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## SUPPLEMENTARY ONLINE MATERIAL FOR

### **A new sauropodomorph dinosaur from the Late Triassic of the Mid-Zambezi Basin, Zimbabwe**

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#### **Supplementary Online Material**

- SOM 1.** CT model of tibia of *Musankwa sanyatiensis* gen. et sp. nov. (NHMZ 2521) from the Pebbly Arkose Formation (Upper Triassic) of Spurwing Island, Zimbabwe available at [http://app.pan.pl/SOM/app69-Barrett\\_etal\\_SOM/SOM\\_1.ply](http://app.pan.pl/SOM/app69-Barrett_etal_SOM/SOM_1.ply)
- SOM 2.** CT model of astragalus of *Musankwa sanyatiensis* gen. et sp. nov. (NHMZ 2521) from the Pebbly Arkose Formation (Upper Triassic) of Spurwing Island, Zimbabwe available at [http://app.pan.pl/SOM/app69-Barrett\\_etal\\_SOM/SOM\\_2.ply](http://app.pan.pl/SOM/app69-Barrett_etal_SOM/SOM_2.ply)
- SOM 3.** R1 matrix in nex file format available at [http://app.pan.pl/SOM/app69-Barrett\\_etal\\_SOM/SOM\\_3.nex](http://app.pan.pl/SOM/app69-Barrett_etal_SOM/SOM_3.nex)
- SOM 4.** R1 matrix in tnt file format available at [http://app.pan.pl/SOM/app69-Barrett\\_etal\\_SOM/SOM\\_4.tnt](http://app.pan.pl/SOM/app69-Barrett_etal_SOM/SOM_4.tnt)
- SOM 5.**
- I. Updates to the Pol et al. (2021) character matrix
  - II. Character scores for *Musankwa sanyatiensis* (NHMZ 2521) in the modified version of the Pol et al. (2021) data matrix
  - III. Synapomorphies supporting nodes within Massopoda
  - IV. Renumbered character list

#### **References**

## SOM 5.



Figure S1. The house-boat 'Musankwa' which was our base of operations during explorations of the Kariba shoreline in 2017–18, and which gives its name to the new taxon described herein.

### I. Updates to the Pol et al. (2021) character matrix

As *Plateosaurus engelhardti* is a *nomen dubium* we have changed the name of this operational taxonomic unit to *Plateosaurus trossingensis* (see Regalado Fernández et al. 2023). We have removed the problematic taxon *P. ingens* pending a thorough taxonomic revision of this material (see Rauhut et al. 2020) and added *Musankwa sanyatiensis* to give a total of 79 operational taxonomic units.

Although maximum body size might ultimately prove to be a useful phylogenetic character, we deleted Character 353 from this version of the matrix. This is because it's unclear if the femora being scored (as a proxy for body size) all represent animals that have reached the maximum size attainable for each taxon. Deletion of this character helps to avoid incorrect scoring, which might result from the accidental inclusion of juveniles, for example. Osteohistological data would need to be available for all femora scored to ensure that growth had slowed or ended. This gives a total of 418 characters.

Removal of Character 353 results in changes to character numbering, so we provide a slightly revised character list, below. This list is consistent with the character descriptions embedded within the original TNT file supplied with Pol et al. (2021).

Several scoring changes were adopted following personal observations, the advice of the referees (O. Regalado Fernández, pers. comms, Jan 2024) or information from the literature. Character numbers below refer to our revised character list (see below) which differ from those originally given in Pol et al. (2021).

Character 74:

- i. *Eoraptor* changed from “1” to “?” as the back of the skull is too badly crushed to accurately score this character state (see Sereno 2013).
- ii. *Panphagia* changed from “1” to “?” as the holotype lacks this region (see Martínez and Alcober 2009).

Character 171:

- i. *Lessemsaurus* changed to “0” (see Bonaparte 1999).
- ii. *Isanosaurus* changed to “1” because Buffetaut et al. (2000) describe it as having the “incipient” condition.

Character 353:

- i. *Blikanasaurus* is now state “0” because its medial flange extends much farther than the lateral flange (based on personal observation of the holotype material).
- ii. *Massospondylus carinatus* is now state “0” because the flanges are subequal (personal observation of the condition in the referred specimen BP-1-5241).
- iii. NMQR 1551 is now state “0” based on personal inspection of the material, the medial flange extends farther than the lateral flange.
- iv. *Antetonitrus* is now state “0” based on personal inspection of the holotype with reference to McPhee et al.’s (2014) monograph. The medial flange extends farther.

(NB, this is character 354 in Pol et al. [2021], number has changed due to deletion of original Character 353, see above).

Character 389:

- i. This feature is stated to be present in *Tazoudasaurus* by Allain & Aquesbi (2008), so this is changed to “1”.

(NB, this is character 390 in Pol et al. [2021], the number has changed due to deletion of original Character 353, see above).

Character 390:

- i. *Pulanesaura* changed to a “?” because it lacks distal caudals.

(NB, in the character list provided by Pol et al. [2021] this is listed as Character 198, but in their TNT file it is Character 391).

Character 391:

- i. *Plateosauravus* changed to state “0” based on re-inspection of the type material.
- ii. *Vulcanodon* changed to state “?” because the proximal humerus is not preserved in the type (Cooper 1984).

(NB, this is Character 392 in Pol et al. [2021], as the number has changed due to deletion of original Character 353, see above).



Character 190: 0→1. Longitudinal ventral sulcus on proximal and middle caudal vertebrae absent. Homoplastic across the tree – this feature is common in earlier-branching taxa and present again in many sauropodiforms, e.g., Lessemsauridae. NB, this optimises as a synapomorphy in only some of the MPTs.

Character 289: 0→1. Height of the lesser trochanter in cross section at least as high as basal width. Present homoplastically in *Nambalia* and *Camelotia* among ingroup taxa.

Character 295: 1→0. Rounded profile to fourth trochanter.

#### IV. Renumbered character list

1. Skull to femur ratio
  - 0 greater than 0.6
  - 1 less than 0.6
  
2. Lateral plates appressed to the labial side of the premaxillary maxillary and dentary teeth
  - 0 absent
  - 1 present
  
3. Relative height of the rostrum at the posterior margin of the naris
  - 0 more than 0.6 of the height of the skull at the middle of the orbit
  - 1 less than 0.6 of the height of the skull at the middle of the orbit
  
4. Foramen on the lateral surface of the premaxillary body
  - 0 absent
  - 1 present
  
5. Distal end of the dorsal premaxillary process
  - 0 tapered
  - 1 transversely expanded
  
6. Profile of premaxilla
  - 0 convex
  - 1 with an inflection at the base of the dorsal process
  
7. Size and position of the posterolateral process of premaxilla
  - 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 posterolateral process of the premaxilla and the anteroventral process of the nasal
  - 0 broad sutured contact
  - 1 point contact
  - 2 briefly separated by maxilla
  - 3 well separated from each other by the entire posterior margin of the external nares
  
9. Posteromedial process of the premaxilla
  - 0 absent

1 present

10. Shape of the anteromedial process of the maxilla

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

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

0 weak and orientated laterally to dorsolaterally

1 well developed and forming a horizontal shelf

13. Size and position of subnarial foramen

0 absent

1 small no larger than adjacent maxillary neurovascular foramina and positioned outside of narial fossa

2 large and on the rim of or inside the narial fossa

14. Shape of subnarial foramen

0 rounded

1 slot shaped

15. Maxillary contribution to the margin of the narial fossa

0 absent

1 present

16. Diameter of external naris

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 adults

0 rounded

1 subtriangular with an acute posteroventral corner

18. Level of the anterior margin of the external naris

0 anterior to the midlength of the premaxillary body

1 posterior to the midlength of the premaxillary body

19. Level of the posterior margin of external naris

0 anterior to or level with the premaxilla maxilla suture

1 posterior to the first maxillary alveolus

2 posterior to the midlength of the maxillary tooth row and the anterior margin of the antorbital fenestra

20. Dorsal profile of the snout

- 0 straight to gently convex
- 1 with a depression behind the naris

21. Elongate median nasal depression

- 0 absent
- 1 present

22. Width of anteroventral process of nasal at its base

- 0 less than width of anterodorsal process at its base
- 1 greater than width of anterodorsal process at its base

23. Nasal relationship with dorsal margin of antorbital fossa

- 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 caudolateral process of the nasal overlapping the lachrymal

- 0 absent
- 1 present

25. Anterior profile of the maxilla

- 0 slopes continuously towards the rostral tip
- 1 with a strong inflection at the base of the ascending ramus creating a rostral ramus with parallel dorsal and ventral margins

26. Length of rostral ramus of the maxilla

- 0 less than its dorsoventral depth
- 1 greater than its dorsoventral depth

27. Shape of the main body of the maxilla

- 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

- 0 tapering dorsally
- 1 with an anteroposterior expansion at the dorsal end

29. Rostrocaudal length of the antorbital fossa

- 0 greater than that of the orbit
- 1 less than that of the orbit

30. Posteroventral extent of medial wall of antorbital fossa

- 0 reaching the anterior tip of the jugal
- 1 terminating anterior to the anterior tip of the jugal

31. Development of the antorbital fossa on the ascending ramus of the maxilla

- 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
- 32. Shape of the antorbital fossa
  - 0 crescentic with a strongly concave posterior margin that is roughly parallel to the rostral margin of the antorbital fossa
  - 1 subtriangular with a straight to gently concave posterior margin
  - 2 antorbital fossa absent
- 33. Size of the neurovascular foramen at the caudal end of the lateral maxillary row
  - 0 not larger than the others
  - 1 distinctly larger than the others in the row
- 34. Direction that the neurovascular foramen at the caudal end of the lateral maxillary row opens
  - 0 caudally
  - 1 rostrally ventrally or laterally
- 35. Arrangement of lateral maxillary neurovascular foramina
  - 0 linear
  - 1 irregular
- 36. Longitudinal ridge on the posterior lateral surface of the maxilla
  - 0 absent
  - 1 present
- 37. Dorsal exposure of the lachrymal
  - 0 present
  - 1 absent
- 38. Shape of the lachrymal
  - 0 dorsoventrally short and blocks shaped
  - 1 dorsoventrally elongate and shaped like an inverted L
- 39. Orientation of the lachrymal orbital margin
  - 0 strongly sloping anterodorsally
  - 1 erect and close to vertical
- 40. Length of the anterior ramus of the lachrymal
  - 0 greater than half the length of the ventral ramus or absent altogether
  - 1 less than half the length of the ventral ramus
  - 2 absent altogether
- 41. Web of bone spanning junction between anterior and ventral rami of lachrymal
  - 0 absent and antorbital fossa laterally exposed
  - 1 present obscuring posterodorsal corner of antorbital fossa
- 42. Extension of the antorbital fossa onto the ventral end of the lachrymal



0 present

1 absent

43. Length of the caudal process of the prefrontal

0 short

1 elongated so that total prefrontal length is equal to the rostrocaudal diameter of the orbit

44. Ventral process of prefrontal extending down the posteromedial side of the lachrymal

0 present

1 absent

45. Maximum transverse width of the prefrontal

0 less than 0.25 of the skull width at that level

1 more than 0.25 of the skull width at that level

46. Shape of the orbit

0 subcircular

1 ventrally constricted making the orbit subtriangular

47. Slender anterior process of the frontal intruding between the prefrontal and the nasal

0 absent

1 present

48. Jugal lachrymal relationship

0 lachrymal overlapping lateral surface of jugal or abutting it dorsally

1 jugal overlapping lachrymal laterally

49. Shape of the suborbital region of the jugal

0 an anteroposteriorly elongate bar

1 an anteroposteriorly shortened plate

50. Jugal contribution to the antorbital fenestra

0 present

1 absent

51. Dorsal process of the anterior jugal

0 present

1 absent

52. Ratio of the minimum depth of the jugal below the orbit to the distance between the rostral end of the jugal and the rostroventral corner of the infratemporal fenestra

0 less than 0.2

1 greater than 0.2

53. Transverse width of the ventral ramus of the postorbital

0 less than its rostrocaudal width at midshaft

- 1 greater than its rostrocaudal width at midshaft
54. Shape of the dorsal margin of postorbital in lateral view  
0 straight to gently curved  
1 with a distinct embayment between the anterior and posterior dorsal processes
55. Height of the postorbital rim of the orbit  
0 flush with the posterior lateral process of the postorbital  
1 raised so that it projects laterally to the posterior dorsal process
56. Postfrontal bone  
0 present  
1 absent
57. Position of the rostral margin of the infratemporal fenestra  
0 behind the orbit  
1 extends under the rear half of the orbit  
2 extends as far forward as the midlength of the orbit
58. Frontal contribution to the supratemporal fenestra  
0 present  
1 absent
59. Orientation of the long axis of the supratemporal fenestra  
0 longitudinal  
1 transverse
60. Medial margin of supratemporal fossa  
0 simple smooth curve  
1 with a projection at the frontal postorbital parietal suture producing a scalloped margin
61. Length of the quadratojugal ramus of the squamosal relative to the width at its base  
0 less than four times its width  
1 greater than four times its width
62. Proportion of infratemporal fenestra b by squamosal  
0 more than 0.5 of the depth of the infratemporal fenestra  
1 less than 0.5 of the depth of the infratemporal fenestra
63. Squamosal quadratojugal contact  
0 present  
1 absent
64. Angle of divergence between jugal and squamosal rami of quadratojugal  
0 close to 90  
1 close to parallel

65. Length of jugal ramus of quadratojugal  
0 no longer than the squamosal ramus  
1 longer than the squamosal ramus
66. Shape of the rostral end of the jugal ramus of the quadratojugal  
0 tapered  
1 dorsoventrally expanded
67. Relationship of quadratojugal to jugal  
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
68. Position of the quadrate foramen  
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
69. Shape of posterolateral margin of quadrate  
0 sloping anterolaterally from posteromedial ridge  
1 everted posteriorly creating a posteriorly facing fossa  
2 posterior fossa deeply excavated invading quadrate body
70. Exposure of the lateral surface of the quadrate head  
0 absent covered by lateral sheet of the squamosal  
1 present
71. Proportion of the length of the quadrate that is occupied by the pterygoid wing  
0 at least 70%  
1 less than 70%
72. Depth of the occipital wing of the parietal  
0 less than 1.5 times the depth of the foramen magnum  
1 more than 1.5 times the depth of the foramen magnum
73. Position of foramina for mid cerebral vein on occiput  
0 between supraoccipital and parietal  
1 on the supraoccipital
74. Postparietal fenestra between supraoccipital and parietals  
0 absent  
1 present
75. Shape of the supraoccipital  
0 diamond shaped at least as high as wide  
1 semilunate and wider than high

76. Orientation of the supraoccipital plate  
0 erect to gently sloping  
1 strongly sloping forward so that the dorsal tip lies level with the basiptyergoid processes
77. Orientation of the paroccipital processes in occipital view  
0 slightly dorsolaterally directed to horizontal  
1 ventrolaterally directed
78. Orientation of the paroccipital processes in dorsal view  
0 posterolateral forming a V shaped occiput  
1 lateral forming a flat occiput
79. Size of the post temporal fenestra  
0 large fenestra  
1 a small hole that is much less than half the depth of the paroccipital process
80. Exit of the mid cerebral vein  
0 through trigeminal foramen  
1 through a separate foramen
81. Shape of the floor of the braincase in lateral view  
0 relatively straight with the basal tuberae basiptyergoid processes and parasphenoid rostrum roughly aligned  
1 bent with the basiptyergoid processes and the parasphenoid rostrum below the level of the basioccipital condyle and the basal tuberae  
2 bent with the basal tuberae lowered below the level of the basioccipital and the parasphenoid rostrum raised above it
82. Basioccipital component of basal tubera medial component in relation to the parabasisphenoidal components  
0 present  
1 absent
83. Length of the basiptyergoid processes from the top of the parasphenoid to the tip of the process  
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
84. Basioccipita parabasisphenoid junction on the ventral surface of the bones  
0 straight line  
1 U V shaped
85. Subsellar recess

- 0 maximum width equal or greater than the dorsoventral height
- 1 maximum width smaller than the dorsoventral height

86. Dorsoventral depth of the parasphenoid rostrum

- 0 much less than the transverse width
- 1 about equal to the transverse width

87. Shape of jugal process of ectopterygoid

- 0 gently curved
- 1 strongly recurved and hook like

88. Pneumatic fossa on the ventral surface of the ectopterygoid

- 0 absent
- 1 present

89. Relationship of the ectopterygoid to the pterygoid

- 0 ectopterygoid overlapping the ventral
- 1 dorsal surface of the pterygoid

90. Position of the maxillary articular surface of the palatine

- 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

91. Centrally located tubercle on the ventral surface of palatine

- 0 absent
- 1 present

92. Medial process of the pterygoid forming a hook around the basiptyergoid process

- 0 absent
- 1 flat and blunt ended
- 2 bent upward and pointed

93. Length of the vomers

- 0 less than 0.25 of the total skull length
- 1 more than 0.25 of the total skull length

94. Position of jaw joint

- 0 no lower than the level of the dorsal margin of the dentary
- 1 depressed well below this level

95. Shape of upper jaws in ventral view

- 0 narrow with an acute rostral apex
- 1 broad and U shaped

96. Length of the external mandibular fenestra

- 0 more than 0.1 the length of the mandible

1 less than 0.1 of the length of the mandible

97. Caudal end of dentary tooth row medially inset with a thick lateral ridge on the dentary forming a buccal emargination

0 absent

1 present

98. Height length ratio of the dentary

0 less than 0.2

1 greater than 0.2

99. Orientation of the symphyseal end of the dentary

0 in line with the long axis of the dentary

1 strongly curved ventrally

100. Position of first dentary tooth

0 adjacent to symphysis

1 inset one tooth s width from the symphysis

101. Dorsoventral expansion at the symphyseal end of the dentary

0 absent

1 present

102. Splenial foramen

0 absent

1 present and enclosed

2 present and open anteriorly

103. Splenial angular joint

0 flattened sutured contact

1 synovial joint surface between tongue like process of angular fitting in groove of the splenial

104. A stout triangular medial process of the articular behind the glenoid

0 present

1 absent

105. Length of the retroarticular process

0 less than the depth of the mandible below the glenoid

1 greater than than the depth of the mandible below the glenoid

106. Strong medial embayment behind glenoid of the articular in dorsal view

0 absent

1 present

107. Number of premaxillary teeth

0 four

1 more than four

108. Number of dentary teeth in adults

0 less than 18

1 18 or more

109. Arrangement of teeth within the jaws

0 linearly placed crowns not overlapping

1 imbricated with distal side of tooth overlapping mesial side of the succeeding tooth

110. Orientation of the maxillary tooth crowns

0 erect

1 procumbent

111. Orientation of the dentary tooth crowns

0 erect

1 procumbent

112. Teeth with basally constricted crowns

0 absent

1 present

113. Tooth tooth occlusal wear facets

0 absent

1 present

114. Mesial and distal serrations of the mid posterior teeth

0 fine and set at right angles to the margin of the tooth

1 coarse and angled upwards at an angle of 45° to the margin of the tooth

115. Distribution of serrations on the maxillary and mid posterior dentary teeth

0 present on both the mesial and distal carinae

1 absent on the posterior carinae

2 absent on both carinae

116. Long axis of the tooth crowns distally recurved

0 present

1 absent

117. Texture of the enamel surface

0 entirely smooth

1 finely wrinkled in some patches

2 extensively and coarsely wrinkled

118. Lingual concavities of the teeth

0 absent

1 present

119. Longitudinal labial grooves on the teeth  
0 absent  
1 present
120. Distribution of the serrations along the mesial and distal carinae of the mid posterior teeth  
0 extend along most of the length of the crown  
1 are restricted to the upper half of the crown
121. Number of cervical vertebrae  
0 eight or fewer  
1 9-10  
2 12-13  
3 more than 13
122. Shallow dorsally facing fossa on the atlantal neurapophysis by a dorsally everted lateral margin  
0 absent  
1 present
123. Width of axial intercentrum  
0 less than width of axial centrum  
1 greater than width of axial centrum
124. Position of axial prezygapophyses  
0 on the anterolateral surface of the neural arch  
1 mounted on anteriorly projecting pedicels
125. Posterior margin of the axial postzygapophyses  
0 overhang the axial centrum  
1 are flush with the caudal face of the axial centrum
126. Length of the axial centrum  
0 less than three times the height of the centrum  
1 at least three times the height of the centrum
127. Length of the anterior cervical centra cervicals 3 5  
0 no more than the length of the axial centrum  
1 greater than the length of the axial centrum
128. Length of middle to posterior cervical centra cervicals 6 8  
0 no more than the length of the axial centrum  
1 greater than the length of the axial centrum
129. Dorsal excavation of the cervical parapophyses  
0 absent



1 present

130. Lateral compression of the anterior cervical vertebrae

0 centra are no higher than they are wide

1 are approximately 1.25 times higher than wide

131. Relative elongation of the anterior cervical centra cervicals 3 5

0 lengths of the centra are less than 2.5 times the height of their anterior faces

1 lengths are 2.5 to 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

132. Ventral keels on cranial cervical centra

0 present

1 absent

133. Height of the mid cervical neural arches

0 no more than height of the posterior centrum face

1 greater than height of the posterior centrum face

134. Cervical epipophyses on the dorsal surface of the postzygapophyses

0 absent

1 present on at least some cervical vertebrae

135. Caudal ends of cranial postaxial epipophyses

0 with a free pointed tip

1 joined to the postzygapophysis along their entire length

136. Shape of the epipophyses

0 tall ridges

1 flattened horizontal plates

137. Epipophyses overhanging the rear margin of the postzygapophyses

0 absent

1 present in at least some postaxial cervical vertebrae

138. Anterior spur like projections on mid cervical neural spines

0 absent

1 present

139. Shape of mid cervical neural spines

0 less than twice as long as high

1 at least twice as long as high

140. Shape of cervical rib shafts

0 short and posteroventrally directed

1 longer than the length of their centra and extending parallel to cervical column

141. Position of the base of the cervical rib shaft  
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
142. Postzygodiapophyseal lamina in cervical neural arches 4-8  
0 present  
1 absent
143. Laminae of the cervical neural arches 4-8  
0 well developed tall laminae  
1 weakly developed low ridges
144. Shape of anterior centrum face in cervical centra  
0 concave  
1 flat  
2 convex
145. Ventral surface of the centra in the cervicodorsal transition  
0 transversely rounded  
1 with longitudinal keels
146. Number of vertebrae between cervicodorsal transition and primordial sacral vertebrae  
0 15-16  
1 no more than 14
147. Lateral surfaces of the dorsal centra  
0 with at most vague shallow depressions  
1 with deep fossae that approach the midline  
2 with invasive sharp rimmed pleurocoels
148. Oblique ridge dividing pleural fossa of cervical vertebrae  
0 absent  
1 present
149. Laterally expanded tables at the midlength of the dorsal surface of the neural spines  
0 absent in all vertebrae  
1 present on the pectoral vertebrae  
2 present on the pectoral and cervical vertebrae
150. Dorsal centra  
0 entirely amphicoelous to amphiplatyan  
1 first two dorsals are opisthocoelous  
2 cranial half of dorsal column is opisthocoelous
151. Shape of the posterior dorsal centra  
0 relatively elongated for their size  
1 strongly axially compressed for their size

152. Laminae bounding triangular infradiapophyseal fossae chonae on dorsal neural arches  
0 absent  
1 present
153. Location of parapophysis in first two dorsals  
0 at the anterior end of the centrum  
1 located at the mid length of the centrum within the middle chonos
154. Parapophyses of the dorsal column completely shift from the centrum to the neural arch  
0 anterior the thirteenth presacral vertebra  
1 posterior to the thirteenth presacral vertebra
155. Orientation of the transverse processes of the dorsal vertebrae  
0 most horizontally directed  
1 all upwardly directed
156. Contribution of the paradiapophyseal lamina to the margin of the anterior chonos in mid dorsal vertebrae  
0 present  
1 prevented by high placement of parapophysis
157. Hyposphenes in the dorsal vertebrae  
0 absent  
1 present but less than the height of the neural canal  
2 present and equal to the height of the neural canal
158. Prezygodiapophyseal lamina and associated anterior triangular fossa chonos  
0 present on all dorsals  
1 absent in mid dorsals
159. Anterior centroparapophyseal lamina in dorsal vertebrae  
0 absent  
1 present
160. Prezygoparapophyseal lamina in dorsal vertebrae  
0 absent  
1 present
161. Accessory lamina dividing posterior chonos from postzygapophysis  
0 absent  
1 present
162. Pneumatic excavation of the dorsal neural arches  
0 absent  
1 present

163. Separation of lateral surfaces of anterior dorsal neural arches under transverse processes
- 0 widely spaced
  - 1 only separated by a thin midline septum
164. Height of dorsal neural arches from neurocentral suture to level of zygapophyseal facets
- 0 much less than height of centrum
  - 1 subequal to or greater than height of centrum
165. Form of anterior surface of neural arch
- 0 simple centroprezygopophyseal ridge
  - 1 broad anteriorly facing surface bounded laterally by centroprezygopophyseal lamina
166. Shape of posterior dorsal neural canal
- 0 subcircular
  - 1 slit shaped
167. Height of middle dorsal neural spines
- 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
168. Shape of anterior dorsal neural spines
- 0 lateral margins parallel in anterior view
  - 1 transversely expanding towards dorsal end
169. Cross sectional shape of dorsal neural spines
- 0 transversely compressed
  - 1 broad and triangular
  - 2 square shaped in posterior vertebrae
170. Spinodiapophyseal lamina on dorsal vertebrae
- 0 absent
  - 1 present and separated from spinopostzygapophyseal lamina
  - 2 present and joining spinopostzygapophyseal lamina to create a composite posterolateral spinal lamina
171. Well developed sheet like suprapostzygapophyseal laminae (spinopostzygapophyseal laminae sensu Wilson 1999)
- 0 absent
  - 1 present on at least the caudal dorsal vertebrae
172. Shape of the spinopostzygapophyseal lamina in middle and posterior dorsal vertebrae
- 0 singular
  - 1 bifurcated at its distal end

173. Shape of posterior margin of middle dorsal neural spines in lateral view  
0 approximately straight  
1 concave with a projecting posterodorsal corner
174. Transversely expanded plate like summits of posterior dorsal neural spines  
0 absent  
1 present
175. Last presacral rib  
0 free  
1 fused to vertebra
176. Sacral rib much narrower than the transverse process of the first primordial sacral vertebra and dorsosacral if present in dorsal view  
0 absent  
1 present
177. Number of dorsosacral vertebrae  
0 none  
1 one  
2 two
178. Caudosacral vertebra  
0 absent  
1 present
179. Shape of the iliac articular facets of the first primordial sacral rib  
0 singular  
1 divided into dorsal and ventral facets separated by a non articulating gap
180. Depth of the iliac articular surface of the primordial sacral  
0 less than 0.75 of the depth of the ilium  
1 greater than 0.75 of the depth of the ilium
181. Sacral ribs contributing to the rim of the acetabulum  
0 absent  
1 present
182. Posterior and anterior expansion of the transverse processes of the first and second primordial sacral vertebrae respectively partly roofing the intercostal space  
0 absent  
1 present
183. Length of first caudal centrum  
0 greater than its height  
1 less than its height

2 highly compressed dorsoventral height at least twice anteroposterior length

184. Length of base of the proximal caudal neural spines

0 less than half the length of the neural arch

1 greater than half the length of the neural arch

185. Position of postzygapophyses in proximal caudal vertebrae

0 protruding with an interpostzygapophyseal notch visible in dorsal view

1 placed on either side of the caudal end of the base of the neural spine without any interpostzygapophyseal notch

186. A hyposphenal ridge on caudal vertebrae

0 absent

1 present

187. Depth of the bases of the proximal caudal transverse processes

0 shallow restricted to the neural arches

1 deep extending from the centrum to the neural arch

188. Position of last caudal vertebra with a protruding transverse process

0 distal to caudal 16

1 proximal to caudal 16

189. Orientation of posterior margin of proximal caudal neural spines

0 sloping posterodorsally

1 vertical

190. Longitudinal ventral sulcus on proximal and middle caudal vertebrae

0 present

1 absent

191. Length of midcaudal centra

0 greater than twice the height of their anterior faces

1 less than twice the height of their anterior faces

192. Cross sectional shape of the distal caudal centra

0 oval with rounded lateral and ventral sides

1 square shaped with flattened lateral and ventral sides

193. Length of distal caudal prezygapophyses

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

194. Shape of the terminal caudal vertebrae

0 unfused size decreasing toward tip

1 expanded and fused to form a club shaped tail

195. Length of the longest chevron  
0 is less than twice the length of the preceding centrum  
1 greater than twice the length of the preceding centrum
196. Anteroventral process on distal chevrons  
0 absent  
1 present
197. Mid caudal chevrons with a ventral slit  
0 absent  
1 present
198. Longitudinal ridge on the dorsal surface of the sternal plate  
0 absent  
1 present
199. Craniocaudal length of the acromion process of the scapula  
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
200. Minimum width of the scapula  
0 less than 20% of its length  
1 greater than 20% of its length
201. Caudal margin of the acromion process of the scapula  
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
202. Width of dorsal expansion of the scapula  
0 less than the width of the ventral end of the scapula  
1 equal to the width of the ventral end of the scapula
203. Flat caudoventrally facing surface on the coracoid between glenoid and coracoid tubercle  
0 absent  
1 present
204. Coracoid tubercle  
0 present  
1 absent
205. Length of the humerus  
0 less than 55% of the length of the femur  
1 55-65% of the length of the femur  
2 65-70% of the length of the femur

3 more than 70% of the length of the femur

206. Shape of the deltopectoral crest

- 0 subtriangular
- 1 subrectangular

207. Length of the deltopectoral crest of the humerus

- 0 less than 30% of the length of the humerus
- 1 30-50% of the length of the humerus
- 2 greater than 50% of the length of the humerus

208. Shape of the anterolateral margin of the deltopectoral crest of the humerus

- 0 straight
- 1 strongly sinuous

209. Rugose pit centrally located on the lateral surface of the deltopectoral crest

- 0 absent
- 1 present

210. Well defined fossa on the distal flexor surface of the humerus

- 0 present
- 1 absent

211. Transverse width of the distal humerus

- 0 is less than 33% of the length of the humerus
- 1 greater than 33% of the length of the humerus

212. Shape of the entepicondyle of the distal humerus

- 0 rounded process
- 1 with a flat distomedially facing surface bounded by a sharp proximal margin

213. Length of the radius

- 0 greater than 80% of the humerus
- 1 less than 80% of the humerus

214. Deep radial fossa bounded by an anterolateral process on proximal ulna

- 0 absent
- 1 present but poorly defined
- 2 a well defined recess deeper than the transverse width of the anterior end of the anterior process

215. Olecranon process on proximal ulna

- 0 present
- 1 absent

216. Maximum linear dimensions of the ulnare and radiale

- 0 exceed that of at least one of the first three distal carpals



1 are less than any of the distal carpals

217. Transverse width of the first distal carpal

0 less than 120% of the transverse width of the second distal carpal

1 greater than 120% of the transverse width of the second distal carpal

218. Sulcus across the medial end of the first distal carpal

0 absent

1 present

219. Lateral end of first distal carpal

0 abuts second distal carpal

1 overlaps second distal carpal

220. Second distal carpal

0 completely covers the proximal end of the second metacarpal

1 does not completely cover the proximal end of the second metacarpal

221. Ossification of the fifth distal carpal

0 present

1 absent

222. Length of the manus

0 less than 38% of the humerus + radius

1 38-45% of the humerus + radius

2 greater than 45% of the humerus plus radius

223. Shape of metacarpus

0 flattened to gently curved and spreading

1 a colonnade of subparallel metacarpals tightly curved into a U shape

224. Proximal width of first metacarpal

0 less than the proximal width of the second metacarpal

1 greater than the proximal width of the second metacarpal

225. Minimum transverse shaft width of first metacarpal

0 less than twice the minimum transverse shaft width of second metacarpal

1 greater than twice the minimum transverse shaft width of second metacarpal

226. Proximal end of first metacarpal

0 flush with other metacarpals

1 inset into the carpus

227. Shape of the first metacarpal

0 proximal width less than 65% of its length

1 proximal width 65-80% of its length

2 proximal width 80-100% of its length

3 proximal width greater than 100% of its length

228. Strong asymmetry in the lateral and medial distal condyles of the first metacarpal

0 absent

1 present

229. Deep distal extensor pits on the second and third metacarpals

0 absent

1 present

230. Shape of the distal ends of second and third metacarpals

0 subrectangular in distal view

1 trapezoidal with flexor rims of distal collateral ligament pits flaring beyond extensor rims

231. Shape of the fifth metacarpal

0 longer than wide at the proximal end with a flat proximal surface

1 close to as wide as it is long with a strongly convex proximal articulation surface

232. Length of the fifth metacarpal

0 less than 75% of the length of the third metacarpal

1 greater than 75% of the length of the third metacarpal

233. Length of manual digit one

0 less than the length of manual digit two

1 greater than the length of manual digit two

234. Ventrolateral twisting of the transverse axis of the distal end of the first phalanx of manual digit one relative to its proximal end

0 absent

1 present but much less than 60

2 60

235. Length of the first phalanx of manual digit one

0 less than the length of the first metacarpal

1 greater than the length of the first metacarpal

236. Shape of the proximal articular surface of the first phalanx of manual digit one

0 rounded

1 with an embayment on the medial side

237. Shape of the first phalanx of manual digit one

0 elongate and subcylindrical

1 strongly proximodistally compressed and wedge shaped

238. Length of the penultimate phalanx of manual digit two

0 less than the length of the second metacarpal

- 1 greater than the length of the second metacarpal
239. Length of the penultimate phalanx of manual digit three  
0 less than the length of the third metacarpal  
1 greater than the length of the third metacarpal
240. Shape of non terminal phalanges of manual digits two and three  
0 longer than wide  
1 as long as wide
241. Shape of the unguals of manual digits two and three  
0 straight  
1 strongly curved with tips projecting well below flexor margin of proximal articular surface
242. Length of the ungual of manual digit two  
0 greater than the length of the ungual of manual digit one  
1 75-100% of the ungual of manual digit one  
2 less than 75% of the ungual of manual digit one  
3 the ungual of manual digit two is absent
243. Phalangeal formula of manual digits two and three  
0 three and four respectively  
1 with at least one phalanx missing from each digit
244. Phalangeal formula of manual digits four and five  
0 greater than 2-0 respectively  
1 less than 2-0 respectively
245. Strongly convex dorsal margin of the ilium  
0 absent  
1 present
246. Cranial extent of preacetabular process of ilium  
0 does not project further forward than cranial end of the pubic peduncle  
1 does project further forward than cranial end of the pubic peduncle
247. Shape of the preacetabular process  
0 blunt and rectangular  
1 with a pointed projecting cranioventral corner and a rounded dorsum
248. Depth of the preacetabular process of the ilium  
0 much less than the depth of the ilium above the acetabulum  
1 subequal to the depth of the ilium above the acetabulum
249. Length of preacetabular process of the ilium  
0 less than twice its depth

1 greater than twice its depth

250. Buttress between preacetabular process and the supraacetabular crest of the ilium

0 present

1 absent

251. Medial wall of acetabulum

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

252. Length of the pubic peduncle of the ilium

0 less than twice the craniocaudal width of its distal end

1 greater than twice the craniocaudal width of its distal end

253. Caudally projecting heel at the distal end of the ischial peduncle

0 absent

1 present

254. Length of the ischial peduncle of the ilium

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

255. Length of the postacetabular process of the ilium

0 between 40% and 100% of the distance between the pubic and ischial peduncles

1 less than 40% of this distance

2 more than 100% of this distance

256. Well developed brevis fossa with sharp margins on the ventral surface of the postacetabular process of the ilium

0 absent

1 present

257. Anterior end of ventrolateral ridge bounding brevis fossa

0 not connected to supracetabular crest

1 joining supracetabular crest

258. Shape of the caudal margin of the postacetabular process of the ilium

0 rounded to bluntly pointed

1 square ended

2 with a pointed ventral corner and a rounded caudodorsal margin

259. Width of the conjoined pubes  
0 less than 75% of their length  
1 greater than 75% of their length
260. Pubic tubercle on the lateral surface of the proximal pubis  
0 present  
1 absent
261. Proximal anterior profile of pubis  
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
262. Minimum transverse width of the pubic apron  
0 much more than 40% of the width across the iliac peduncles of the ilium  
1 less than 40% of the width across the iliac peduncles of the ilium
263. Position of the obturator foramen of the pubis  
0 at least partially occluded by the iliac pedicel in anterior view  
1 completely visible in anterior view
264. Lateral margins of the pubic apron in anterior view  
0 straight  
1 concave
265. Orientation of distal third of the blades of the pubic apron  
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
266. Orientation of the entire blades of the pubic apron  
0 transverse  
1 twisted posteromedially
267. Craniocaudal expansion of the distal pubis  
0 absent  
1 less than 15%  
2 greater than 15% of the length of the pubis
268. Notch separating posteroventral end of the ischial obturator plate from the ischial shaft  
0 present  
1 absent
269. Elongate interischial fenestra  
0 absent  
1 present

270. Longitudinal dorsolateral sulcus on proximal ischium  
0 absent  
1 present
271. Shape of distal ischium  
0 broad and plate like not distinct from obturator region  
1 with a discrete rod like distal shaft
272. Length of ischium  
0 less than that of the pubis  
1 greater than that of the pubis
273. Ischial component of acetabular rim  
0 larger than the pubic component  
1 equal to the pubic component
274. Shape of the transverse section of the ischial shaft  
0 ovoid to subrectangular  
1 triangular
275. Orientation of the long axes of the transverse section of the distal ischia  
0 meet at an angle  
1 are coplanar
276. Depth of the transverse section of the ischial shaft  
0 much less than the transverse width of the section  
1 at least as great as the transverse width of the section
277. Distal ischial expansion  
0 absent  
1 present
278. Transverse width of the conjoined distal ischial expansions  
0 greater than their sagittal depth  
1 less than their sagittal depth
279. Length of the hindlimb  
0 greater than the length of the trunk  
1 less than the length of the trunk
280. Longitudinal axis of the femur in lateral view  
0 strongly bent with an offset between the proximal and distal axes greater than 15 degrees  
1 weakly bent with an offset of less than 10 degrees  
2 straight

281. Shape of the cross section of the mid shaft of the femur  
0 subcircular  
1 strongly elliptical eccentricity  $> 1.5$  with the long axis orientated mediolaterally
282. Angle between the long axis of the femoral head and the transverse axis of the distal femur  
0 about 30 degrees  
1 close to 0 degrees
283. Shape of femoral head  
0 roughly rectangular in profile with a sharp medial distal corner  
1 roughly hemispherical with no sharp medial distal corner
284. Posterior proximal tubercle on femur  
0 well developed  
1 indistinct to absent
285. Shape of the lesser trochanter  
0 small rounded tubercle  
1 proximodistally orientated elongate ridge  
2 absent
286. Position of proximal tip of lesser trochanter  
0 level with the femoral head  
1 distal to the femoral head
287. Projection of the lesser trochanter  
0 just a scar upon the femoral surface  
1 a raised process
288. Transverse ridge extending laterally from the lesser trochanter  
0 absent  
1 present
289. Height of the lesser trochanter in cross section  
0 less than basal width  
1 at least as high as basal width
290. Position of the lesser trochanter  
0 near the centre of the anterior face  
1 close to the lateral margin of the femoral shaft in anterior view
291. Visibility of the lesser trochanter in posterior view  
0 not visible  
1 visible
292. Height of the fourth trochanter

- 0 a low rugose ridge
  - 1 tall crest
293. Position of the fourth trochanter along the length of the femur
- 0 in the proximal half
  - 1 straddling the midpoint
294. Symmetry of the profile of the fourth trochanter of the femur
- 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
295. Shape of the profile of the fourth trochanter of the femur
- 0 rounded
  - 1 subrectangular
296. Position of fourth trochanter along the mediolateral axis of the femur
- 0 centrally located
  - 1 on the medial margin
297. Extensor depression on anterior surface of the distal end of the femur
- 0 absent
  - 1 present
298. Size of the medial condyle of the distal femur
- 0 subequal to the fibular plus lateral condyles
  - 1 larger than the fibular plus lateral condyles
299. Tibia femur length ratio
- 0 greater than 1.0
  - 1 between 0.6 and 1.0
  - 2 less than 0.6
300. Orientation of cnemial crest
- 0 projects anteriorly to anterolaterally
  - 1 projecting laterally
301. Paramarginal ridge on lateral surface of cnemial crest
- 0 absent
  - 1 present
302. Position of the tallest point of the cnemial crest
- 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



303. Proximal end of tibia with a flange of bone that contacts the fibula  
0 absent  
1 present
304. Position of the posterior end of the fibular condyle on the proximal articular surface tibia  
0 anterior to the posterior margin of proximal articular surface  
1 level with the posterior margin of proximal articular surface
305. Shape of the proximal articular surface of the tibia  
0 ovoid anteroposteriorly longer than transversely wide  
1 subcircular and as wide transversely as anteroposteriorly long
306. Transverse width of the distal tibia  
0 subequal to its craniocaudal length  
1 greater than its craniocaudal length
307. Anteroposterior width of the lateral side of the distal articular surface of the tibia  
0 as wide as the anteroposterior width of the medial side  
1 narrower than the anteroposterior width of the medial side
308. Relationship of the posterolateral process of the distal end of the tibia with the fibula  
0 not flaring laterally and not making significant contact with the fibula  
1 flaring laterally and backing the fibula
309. Shape of the distal articular end of the tibia in distal view  
0 ovoid  
1 subrectangular
310. Shape of the anteromedial corner of the distal articular surface of the tibia  
0 forming a right angle  
1 forming an acute angle
311. Position of the lateral margin of descending caudoventral process of the distal end of the tibia  
0 protrudes laterally at least as far as the cranio-lateral corner of the distal tibia  
1 set well back from the cranio-lateral corner of the distal tibia
312. A triangular rugose area on the medial side of the fibula  
0 absent  
1 present
313. Transverse width of the midshaft of the fibula  
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

314. Position of fibula trochanter  
0 on anterior surface of fibula  
1 laterally facing  
2 anteriorly facing but with strong lateral bulge
315. Depth of the medial end of the astragalar body in cranial view  
0 roughly equal to the lateral end  
1 much shallower creating a wedge shaped astragalar body
316. Shape of the posteromedial margin of the astragalus in dorsal view  
0 forming a moderately sharp corner of a subrectangular astragalus  
1 evenly rounded without formation of a caudomedial corner
317. Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus  
0 present  
1 absent with a largely vertical fibular facet
318. Pyramidal dorsal process on the posteromedial corner of the astragalus  
0 absent  
1 present
319. Shape of the ascending process of the astragalus  
0 anteroposteriorly deeper than transversely wide  
1 transversely wider than anteroposteriorly deep
320. Posterior extent of ascending process of the astragalus  
0 well anterior to the posterior margin of the astragalus  
1 close to the posterior margin of the astragalus
321. Sharp medial margin around the depression posterior to the ascending process of the astragalus  
0 absent  
1 present
322. Buttress dividing posterior fossa of astragalus and supporting ascending process  
0 absent  
1 present
323. Vascular foramina set in a fossa at the base of the ascending process of the astragalus  
0 present  
1 absent
324. Transverse width of the calcaneum  
0 greater than 30% of the transverse width of the astragalus  
1 less than 30% of the transverse width of the astragalus

325. Lateral surface of calcaneum  
0 simple  
1 with a fossa
326. Medial peg of calcaneum fitting into astragalus  
0 present even if rudimentary  
1 absent
327. Calcaneal tuber  
0 large and well developed  
1 highly reduced to absent
328. Shape of posteromedial heel of distal tarsal four lateral distal tarsal  
0 proximodistally deepest part of the bone  
1 no deeper than the rest of the bone
329. Shape of posteromedial process of distal tarsal four in proximal view  
0 rounded  
1 pointed
330. Ossified distal tarsals  
0 present  
1 absent
331. Proximal width of the first metatarsal  
0 less than the proximal width of the second metatarsal  
1 at least as great as the proximal width of the second metatarsal
332. Orientation of proximal articular surface of metatarsal one  
0 horizontal  
1 sloping proximolaterally relative to the long axis of the bone
333. Orientation of the transverse axis of the distal end of metatarsal one  
0 horizontal  
1 angled proximomedially
334. Shape of the medial margin of the proximal surface of the second metatarsal  
0 straight  
1 concave
335. Shape of the lateral margin of the proximal surface of the second metatarsal  
0 straight  
1 concave
336. Length of the third metatarsal  
0 greater than 40% of the length of the tibia  
1 less than 40% of the length of the tibia

337. Minimum transverse shaft diameters of third and fourth metatarsals
- 0 greater than 60% of the minimum transverse shaft diameter of the second metatarsal
  - 1 less than 60% of the minimum transverse shaft diameter of the second metatarsal
338. Transverse width of the proximal end of the fourth metatarsal
- 0 less than twice the anteroposterior depth of the proximal end
  - 1 at least twice the anteroposterior depth of the proximal end
339. Transverse width of the proximal end of the fifth metatarsal
- 0 less than 25% of the length of the fifth metatarsal
  - 1 between 30% and 49% of the length of the fifth metatarsal
  - 2 greater than 50% of the length of the fifth metatarsal
340. Transverse width of distal articular surface of metatarsal four in distal view
- 0 greater than anteroposterior depth
  - 1 less than anteroposterior depth
341. Pedal digit five
- 0 reduced non weight bearing
  - 1 large fifth metatarsal at least 70% of fourth metatarsal robust and weight bearing
342. Length of non terminal pedal phalanges
- 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
343. Length of the first phalanx of pedal digit one
- 0 greater than the length of the ungual of pedal digit one
  - 1 less than the length of the ungual of pedal digit one
344. Length of the ungual of pedal digit one
- 0 less than at least some non terminal phalanges
  - 1 longer than all non terminal phalanges but shorter than first metatarsal
  - 2 longer than first metatarsal
345. Shape of the ungual of pedal digit one
- 0 shallow pointed with convex sides and a broad ventral surface
  - 1 deep abruptly tapering with flattened sides and a narrow ventral surface
346. Shape of proximal articular surface of pedal unguals
- 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

347. Penultimate phalanges of pedal digits two and three  
0 well developed  
1 reduced disc shaped elements if they are ossified at all
348. Shape of the unguals of pedal digits two and three  
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
349. Length of the ungual of pedal digit two  
0 greater than the length of the ungual of pedal digit one  
1 between 90% and 100% of the length of the ungual of pedal digit one  
2 less than 90% of the length of the ungual of pedal digit one
350. Size of the ungual of pedal digit three  
0 greater than 85% of the ungual of pedal digit two in all linear dimensions  
1 less than 85% of the ungual of pedal digit two in all linear dimensions
351. Number of phalanges in pedal digit four  
0 four  
1 fewer than four
352. Phalanges of pedal digit five  
0 present  
1 absent
353. Lateral extent of ventrolateral flange on plantar surface of MT II in proximal aspect  
0 similar in development to ventromedial flange  
1 well developed extending further laterally than ventromedial flange extends medially
354. Distal articular surface of astragalus  
0 relatively flat or weakly convex  
1 extremely convex and roller shaped
355. Distal surface of tibiofibular crest  
0 as deep anteroposteriorly as wide mediolaterally or deeper  
1 wider mediolaterally than deep anteroposteriorly
356. Well developed facet on proximolateral corner of plantar ventrolateral flange of MT II for articulation with medial distal tarsal  
0 absent  
1 present
357. Proximal outline of metatarsal III  
0 subtriangular with acute or rounded posterior border  
1 subtrapezoidal with posterior border broadly exposed in plantar view

358. Angle formed by the anterior and anteromedial borders of metatarsal IV  
0 obtuse  
1 right angle or acute
359. Well developed tibiofibular crest on distal femur  
0 absent  
1 present
360. Shaft of metatarsal I  
0 closely appressed to metatarsal II throughout its length  
1 only closely appressed proximally with a space between metatarsals I and II distally
361. Posterior margin of astragalus  
0 straight  
1 convex
362. Ventromedial ridge of scapula  
0 absent  
1 present
363. Mediolateral surface of distal astragalus  
0 straight  
1 concave  
2 convex
364. Anterior fossa on the proximal region of the pubic apron  
0 absent  
1 present
365. Proximal end of the tibia with a transverse to anteroposterior length ratio  
0 narrow ratio less than 0.7  
1 broad more than 0.7
366. Caudodistal tubercle of the radius  
0 absent  
1 present
367. Biceps tubercle of the radius  
0 absent  
1 present
368. Ventromedial margin of first metacarpal  
0 poorly concave  
1 deeply concave
369. Length of first phalanx of manual digit 1

- 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

370. Muscle origin areas Mm. flexor tibialis and iliobtibialis on the posterior portion of the postacetabular process of the ilium

- 0 smooth or as a rectangular rugosity
- 1 strong trapezoidal rugosity extended along the whole height of the posterior third of the process

371. Supraacetabular crest of ilium

- 0 not extended along the pubic peduncle or only at the base of the peduncle
- 1 extended along the pubic peduncle as a faint ridge
- 2 extended along the entire pubic peduncle and contacts the distal end as a well developed crest

372. Subnarial gap i.e. posterior part of premaxillary alveolar margin edentulous resulting in an interruption of the upper tooth row

- 0 absent
- 1 present

373. Alveolar margin of anterior most maxilla

- 0 relatively straight or slightly convex
- 1 strongly but gradually upturned from an extension of more than three teeth along the alveolar margin and orienting the first maxillary alveolus anteroventrally
- 2 sharply mediodorsally upturned in the anterior most tip of the maxilla and orienting the first maxillary alveolus anteroventrally

374. Anterior margin of maxillary antorbital fossa

- 0 rounded or pointed
- 1 squared

375. Dorsoventrally compressed ridge on lateral surface of maxilla forming the ventral border of the antorbital fossa alveolar ridge

- 0 absent
- 1 present

376. Exposition of the lacrimal antorbital fossa in lateral view

- 0 lateral lamina of bone covering most of the bone with antorbital fossa exposed only at the distal end of the vertical process
- 1 lateral lamina of bone only interrupting the fossa near the proximal end of the ventral ramus and ventrally restricted to posterior margin of the ventral ramus

377. Medial distal condyle of metacarpal I

- 0 of the same size than the lateral distal condyle
- 1 dorsoventrally smaller than the lateral distal condyle

378. Metacarpals IV and V ventral to metacarpals I III

- 0 absent
- 1 present

379. Supraacetabular crest of ilium

- 0 present as a weakly developed ridge
- 1 present as a well developed raised shelf
- 2 flares lateroventrally to form a hood like overhang that hides anterodorsal half of acetabulum in lateral view

380. Iliac blade in dorsal view

- 0 straight or slightly laterally curved along the whole of its anteroposterior extension
- 1 strongly laterally curved with a deeply concave lateral border

381. Pubic shaft

- 0 posteriorly bowed
- 1 nearly straight

382. Femoral head

- 0 weakly developed and slightly inturned oriented at more than 120° from the main axis of the femoral shaft
- 1 strongly inturned oriented at less than 120° from the main axis of the femoral head and distinctively separated from the shaft by a well developed femoral neck

383. Posterolateral corner of the distal end of the tibia

- 0 convex
- 1 concave

384. Ungual of pedal digit II

- 0 shorter or equal in length to pedal phalanx II 2
- 1 longer than pedal phalanx II 2

385. Distal outline of ischium

- 0 roughly semicircular
- 1 sub triangular

386. Orientation of the pubic shaft

- 0 anteroventral
- 1 ventral almost perpendicular to the longitudinal axis of the ilium or slightly posteroventral
- 2 strongly posteroventral with the pubic shaft parallel to the ischial shaft

387. Femoral distal transverse width

- 0 equal or lesser than 1.4 times its largest anteroposterior depth across the fibular condyle.
- 1 greater than 1.4 times its largest anteroposterior depth across the fibular condyle.



388. Astragalus with medial condyle anteroposterior depth  
0 less than 1.6 times the depth of the lateral condyle  
1 equal or more than 1.6 times the depth of the lateral condyle
389. Prezygodiapophyseal laminae on anterior caudal vertebrae  
0 absent  
1 present
390. Weaponized dermal spikes on tail  
0 absent  
1 present
391. Shape of the humeral head  
0 weakly developed rounded in anterior posterior view but minimally expanded perpendicular to the latter axis  
1 flat in anterior posterior view with only a slightly expanded lateral component  
2 domed being convex or hemispherical in anterior posterior view with a strong lateral incursion onto the humeral shaft
392. Size of first metatarsal  
0 maximum proximal breadth less than 0.4 times its proximodistal length  
1 maximum proximal breadth between 0.4 and 0.7 times its proximodistal length  
2 maximum proximal breadth greater than 0.7times its proximodistal length
393. Laminae or ridges extending from the basiptyergoid process onto the parasphenoid rostrum  
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
394. Angle between basiptyergoid process and cultriform process of the parabasisphenoid  
0 <90  
1 90  
2 >90
395. 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  
0 longer or equal  
1 shorter
396. Notch in the posterodorsal margin of the lateral portion of the parabasisphenoid  
0 absent  
1 present
397. Number of foramina in the otoccipital between the exoccipital pillar excluding the foramina for the hypoglossal nerve posteriorly and fenestra ovalis anteriorly  
0 one

1 two

398. Unossified gap between the basioccipital and basisphenoidal component of the basal tubera and ventral ramus of the opisthotic

0 absent

1 present

399. Otophenoidal crest

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

400. Frontal anteroposterior length

0 approximately twice the minimum transverse breadth

1 less than minimum transverse breadth

401. Parietal distance separating supratemporal fenestrae

0 less than long axis of supratemporal fenestra

1 twice the long axis of supratemporal fenestra

402. Supratemporal region anteroposterior length

0 temporal bar longer anteroposteriorly than transversely

1 temporal bar shorter anteroposteriorly than transversely

403. Orientation of the anterior to middle cervical postzygapophyses

0 planar minimally offset with respect to the prezygapophyses

1 dorsally raised roughly 20° relative to the coronal plane

2 dorsally raised at least 30° or more relative to the coronal plane

404. Dorsoventral height of the lacrimal ramus ventral process of the prefrontal

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

405. Distal end of frontal ramus of postorbital

0 single rounded process

1 forked into parietal and frontal processes with a distinct concave notch between them

406. Anterior portion of supratemporal fossa on posterior end of dorsal surface of frontal

0 weakly excavated

1 deeply excavated forming a scarp like margin

407. Squamosal quadratojugal contact

0 point contact or a dorsoventrally oriented short contact

1 broad contact anteroposteriorly or obliquely oriented

408. Angle between quadratojugal and pterygoid rami of quadrate  
0 acute angle between 0 and 30 degrees  
1 between 30 degrees and 90 degrees  
2 greater than 90 degrees
409. Ventral extent of quadrate condyles  
0 both condyles extend to the same ventral level  
1 medial condyle extends farther ventrally  
2 or lateral condyle extends farther ventrally
410. Shape of anteroventral portion of prootic  
0 rectangular anteroposteriorly longer than dorsoventrally high  
1 or bulbous almost as anteroposteriorly long as dorsoventrally high
411. Angle separating the long axes of the basiperygoid processes in anterior view  
0 60 degrees or less  
1 more than 60 degrees
412. Length of postorbital ramus of laterosphenoid  
0 short subequal to supraoccipital ramus  
1 or more than 10% longer than supraoccipital ramus
413. Orientation of postorbital ramus of laterosphenoid  
0 extends laterally  
1 extends anterodorsally
414. Orientation of frontal ramus of laterosphenoid  
0 extends medially  
1 extends anteromedially
415. Distal end of jugal ramus of ectopterygoid  
0 tapering  
1 broad subrectangular distal end  
2 expanded anteroposteriorly forming a T shaped dorsal and ventral profile
416. Denticles on premaxillary teeth  
0 present  
1 absent
417. Growth marks in long bones  
0 present in the whole cortex  
1 growth marks absent or only formed in the outer cortex
418. Relative abundance of woven fibered WFB versus parallel fibered bone PFB in the primary compact bone  
0 PFB>WFB  
1 WFB>PFB

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