly projecting 'heel' at the distal end of the ischial peduncle (Yates 2003b):
 - (0) absent
 - (1) present
- 282. Length of the ischial peduncle of the ilium (Upchurch et al. 2004): (ORDERED)
 - (0) similar to pubic peduncle
 - (1) much shorter than pubic peduncle
 - (2) virtually absent so that the chord connecting the distal end of the pubic peduncle with the ischial articular surface contacts the postacetabular process
- 283. Length of the postacetabular process of the ilium (Yates 2007):
 - (0) between 40 and 100 per cent of the distance between the pubic and ischial peduncles
 - (1) less than 40 per cent of the distance between the pubic and ischial peduncles
 - (2) more than 100 per cent of the distance between the pubic and ischial peduncles
- 284. Well-developed brevis fossa with sharp margins on the ventral surface of the postacetabular process of the ilium (modified from Gauthier 1986):
 - (0) absent
 - (1) present, ventrally facing
 - (2) present, lateroventrally facing
- 285. Anterior end of ventrolateral ridge bounding brevis fossa (Yates 2007):
 - (0) not connected to supracetabular crest
 - (1) joining supracetabular crest
- 286. Shape of the posterior margin of the postacetabular process of the ilium (Yates 2003b):
 - (0) rounded to bluntly pointed
 - (1) square ended
 - (2) with a pointed ventral corner and a rounded posterodorsal margin
- 287. Width of the conjoined pubes (Cooper 1984):
 - (0) less than 75 per cent of their length
 - (1) greater than 75 per cent of their length
- 288. Pubic tubercle on the lateral surface of the proximal pubis (Yates 2003a):
 - (0) present
 - (1) absent
- 289. Proximal anterior profile of pubis (Yates 2007):
 - (0) anterior margin of pubic apron smoothly confluent with anterior margin of iliac pedicel
 - (1) iliac pedicel set anterior to the pubic apron creating a prominent inflection in the proximal anterior profile of the pubis

290. Anterior fossa on the proximal region of the pubic apron (Apaldetti et al. 2013):
(0) absent
(1) present
291. Minimum transverse width of the pubic apron (Yates 2007):
(0) much more than 40 per cent of the width across the iliac peduncles of the ilium
(1) less than 40 per cent of the width across the iliac peduncles of the ilium
292. Position of the obturator foramen of the pubis (Galton and Upchurch 2004):
(0) at least partially occluded by the iliac pedicel in anterior view
(1) completely visible in anterior view
293. Lateral margins of the pubic apron in anterior view (Yates and Kitching 2003):
(0) straight
(1) concave
294. Orientation of distal third of the blades of the pubic apron (Langer 2004):
(0) confluent with the proximal part of the pubic apron
(1) twisted posterolaterally relative to proximal section so that the anterior surface turns to face laterally
295. Orientation of the entire blades of the pubic apron (Wilson and Sereno 1998):
(0) transverse
(1) twisted posteromedially
296. Anteroposterior expansion of the distal pubis (modified from Gauthier 1986):
(ORDERED)
(0) absent
(1) less than 15 per cent of the length of the pubis
(2) greater than 15 per cent of the length of the pubis
297. Elongate interischial fenestra (Yates 2003b):
(0) absent
(1) present
298. Longitudinal dorsolateral sulcus extending along proximal half of the shaft of the ischium (Yates 2003a):
(0) absent
(1) present
299. Shape of distal ischium (Yates 2007):
(0) broad and plate-like, not distinct from obturator region
(1) with a discrete rod-like distal shaft
300. Length of ischium (Salgado et al. 1997):
(0) less than that of the pubis
(1) greater than that of the pubis
301. Ischial component of acetabular rim (Galton and Upchurch 2004):
(0) larger than the pubic component
(1) equal to the pubic component
302. Shape of the transverse section of the ischial shaft (Sereno 1999):
(0) ovoid to subrectangular
(1) triangular

303. Orientation of the long axes of the transverse section of the distal ischia (Wilson and Sereno 1998):
- (0) meet at an angle
 - (1) are coplanar
304. Depth of the transverse section of the ischial shaft (Wilson and Sereno 1998):
- (0) much less than the transverse width of the section
 - (1) at least as great as the transverse width of the section
305. Distal ischial expansion (Holtz 1994):
- (0) absent
 - (1) present
306. Transverse width of the conjoined distal ischial expansions (Yates 2003a):
- (0) greater than their sagittal depth
 - (1) less than their sagittal depth
307. Length of the hindlimb (Gauthier 1986)
- (0) greater than the length of the trunk
 - (1) less than the length of the trunk
308. Longitudinal axis of the femur in lateral view (modified from Cooper 1984):
(ORDERED)
- (0) strongly bent with an offset between the proximal and distal axes greater than 20 degrees
 - (1) weakly bent with an offset of around 20 degrees or less
 - (2) straight
309. Shape of the cross-section of the mid-shaft of the femur (Wilson and Sereno 1998):
- (0) subcircular
 - (1) strongly elliptical with the long axis orientated mediolaterally
310. Angle between the long axis of the femoral head and the transverse axis of the distal femur (Carrano 2000):
- (0) about 30 degrees
 - (1) close to 0 degrees
311. Shape of femoral head (Yates 2007):
- (0) roughly rectangular in profile with a sharp medial distal corner
 - (1) roughly hemispherical with no sharp medial distal corner
312. Posterior proximal tubercle on femur (Novas 1996):
- (0) well developed, producing a pronounced swelling on the posterior margin of the femoral head
 - (1) reduced to absent
313. Shape of the lesser trochanter (modified from Gauthier 1986):
- (0) small rounded tubercle
 - (1) proximodistally orientated, elongate ridge
 - (2) absent
314. Position of proximal tip of lesser trochanter (Galton and Upchurch 2004):
- (0) level with the femoral head
 - (1) distal to the femoral head
315. Projection of the lesser trochanter (Yates 2007):

- (0) just a scar upon the femoral surface
 - (1) a raised process
316. Transverse ridge extending laterally from the lesser trochanter (Rowe 1989):
- (0) absent
 - (1) present
317. Height of the lesser trochanter in cross section (modified from Galton 1990):
- (0) less than its basal width
 - (1) at least as high as its basal width
318. Position of the lesser trochanter in anterior view (Yates 2007):
- (0) near the centre of the anterior face of the femoral shaft
 - (1) close to the lateral margin of the femoral shaft
319. Visibility of the lesser trochanter in posterior view (Galton and Upchurch 2004):
- (0) not visible
 - (1) visible
320. Height of the fourth trochanter (Gauthier 1986):
- (0) a tall crest
 - (1) a low rugose ridge
321. Position of the fourth trochanter along the length of the femur (Galton 1990):
- (0) in the proximal half
 - (1) straddling the midpoint
322. Symmetry of the profile of the fourth trochanter of the femur (modified from Langer 2004):
- (0) subsymmetrical without a sharp distal corner
 - (1) asymmetrical with a steeper distal slope than the proximal slope and a distinct distal corner
 - (2) symmetrical, almost rectangular in lateral view with proximal and distal corners approaching an angle of 90 degrees
323. Shape of the profile of the fourth trochanter of the femur (Yates 2007):
- (0) rounded
 - (1) subrectangular
324. Position of fourth trochanter along the mediolateral axis of the femur (Galton 1990):
- (0) centrally located
 - (1) on the medial margin
325. Extensor depression on anterior surface of the distal end of the femur (Molnar et al. 1990):
- (0) absent
 - (1) present
326. Size of the medial condyle of the distal femur (modified from Wilson 2002):
- (0) subequal to the fibular + lateral condyles
 - (1) larger than the fibular + lateral condyles
327. Well-developed tibiofibular crest on distal femur (Smith and Pol 2007):
- (0) absent
 - (1) present
328. Distal surface of tibiofibular crest (Smith and Pol 2007):

- (0) as deep anteroposteriorly as wide mediolaterally or deeper
 - (1) wider mediolaterally than deep anteroposteriorly
329. Tibia: femur length ratio (modified from Gauthier 1986): (ORDERED)
- (0) tibia subequal or longer than the femur
 - (1) between 0.6 and 0.9
 - (2) less than 0.6
330. Orientation of cnemial crest (Wilson and Sereno 1998):
- (0) projects anteriorly to anterolaterally
 - (1) projecting laterally
331. Paramarginal ridge on lateral surface of cnemial crest (Yates 2007):
- (0) absent
 - (1) present
332. Position of the tallest point of the cnemial crest (Yates 2007):
- (0) close to the proximal end of the crest
 - (1) about half-way along the length of the crest, creating an anterodorsally sloping proximal margin of the crest
333. Proximal end of tibia with a flange of bone that contacts the fibula (Gauthier 1986):
- (0) absent
 - (1) present
334. Position of the posterior end of the fibular condyle on the proximal articular surface tibia (Yates 2007):
- (0) anterior to the posterior margin of the proximal articular surface
 - (1) level with the posterior margin of the proximal articular surface
335. Shape of the proximal articular surface of the tibia (McPhee et al. 2015a, modified from Wilson and Sereno 1998): (ORDERED)
- (0) transverse width subequal to anteroposterior length
 - (1) transverse width between 0.6 and 0.9 times anteroposterior length
 - (2) anteroposterior length twice the transverse width or higher
336. Proximal end of the tibia with a transverse/anteroposterior length ratio (Apaldetti et al. 2013):
- (0) narrow (ratio less than 0.7)
 - (1) broad (more than 0.7)
337. Transverse width of the distal tibia (Gauthier 1986):
- (0) subequal to its anteroposterior length
 - (1) greater than its anteroposterior length
338. Anteroposterior width of the lateral side of the distal articular surface of the tibia (Yates 2007):
- (0) as wide as the anteroposterior width of the medial side
 - (1) narrower than the anteroposterior width of the medial side
339. Relationship of the posterolateral process of the distal end of the tibia with the fibula (Yates 2007):
- (0) not flaring laterally and not making significant contact with the fibula
 - (1) flaring laterally and backing the fibula
340. Shape of the distal articular end of the tibia in distal view (Yates 2007):

- (0) ovoid
 - (1) subrectangular
341. Shape of the anteromedial corner of the distal articular surface of the tibia (Langer 2004):
- (0) forming a right angle
 - (1) forming an acute angle
342. Position of the lateral margin of descending posteroventral process of the distal end of the tibia (Wilson and Sereno 1998):
- (0) protrudes laterally at least as far as the anterolateral corner of the distal tibia
 - (1) set well back from the anterolateral corner of the distal tibia
343. A triangular rugose area on the medial side of the fibula (Wilson and Sereno 1998):
- (0) absent
 - (1) present
344. Transverse width of the midshaft of the fibula (Langer 2004): (ORDERED)
- (0) greater than 0.75 of the transverse width of the midshaft of the tibia
 - (1) between 0.5 and 0.75 of the transverse width of the midshaft of the tibia
 - (2) less than 0.5 of the transverse width of the midshaft of the tibia
345. Position of fibula trochanter (modified from Wilson and Sereno 1998):
- (0) on anterior surface of fibula
 - (1) laterally facing
 - (2) anteriorly facing but with strong lateral bulge
346. Depth of the medial end of the astragalar body in anterior view (Wilson and Sereno 1998):
- (0) roughly equal to the lateral end
 - (1) much shallower creating a wedge-shaped astragalar body
347. Shape of the posteromedial margin of the astragalus in dorsal view (Wilson and Sereno 1998):
- (0) evenly rounded without formation of a caudomedial corner
 - (1) forming a moderately sharp corner of a subrectangular astragalus
348. Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus (Sereno 1999):
- (0) present
 - (1) absent with a largely vertical fibular facet
349. Pyramidal dorsal process on the posteromedial corner of the astragalus (Yates 2007):
- (0) absent
 - (1) present
350. Shape of the ascending process of the astragalus (Yates 2007):
- (0) anteroposteriorly deeper than transversely wide
 - (1) transversely wider than anteroposteriorly deep
351. Posterior extent of ascending process of the astragalus (Wilson and Sereno 1998):
- (0) well anterior to the posterior margin of the astragalus
 - (1) close to the posterior margin of the astragalus
352. Sharp medial margin around the depression posterior to the ascending process of the astragalus (Novas 1996):

- (0) absent
- (1) present
- 353. Buttress dividing posterior fossa of astragalus and supporting ascending process (Wilson and Sereno 1998):
 - (0) absent
 - (1) present
- 354. Astragalus, ascending process, anterior base, fossa and/or foramina (Otero and Pol 2021, modified from Wilson and Sereno 1998):
 - (0) present
 - (1) absent
- 355. Distal articular surface of astragalus (Smith and Pol 2007):
 - (0) relatively flat or weakly convex
 - (1) extremely convex and roller-shaped
- 356. Posterior margin of astragalus (Otero and Pol 2013):
 - (0) straight
 - (1) convex
- 357. Mediolateral surface of distal astragalus (Otero and Pol 2013):
 - (0) straight
 - (1) concave
 - (2) convex
- 358. Transverse width of the calcaneum (Yates and Kitching 2003):
 - (0) greater than 30 per cent of the transverse width of the astragalus
 - (1) less than 30 per cent of the transverse width of the astragalus
- 359. Lateral surface of calcaneum (Yates 2007):
 - (0) simple
 - (1) with a fossa
- 360. Medial peg of calcaneum fitting into astragalus (Sereno et al. 1993):
 - (0) present, even if rudimentary
 - (1) absent
- 361. Calcaneal tuber (Yates 2007):
 - (0) large and well developed
 - (1) highly reduced to absent
- 362. Shape of posteromedial heel of distal tarsal four (lateral distal tarsal) (Sereno et al. 1993):
 - (0) proximodistally deepest part of the bone
 - (1) no deeper than the rest of the bone
- 363. Shape of posteromedial process of distal tarsal four in proximal view (Langer 2004):
 - (0) rounded
 - (1) pointed
- 364. Ossified distal tarsals (Gauthier 1986):
 - (0) present
 - (1) absent
- 365. Proximal width of the first metatarsal (modified from Wilson and Sereno 1998):
 - (0) is less than the proximal width of the second metatarsal

- (1) at least as great as the proximal width of the second metatarsal
- 366. Size of first metatarsal (McPhee et al. 2015a): (ORDERED)
 - (0) maximum proximal breadth 0.4 times its proximodistal length or less
 - (1) maximum proximal breadth between 0.4 and 0.7 times its proximodistal length
 - (2) maximum proximal breadth greater than 0.7 times its proximodistal length
- 367. Orientation of proximal articular surface of metatarsal one (Wilson 2002):
 - (0) horizontal
 - (1) sloping proximolaterally relative to the long axis of the bone
- 368. Shaft of metatarsal I (Smith and Pol 2007):
 - (0) closely appressed to metatarsal II throughout its length
 - (1) only closely appressed proximally, with a space between metatarsals I and II distally
- 369. Orientation of the transverse axis of the distal end of metatarsal one (Wilson 2002):
 - (0) horizontal
 - (1) angled dorsomedially
- 370. Shape of the medial margin of the proximal surface of the second metatarsal (modified from Sereno 1999):
 - (0) straight
 - (1) concave
- 371. Shape of the lateral margin of the proximal surface of the second metatarsal (modified from Sereno 1999):
 - (0) straight
 - (1) concave
- 372. Projection of ventral flange on proximal surface of second metatarsal (McPhee et al. 2015a):
 - (0) neither corner appreciably more developed than the other
 - (1) laterally flaring
 - (2) medially flaring
- 373. Lateral extent of ventrolateral flange on plantar surface of metatarsal II in proximal aspect (Smith and Pol 2007):
 - (0) similar in development to ventromedial flange
 - (1) well-developed, extending further laterally than ventromedial flange extends medially
- 374. Well-developed facet on proximolateral corner of plantar ventrolateral flange of metatarsal II for articulation with medial distal tarsal (Smith and Pol 2007):
 - (0) absent
 - (1) present
- 375. Length of the third metatarsal (Gauthier 1986):
 - (0) greater than 40 per cent of the length of the tibia
 - (1) less than 40 per cent of the length of the tibia
- 376. Proximal outline of metatarsal III (Smith and Pol 2007):
 - (0) subtriangular with acute or rounded posterior border
 - (1) subtrapezoidal, with posterior border broadly exposed in plantar view

377. Minimum transverse shaft diameters of third and fourth metatarsals (Wilson and Sereno 1998):
- (0) greater than 60 per cent of the minimum transverse shaft diameter of the second metatarsal
 - (1) less than 60 per cent of the minimum transverse shaft diameter of the second metatarsal
378. Transverse width of the proximal end of the fourth metatarsal (modified from Sereno 1999)
- (0) less than twice the anteroposterior depth of the proximal end
 - (1) at least twice the anteroposterior depth of the proximal end
379. Angle formed by the anterior and anteromedial borders of metatarsal IV (Smith and Pol 2007)
- (0) obtuse
 - (1) right angle, or acute
380. Transverse width of the proximal end of the fifth metatarsal (modified from Sereno 1999): (ORDERED)
- (0) less than 25 per cent of the length of the fifth metatarsal
 - (1) between 30 and 49 per cent of the length of the fifth metatarsal
 - (2) greater than 50 per cent of the length of the fifth metatarsal
381. Transverse width of distal articular surface of metatarsal four in distal view (Sereno 1999)
- (0) greater than the anteroposterior depth
 - (1) less than the anteroposterior depth
382. Fifth metatarsal, ventral surface, muscle scar (Otero and Pol 2021):
- (0) present
 - (1) absent
383. Pedal digit five (Wilson and Sereno 1998):
- (0) reduced, non-weight bearing
 - (1) large (fifth metatarsal at least 70 per cent of fourth metatarsal), robust and weight bearing
384. Length of non-terminal pedal phalanges (modified from Wilson and Sereno 1998): (ORDERED)
- (0) all longer than wide
 - (1) proximalmost phalanges longer than wide while more distal phalanges are as wide as long
 - (2) all non-terminal phalanges are as wide, if not wider, than long
385. Length of the first phalanx of pedal digit one (Yates and Kitching 2003):
- (0) greater than the length of the ungual of pedal digit one
 - (1) less than the length of the ungual of pedal digit one
386. Length of the ungual of pedal digit one (modified from Yates 2007): (ORDERED)
- (0) less than at least some non-terminal phalanges
 - (1) longer than all non-terminal phalanges but shorter than first metatarsal
 - (2) longer than the first metatarsal
387. Shape of the ungual of pedal digit one (Wilson and Sereno 1998):

- (0) shallow, pointed, with convex sides and a broad ventral surface
 - (1) deep, abruptly tapering, with flattened sides and a narrow ventral surface
388. Shape of proximal articular surface of pedal unguals (Wilson and Sereno 1998):
- (0) proximally facing, visible on medial and lateral sides
 - (1) proximomedially facing and visible only in medial view, causing medial deflection of pedal unguals in articulation
389. Penultimate phalanges of pedal digits two and three (Wilson and Sereno 1998):
- (0) well-developed
 - (1) reduced disc-shaped elements if they are ossified at all
390. Shape of the unguals of pedal digits two and three (Wilson and Sereno 1998):
- (0) dorsoventrally deep with a proximal articulating surface that is at least as deep as it is wide
 - (1) dorsoventrally flattened with a proximal articulating surface that is wider than deep
391. Length of the ungual of pedal digit two (modified from Gauthier 1986): (ORDERED)
- (0) greater than the length of the ungual of pedal digit one
 - (1) between 90 and 100 per cent of the length of the ungual of pedal digit one
 - (2) less than 90 per cent of the length of the ungual of pedal digit one
392. Size of the ungual of pedal digit three (Yates 2003a):
- (0) greater than 85 per cent of the ungual of pedal digit two in all linear dimensions
 - (1) less than 85 per cent of the ungual of pedal digit two in all linear dimensions
393. Number of phalanges in pedal digit four (Gauthier 1986):
- (0) four
 - (1) fewer than four
394. Phalanges of pedal digit five (Gauthier 1986):
- (0) present
 - (1) absent
395. Femoral length (modified from Yates 2004): (ORDERED)
- (0) less than 200 mm
 - (1) between 200 and 399 mm
 - (2) between 400 and 599 mm
 - (3) between 600 and 799 mm
 - (4) between 800 and 1000 mm
 - (5) greater than 1000 mm
396. The presence of growth marks (LAGs and/or annuli) in the cortical bone (Cerda et al. 2017):
- (0) growth marks present in the whole cortex
 - (1) growth marks absent or only formed in the outer cortex
397. The relative abundance of woven fibered (WFB) versus parallel fibered bone (PFB) in the primary compact bone (Cerda et al. 2017):
- (0) PFB>WFB
 - (1) WFB>PFB
398. The proximal end of metacarpal V (New character):

- (0) transversely wider than the distal end
- (1) as wide as the distal end
- (2) transversely narrower than the distal end

References

- Apaldetti C, Pol D, Yates A. 2013. The postcranial anatomy of *Coloradisaurus brevis* (Dinosauria: Sauropodomorpha) from the Late Triassic of Argentina and its phylogenetic implications. *Palaeontology* 56, 277–301.
- Barrett PM, Upchurch P, Wang XL. 2005. Cranial osteology of *Lufengosaurus huenei* Young (Dinosauria: Prosauropoda) from the Lower Jurassic of Yunnan, People's Republic of China. *J. Vert. Paleontol.* 25, 806–822.
- Benton MJ, Juul L, Storrs GW, Galton PM, 2000. Anatomy and systematics of the prosauropod dinosaur *Thecodontosaurus antiquus* from the Upper Triassic of southwest England. *J. Vert. Paleontol.*, 20: 77–108.
- Bonaparte, JF. 1986. Les Dinosaures (Carnosaures, Allosauridés, Sauropodes, Cétiosauridés) du Jurassique moyen de Cerro Cóndor (Chubut, Argentino). *Annales de Paléontologie*, 72, 326–386.
- Bonaparte, JF. 1999. Evolución de las vertebrae presacras en Sauropodomorpha. *Ameghiniana*, 36: 115–187.
- Bronzati M, Benson RB, Rauhut OW. 2018. Rapid transformation in the braincase of sauropod dinosaurs: integrated evolution of the braincase and neck in early sauropods? *Palaeontology* 61, 289–302.
- Bronzati M, Rauhut OWM. 2017. Braincase redescription of *Efraasia minor* (Huene, 1908) (Dinosauria, Sauropodomorpha) from the Late Triassic of Germany, with comments on the evolution of the sauropodomorph braincase. *Zool. J. Linn. Soc.* 182, 173–224.
- Butler RJ, Upchurch P, Norman DB. 2008. The phylogeny of the ornithischian dinosaurs. *J. Syst. Palaeontol.* 6(1): 1–40.
- Carrano, M.T. 2000. Homoplasy and the evolution of dinosaur locomotion. *Paleobiology*, 26(3): 489–512.
- Cerda IA, et al. 2017. Novel insight into the origin of the growth dynamics of sauropod dinosaurs. *PLoS One* 12, e0179707.
- Chapelle KEJ, Choiniere JN. 2018. A revised cranial description of *Massospondylus carinatus* Owen (Dinosauria: Sauropodomorpha) based on computed tomographic scans and a review of cranial characters for basal Sauropodomorpha. *PeerJ* (doi:10.7717/peerj.4224).
- Cooper MR. 1984. A reassessment of *Vulcanodon karibaensis* Raath (Dinosauria: Saurischia) and the origin of the Sauropoda. *Palaeont. afr.*, 25: 203–231.
- Galton PM. 1985. Cranial anatomy of the prosauropod dinosaur *Sellosaurus Gracilis* from the Middle Stubensandstein (Upper Triassic) of Nordwürttemberg, West Germany. *Stuttgarter Beitrage zur Naturkunde*, Series B (118): 1–39.
- Galton PM. 1990. Basal Sauropodomorpha–Prosauropoda P. 733 in D.B. Weishampel, P. Dodson and H. Osmolska (eds) *The Dinosauria*. University of California Press, Berkeley, CA.
- Galton PM, Upchurch P. 2004. Prosauropoda. pp. 232–258 in D.B. Weishampel, P. Dodson and H. Osmolska (eds) *The Dinosauria: 2nd Edition*. The University of California Press, Berkeley.
- Gauthier J. 1986. Saurischian monophyly and the origin of birds. *Memoirs of the Californian Academy of Sciences*, 8: 1–55.

- Holtz TR. 1994. The phylogenetic position of the Tyrannosauridae: implications for theropod systematics. *J. Paleontol.*, 68(5): 1100-1117.
- Langer MC. 2004. Basal Saurischia. pp. 25-46 in D.B. Weishampel, P. Dodson and H. Osmólska (eds) *The Dinosauria*. University of California Press, Berkeley, CA.
- McPhee BW, Yates AM, Choiniere JN, Abdala F. 2014. The complete anatomy and phylogenetic relationships of *Antetonitrus ingenipes* (Sauropodiformes, Dinosauria): implications for the origins of Sauropoda. *Zool. J. Linn. Soc.*, 171(1): 151-205.
- McPhee BW et al. 2015a. A new basal sauropod from the pre-Toarcian Jurassic of South Africa: evidence of niche-partitioning at the sauropodomorph-sauropod boundary? *Scientific Reports* 5, 13224.
- McPhee BW, Choiniere JN. 2018. The osteology of *Pulanesaura eocollum*: implications for the inclusivity of Sauropoda (Dinosauria). *Zool. J. Linn. Soc.* 182, 830–861.
- McPhee BW et al. 2018. A giant dinosaur from the earliest Jurassic of South Africa and the transition to quadrupedality in early sauropodomorphs. *Current Biology*, 28, 3143–3151.
- McPhee BW, Choiniere JN, Yates AM, Viglietti PA. 2015b. A second species of *Eucnemesaurus* Van Hoepen, 1920 (Dinosauria, Sauropodomorpha): new information on the diversity and evolution of the sauropodomorph fauna of South Africa's lower Elliot Formation (latest Triassic). *J. Vert. Paleontol.* 35, e980504.
- McPhee BW, Bittencourt JS, Langer MC, Apaldetti C, Da Rosa ÁAS. 2020. Reassessment of *Unaysaurus tolentinoi* (Dinosauria: Sauropodomorpha) from the Late Triassic (early Norian) of Brazil, with a consideration of the evidence for monophyly within non-sauropodan sauropodomorphs. *J. Syst. Palaeontol.* 18, 259-293.
- Molnar R, Kurzanov S, Dong Z. 1990. Carnosauria. pp. 169-209 in D.B. Weishampel, P. Dodson and H. Osmólska (eds) *The Dinosauria*. University of California Press, Berkeley, CA.
- Novas FE. 1992. Phylogenetic relationships of the basal dinosaurs, the Herrerasauridae. *Palaeontology*, 35(1): 51-62.
- Novas FE. 1993. New information on the systematics and postcranial skeleton of *Herrerasaurus ischigualastensis* (Theropoda: Herrerasauridae) from the Ischigualasto Formation (Upper Triassic) of Argentina. *J. Vert. Paleontol.*, 13(4): 400-423.
- Novas FE. 1996. Dinosaur monophyly. *J. Vert. Paleontol.*, 16(4): 723-741.
- Otero A, Pol D. 2013. Postcranial anatomy and phylogenetic relationships of *Mussaurus patagonicus* (Dinosauria, Sauropodomorpha). *J. Vert. Paleontol.* 33, 1138–1168.
- Otero A et al. 2015. A new basal sauropodiform from South Africa and the phylogenetic relationships of basal sauropodomorphs. *Zool. J. Linn. Soc.* 174, 589–634.
- Otero A, Pol D. 2021. Ontogenetic changes in the postcranial skeleton of *Mussaurus patagonicus* (Dinosauria, Sauropodomorpha) and their impact on the phylogenetic relationships of early sauropodomorphs. *J. Syst. Palaeontol.* 19, 1467-1516.
- Pérez-Moreno BP, Sanz JL, Buscalioni AD, Moratalla JJ, Ortega F, Rasskin-Gutman D. 1994. A unique multitoothed ornithomimosaur dinosaur from the Lower Cretaceous of Spain. *Nature*, 370(6488): 363.
- Pol D, Powell JE. 2007. New information on *Lessemsaurus sauropoides* (Dinosauria: Sauropodomorpha) from the Upper Triassic of Argentina. *Spec. Pap. Palaeontol.* 77: 223-243.

- Pretto FA, Langer MC, Schultz CL. 2018. A new dinosaur (Saurischia: Sauropodomorpha) from the Late Triassic of Brazil provides insights on the evolution of sauropodomorph body plan. *Zool. J. Linn. Soc.* 185, 388–416.
- Rauhut OWM. 2003. The interrelationships and evolution of basal theropod dinosaurs. *Spec. Pap. Palaeontol.* 69, 1–213.
- Remes K. 2008. Evolution of the pectoral girdle and forelimb in Sauropodomorpha (Dinosauria, Saurischia): osteology, myology and function. Ludwig-Maximilians-Universitat Munchen.
- Rowe T. 1989. A new species of the theropod dinosaur *Syntarsus* from the Early Jurassic Kayenta Formation of Arizona. *J. Vert. Paleontol.* 9, 125–136.
- Salgado L, Coria RA, Calvo JO. 1997. Evolution of titanosaurid sauropods. I. Phylogenetic analysis based on the postcranial evidence. *Ameghiniana*, 34: 3-32.
- Sereno PC. 1999. The Evolution of Dinosaurs. *Science*, 284(5423): 2137-2147.
- Sereno PC, Dutheil DB, Iarochene M, Larsson HC, Lyon GH, Magwene PM, Sidor CA, Varricchio DJ, Wilson JA. 1996. Predatory dinosaurs from the Sahara and Late Cretaceous faunal differentiation. *Science*, 272(5264): 986-991.
- Sereno PC, Forster CA, Rogers RR, Monetta AM. 1993. Primitive dinosaur skeleton from Argentina and the early evolution of Dinosauria. *Nature*, 361(6407): 64-66.
- Smith ND, Pol D. 2007. Anatomy of a basal sauropodomorph dinosaur from the Early Jurassic Hanson Formation of Antarctica. *Acta Palaeontol. Pol.* 52, 657–674.
- Upchurch P. 1995. The Evolutionary History of Sauropod Dinosaurs. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 349(1330): 365-390.
- Upchurch P. 1998. The phylogenetic relationships of sauropod dinosaurs. *Zool. J. Linn. Soc.* 124(1): 43-103.
- Upchurch P, Barrett PM, Dodson P. 2004. Sauropoda. pp. 259-322 in D.B. Weishampel, P. Dodson and H. Osmolska (eds) *The Dinosauria*. University of California Press, Berkeley, CA.
- Wang Y-M, You H-L, Wang T. 2017. A new basal sauropodiform dinosaur from the Lower Jurassic of Yunnan Province, China. *Sci. Rep.* 7: 41881, doi:10.1038/srep41881.
- Wilson JA. 1999. A nomenclature for vertebral laminae in sauropods and other saurischian dinosaurs. *J. Vert. Paleontol.* 19(4): 639-653.
- Wilson JA. 2002. Sauropod dinosaur phylogeny: critique and cladistic analysis. *Zool. J. Linn. Soc.* 136: 217–276.
- Wilson JA, Sereno PC. 1998. Early evolution and higher-level phylogeny of sauropod dinosaurs. *J. Vert. Paleontol.* 18(S2): 1-79.
- Yates AM. 2003. A new species of the primitive dinosaur *Thecodontosaurus* (Saurischia: Sauropodomorpha) and its implications for the systematics of early dinosaurs. *Journal of Systematic Palaeontology*, 1(1): 1-42.
- Yates AM. 2004. *Anchisaurus polyzelus* (Hitchcock): the smallest known sauropod dinosaur and the evolution of gigantism among sauropodomorph dinosaurs. *Postilla*, 230: 1-58.
- Yates AM. 2007. The first complete skull of the Triassic dinosaur *Melanorosaurus Haughton* (Sauropodomorpha: Anchisauria). *Spec. Pap. Palaeontol.* 77, 9–55.

- Yates AM, Kitching JW. 2003. The earliest known sauropod dinosaur and the first steps towards sauropod locomotion. *Proc. R. Soc. Lond. Ser. B. Biol. sci.* 270, 1753–1758.
- Zhang Q-N, Jia L, Wang T, Zhang Y-G, You H-L. 2024. The largest sauropodomorph skull from the Lower Jurassic Lufeng Formation of China. *PeerJ* 12: e18629, doi:10.7717/peerj.18629.