Character list for phylogenetic analysis

The current character list is based on previous phylogenetic analyses [1-4] with seven new characters. For a list of the history of these characters please see Dalman, 2024 [3].

Skull

1. Naris, size:
   (0) – small, less than half of the length of the antorbital fenestra
   (1) – large, greater than half but still less than the length of the antorbital fenestra
   (2) – huge, approaching the length of the antorbital fenestra

2. Naris, posterior margin position:
   (0) – anterior to antorbital fossa
   (1) – posterior to or even with the antorbital fossa, but anterior to maxillary fenestra
   (2) – posterior to antorbital fossa, and posterior to the anterior border of the maxillary fenestra

3. Rostrum length compared to posterior skull length (measured from the anterior premaxilla to midpoint of the lacrimal bar divided by basal skull length to end of quadrate):
   (0) – longirostran, rostrum more than 0.65
   (1) – rostrum 0.55 - 0.65 of posterior skull
   (2) – brevirostrine, rostrum 0.4 - 0.55

4. Orbit, shape:
   (0) – round
   (1) – orbit more than 10% taller than wide but less than twice as tall
   (2) – dorsoventrally elongate orbit twice as tall as wide

5. Orbit size:
   (0) – huge, anterioposterior length at least 3 times the anteroposterior length of laterotemporal fenestra
   (1) – small, anterioposterior length less than 3 times the anteroposterior length of laterotemporal fenestra

6. Orbit orientation:
   (0) – laterally directed, orbit is directed parallel to sagittal plane
   (1) – sublaterally, orbit is directed from 10 to 15 degrees from sagittal plane
   (2) – anteriorly directed, orbit is directed anteriorly at greater than 20 degrees from sagittal plane

7. Laterotemporal fenestra, posterior bar:
   (0) – ascending rami of quadrate and quadratojugal meet squamosal to form a straight posterior border
   (1) – angled (kinked) posterior border of the laterotemporal fenestra in lateral view

8. Lateral temporal fenestra, orientation of long axis relative to long axis of orbit:
   (0) – posterodorsally directed long axis of laterotemporal fenestra compared to long axis of orbit
   (1) – the long axis of the orbit and laterotemporal fenestra are approximately parallel

9. Skull width vs skull length:
   (0) – narrow, 37% or less than premaxilla-quadrate length
   (1) – 40% - 58% of premaxilla-quadrate length
   (2) – wide, more than 63% of premaxilla-quadrate length

10. Snout width, mediolateral width of the snout at the level of the posterior-most maxillary tooth:

(0) – twice or less the width of nasals
(1) –approximately three times the width of the nasals

11. Skull height as a ratio of maximum skull height in lateral view to skull length (premaxilla-occipital condyle length):
    (0) – short, less than 30%
    (1) – tall, greater than 35%

12. Skull, anteroposterior length compared to the length of the dorsal vertebral series:
    (0) – skull short, less than 40% of the length of the dorsal vertebrae
    (1) – skull long, greater than 40% of the length of the dorsal vertebrae

Premaxilla

13. Premaxilla, premaxillary symphasis, overall shape in dorsal view:
    (0) – acute, V-shaped
    (1) – rounded, U-shaped
    (2) – transverse, anteriorly facing
    ORDERED

14. Premaxilla, maxillary process orientation in dorsal view:
    (0) – laterally (and resultantly widely visible in lateral view)
    (1) – rostrolaterally (facing almost equally dorsally and laterally)
    (2) – anteriorly (and resultantly mostly hidden in lateral view)

15. Anterior margin of the premaxillary body in lateral view:
    (0) – inclined and extends caudodorsally
    (1) – or extends nearly vertically

16. Premaxilla, shape of anterior margin:
    (0) – smoothly curved
    (1) – discrete inflection point between nearly vertical anterior region and more horizontal dorsal region

17. Premaxilla, nasal processes divergence:
    (0) – nasal processes are appressed
    (1) – nasal processes divergent with medial nasal process intervening in between

18. Premaxilla, subnarial process length:
    (0) – subnarial process absent
    (1) – present but much shorter than narial process
    (2) – subequal to length of narial process
    (3) – much longer than narial process

19. Large foramen in the lateral surface of the base of the nasal process of the premaxilla:
    (0) – absent
    (1) – present

20. Premaxilla, form of narial fossa ventral to internal naris:
    (0) – shallowly excavated
    (1) – deeply excavated, anterior margin invaginated as a deep groove

21. Premaxilla, extent of narial fossa:
    (0) – limited to region immediately ventral to external naris

(1) – extensive, covers more than two thirds of the depth of the body of premaxilla near the posterior end

22. Premaxilla, main body, dorsoventral depth:
    (0) – shallow, less than or equal to anteroposterior length
    (1) – between 1-1.9 times anteroposterior length
    (2) – deep, greater than 2 times anteroposterior length

23. Premaxillary interdental plates:
    (0) – fused
    (1) – unfused

24. Premaxilla, position of palatal process:
    (0) – immediately above interdental plates
    (1) – separated from interdental plates by deep lingual surface of premaxilla

Maxilla

25. Maxilla, constriction between articulated premaxillae and maxillae:
    (0) – absent
    (1) – present

26. Maxilla and premaxilla contact along alveolar margins:
    (0) – in contact at alveolar magins
    (1) – alveolar margins do not contact

27. Maxilla, orientation of the maxillae towards each other in dorsal view:
    (0) – acutely angled
    (1) – subparallel

28. Maxilla, anterior margin, premaxillary suture on body of maxilla in lateral view:
    (0) – sloping
    (1) – vertical

29. Maxilla, anterior process possesses concave step in anterior margin of maxilla:
    (0) – absent
    (1) – present shallow step with relatively short anterior ramus
    (2) – present deep step with long anterior ramus

30. Maxilla, pneumatic excavation/antrum in maxillary anterior process:
    (0) – absent
    (1) – present

31. Maxilla, vertical height at inflection point of anterior end of antorbital fenestra versus total height:
    (0) – short, less than 40% total height
    (1) – from 45% to 55% total height
    (2) – tall, more than 60% total height

32. Maxilla, promaxillary fenestra:
    (0) – absent
    (1) – present

33. Maxillary fenestra:

(0) – absent
(1) – small, fenestra occupies less than half of the depressed area between the anterior margins of the antorbital fossa and antorbital fenestra
(2) – large, takes up greater than half up to 3/4 of the space between the anterior margins of the antorbital fenestra and fossa
(3) – greater than 3/4 of the length of the eyeball-bearing portion of the orbit

34. Maxilla, maxillary fenestra, shape of posterior border:
(0) – round or ovoid
(1) – subrectangular or squared corner

35. Maxilla, maxillary fenestra, location:
(0) – posterior to the anterior margin of the antorbital fossa
(1) – partially overlapped laterally by the anterior margin of the antorbital fossa

36. Maxilla, maxillary fenestra, location:
(0) – dorsal to ventral margin of antorbital fossa
(1) – abuts ventral margin of antorbital fossa

37. Maxilla, secondary posterior maxillary fenestra within interfenestral strut:
(0) – absent
(1) – present

38. Maxilla, elongate secondary fossa dorsal to maxillary fenestra inside antorbital fossa on the lateral surface of the maxilla:
(0) – absent
(1) – present

39. Maxilla, form of contact with nasal in subadult to adult specimens:
(0) – smooth
(1) – weakly scalloped
(2) – deeply scalloped with interlocking transverse ridges on both elements
ORDERED

40. Maxilla, form of external subcutaneous surface texturing:
(0) – random foramina and shallow grooves and ridges
(1) – deep, prominent, dorsoventrally trending grooves and ridges

41. Maxilla, neurovascular foramina, form:
(0) – foramina absent
(1) – primary row of foramina continues as a row posteriorly
(2) – transitions into a sharp groove, paralleling the antorbital fossa rim, posteriorly

42. Maxilla, antorbital fossa, extent on main body under midpoint of antorbital fenestra:
(0) – covers more than 65% of the depth of the main body beneath the midpoint of the antorbital fenestra
(1) – covers 50% to 60% of the depth of the main body beneath the midpoint of the antorbital fenestra
(2) – covers much less than 45% of the depth of the main body beneath the midpoint of the antorbital fenestra

43. Maxilla, ventral margin in lateral view:
(0) – straight

(1) – slightly convex
(2) – highly convex
ORDERED

44. Maxilla, dorsal alveolar ridge or palatal shelf of maxilla dorsal to interdental plates:
    (0) – unexpanded mediolaterally
    (1) – broad mediolateral expansion forming shelf subequal to or wider than alveolar body

45. Maxilla, broad mediolaterally expanded dorsal alveolar ridge or palatal shelf, ventral border:
    (0) – covex below palatal suture
    (1) – concave below palatal suture

46. Maxilla, depressor pits for dentary teeth in dorsal alveolar ridge or palatal shelf of maxilla dorsal to interdental plates:
    (0) – no pits
    (1) – shallow pits along most of the ventral surface of palatal shelf of maxilla, may have deep anterior pits
    (2) – deep pits along ventral surface of palatal shelf of maxilla
    ORDERED

Nasal

47. Nasal, constriction just posterior to subnarial processes, in mediolateral width at posterior end of naris:
    (0) – unconstricted
    (1) – constricted, but less than 30% of the width of widest point of nasal
    (2) – constricted, to less than 50% of the width of widest point of nasal

48. Nasals, fusion along the midline:
    (0) – unfused along entire length (1) – at least partially fused

49. Nasal, crest (or crests):
    (0) – absent
    (1) – midline crest present
    (2) – bilateral crests present along lateral margins of nasals

50. Nasal, crest fenestration:
    (0) – not fenestrate
    (1) – fenestrate
51. Nasal, crest, dorsal wing of lacrimal wraps onto side of nasal crest:
    (0) – absent
    (1) – present

52. Nasal, dorsal surface ornamentation (excluding crests):
    (0) – smooth
    (1) – ornamented

53. Nasal, dorsal ornamentation:
    (0) – irregular rugosities (1) – midline hornlets

54. Nasal, dorsal surface of the nasals (excluding crest morphology):
    (0) – flat for most of length
    (1) – dorsally convex

55. Nasal, dorsal surface of the posterior end of the nasal (frontal process only):
    (0) – flat
    (1) – convex
    (2) – concave

56. Nasal, dorsal surface in dorsal view, mediolateral expansion of anterior end, anterior to the maxillary fenestra:
    (0) – absent
    (1) – present

57. Nasal, in dorsal view, posterior end:
    (0) – the same width as the rest of the element
    (1) – restricted, posterior 1/3 of element narrower than the anterior 2/3
    (2) – expanded, posterior 1/3 of element wider than the anterior 2/3

58. Nasal, dorsal surface in lateral view (excluding crests):
    (0) – straight or convex, relatively flat
    (1) – concave with ventral deflection

59. Nasal, lateral wing for articulation with lacrimal:
    (0) – absent
    (1) – present

60. Nasal, frontal suture shape:
    (0) – simple wedge (V-shaped)
    (1) – W-shaped
    (2) – transverse or gentle U-shaped

Lacrimal

61. Lacrimal, shape in lateral view:
    (0) – inverted "L" shaped, anterior and ventral process at right angles
    (1) – "7" shaped, acute angle between anterior and ventral processes

62. Lacrimal, anterior process length:
    (0) – longer than ventral process
    (1) – from 90% to 70% the length of the ventral process (2) – short less than 65% ventral process length

63. Lacrimal, ornamentation in adult individuals:
    (0) – absent
    (1) – manifest only as surface rugosity
    (2) – dorsal crest

64. Lacrimal, dorsal crest, height in lateral view:
    (0) – low, less than the width of the anterior/posterior length of the descending process
    (1) – relatively tall, at least as tall as the anterior/posterior length of the descending process (New Character)

65. Lacrimal, dorsal crest, cross-section in anterior view:
    (0) – pinched or squared
    (1) – rounded

66. Lacrimal, dorsal crest, shape in lateral view:
    (0) – sharp, with crest forming distinct peak
    (1) – rounded
    (2) – rounded peak

67. Lacrimal, dorsal crest, position of the apex of the ornamentation in lateral view:
    (0) – apex anterior to posterior edge of antorbital fenestra
    (1) – apex posterior to posterior edge of antorbital fenestra

68. Lacrimal, posterior dorsal process:
    (0) – absent, or short
    (1) – present, long and gracile
    (2) – present, well-developed and robust

69. Lacrimal, cornual boss on posterodorsal process:
    (0) – absent
    (1) – present, boss forms ridge or shelf so that ridge and rounded crest are sigmoidal in dorsal view
    (2) – present, forms massive rounded boss

70. Lacrimal, extent of pneumaticity:
    (0) – absent
    (1) – limited, partially hollows bone in the region where the anterior and ventral rami meet
    (2) – extensive, completely hollows bone
    ORDERED

71. Lacrimal, accessory pneumatic recess on anterior process of lacrimal:
    (0) – absent
    (1) – present

72. Lacrimal, position of accessory pneumatic recess:
    (0) – posterior, much closer to ventral process than anterior end of anterior process
    (1) – anterior, much closer to anterior end of anterior process than ventral process

73. Lacrimal, pneumatic recess opening internally onto anteriomedial surface of bone inside antorbital fossa and below anterior process and lacrimal vacuity:
    (0) – absent
    (1) – present

74. Lacrimal, posterior process, medial surface for articulation with frontal, inflated by pneumatic recess:
    (0) – no
    (1) – yes

75. Lacrimal, lacrimal vacuity opening laterally at the angle of the lacrimal above antorbital fenestra:
    (0) – absent
    (1) – present, large, where the vacuity extends posteriorly to the ventral process at least ½ width of ventral process
    (2) – tiny, much less than ½ width ventral process where the vacuity ends cranial to the ventral process

76. Lacrimal, lacrimal vacuity, height to length ratio:
    (0) – tall, greater than 1.1
    (1) – short, less than 0.9
    (2) – subequal

77. Lacrimal, lacrimal vacuity, rim of lacrimal vacuity flush with rim of the antorbital fossa:
    (0) – flush with ventral surface
    (1) – rimmed

78. Lacrimal, lacrimal vacuity, posterodorsal margin of lacrimal vacuity:
    (0) – rimmed
    (1) – rounded

79. Lacrimal, orbitonasal ridge on medial surface, position:
    (0) – anterior to posterior margin of ventral process
    (1) – adjacent to or contacting posterior margin of ventral process
80. Lacrimal, extent of antorbital fossa on ventral process:
    (0) – covers greater than 60% of anteroposterior length along the contact with the jugal
    (1) – less than 60% of anteroposterior length along the contact with the jugal

81. Lacrimal, subocular process restricting anterior orbit margin on caudolateral margin of ventral process, and defining ocular region of orbit:
    (0) – absent
    (1) – present

Prefrontal

82. Prefrontal:
    (0) – present
    (1) – absent

83. Prefrontal, exposure on anterior rim of orbit in lateral view:
    (0) – present, with ventral process forming part of the anterior rim of the orbit
    (1) – absent, displaced posteriorly and/or medially with the ventral process absent
    (2) Prefrontal, extent of exposure on orbital rim in lateral view:
    (3) – exposed with ventral process less than 20% of the diameter of the orbit
    (4) – exposed with long ventral process that extends more than halfway down the ventral process of the lacrimal, anteriorposterior length similar to that of the anterior process of the lacrimal

84. Prefrontal, shape of prefrontal excluded from the anterior rim of the orbit:
    (0) –ventral process absent, but dorsal exposure similar to that of lacrimal
    (1) – excluded from the anterior rim of the, being displaced posteriorly and/or medially; ventral process absent, and greatly reduced in size

85. Anterior extent of the prefrontal position relative to lateral part of frontal process of nasal:
    (0) – anterior to frontal process of nasal
    (1) – even with or lateral to frontal process of nasal
    (2) – posterior to frontal process of nasal

86. Prefrontal, contact with lacrimal and frontal:
    (0) – prefrontal separates lacrimal and frontal
    (1) – lacrimal and frontal contact each other behind the prefrontal
    (2) – lacrimal and frontal contact each other in front of the prefrontal

Frontal

88. Frontal, anterior margin:
    (0) – narrow anteriorly as an elongate wedge between nasals

(1) – anterior end terminates abruptly even if w shaped, suture with nasal transversely oriented

89. Frontal, ratio of anteroposterior length of exposed portion on skull roof to mediolateral width at midpoint of single element:
    (0) – long, greater than 2.5
    (1) – short, less than 2.0

90. Frontal, exposure along orbital margin:
    (0) – broadly exposed along orbital margin
    (1) – present but limited to a small notch
    (2) – excluded by postorbital-lacrimal contact in large specimens

91. Frontal, shape of the prefrontal articular surface on dorsal surface of skull:
    (0) – straight or anteromedial arc
    (1) – notch

92. Frontal, expansion of dorsotemporal fossa onto dorsal surface:
    (0) – dorsotemporal fossa extends anteriorly onto dorsal surface of frontal
    (1) – dorsotemporal fenestra excluded from frontal

93. Frontal, dorsotemporal fossa, anterior emargination:
    (0) – straight or curved
    (1) – sinusoidal

94. Frontal, dorsotemporal fossa, anteroposterior length compared to overall length of exposed portion of frontal on skull roof:
    (0) – less than 30%
    (1) – between 30-45%
    (2) – between 45-55%
    (3) – greater than 60%
    ORDERED

95. Frontal, dorsotemporal fossa, medial extension:
    (0) – fossa restricted to posterolateral corner of frontal
    (1) – meets opposing fossa at the midline

96. Frontal, postorbital suture:
    (0) – dorsoventrally shallow and undifferentiated
    (1) – dorsoventrally shallow (approximately 6 times longer than deep) and differentiated into a vertical region anteriorly and a horizontal region posteriorly
    (2) – dorsoventrally deep (approximately twice as long as deep) and subtly differentiated into vertical and horizontal regions
    ORDERED

97. Frontal, shape of frontal viewed between dorsotemporal fossa:
    (0) – flat
    (1) – low flat-topped or low bilateral sagittal crests without midline peak
    (2) – short, low pyramidal sharp sagittal crest
    (3) – long, tall, bladelike sharp sagittal crest on frontal, sometimes flat-topped
    (4) – domed with dorsally convex surface

Parietal

98. Parietal-frontal suture, form:
    (0) – transversely smooth
    (1) – tab-like wedge from parietal extends anteriorly to overlie frontal on midline

99. Parietals, dorsal surface in transverse view:
    (0) – flat
    (1) – comprised of two parallel crests forming flat table
    (2) – transversly convex with single midsagittal crest

100. Parietals, distinct frontoparietal peak:
    (0) – absent
    (1) – low frontoparietal peak
    (2) – frontoparietal peak ½ to less than 2/3 height of nuchal crest
    (3) – frontoparietal peak nearly as tall as nuchal crest
    ORDERED

101. Parietals, dorsal surface in lateral view:
    (0) – generally flat or concave (1) – arched, dorsally convex

102. Parietals, shape of flat or concave dorsal surface in lateral view:
    (0) – generally flat
    (1) – shallowly concave
    (2) – deeply concave with depth of concavity approaching ½ of length
    ORDERED

103. Parietals, nuchal crest height:
    (0) – as low subequal to roof of the skull
    (1) – equal or shorter than tallest part of the skull
    (2) – taller than any other part of the skull

Postorbital

104. Postorbital, anterior (frontal) process length:
    (0) – short, anterior process is approximately half the length of the ventral process
    (1) – long, anterior process is greater than 60% of the length of the ventral process

105. Postorbital, anterior process:
    (0) – slender process, thickness is much less than the thickness of the midpoint of the ventral process
    (1) – robust process, thickness is subequal to that of the midpoint of the ventral process

106. Postorbital, anterior process curvature in lateral view:
    (0) – straight anterior (frontal) process
    (1) – anterior process strongly arched anterodorsally

107. Postorbital, descending process:
    (0) – relatively narrow and comparable to preorbital bar (lacrimal) in anterior/posterior width
    (1) – at least the midpoint of the postorbital bar (formed by descending process of postorbital and sometimes ascending process of jugal) wide and plate-like, about twice as wide as preorbital bar

108. Postorbital, subocular process:
    (0) – absent

(1) – present, slight expansion into the orbit
(2) – greatly expanded into the orbit so as to greatly restrict ventral part of orbit
ORDERED

109. Postorbital, subocular process, position:
(0) – at ventral end of ventral process
(1) – flange-like, separated from ventral tip of ventral process by a notch

110. Postorbital, ornamentation:
(0) – absent
(1) – present low sculpturing
(2) – present cornual boss of rugose grooves
(3) – present as round knobby cornual boss
ORDERED

111.Postorbital, cornual process, position relative to posterior margin of orbit:
(0) – cornural process positioned posterior to orbit margin
(1) – cornual process confluent with posterior margin of orbit

112.Cornual process undercut at base, so that process is differentiated from the rest of the lateral surface:
(0) – absent
(1) – present

113.Postorbital, squamosal process, form of posterodorsal margin:
(0) – uninterrupted convex arc
(1) – emarginated by squamosal (discrete concave notch within the margin in lateral view)

114. Postorbital, squamosal process length:
(0) – reaches posterior margin of the laterotemporal fenestra
(1) – stops short of posterior margin of fenestra

115. Postorbital, expansion of dorsotemporal fossa onto dorsal surface of postorbital:
(0) – no dorsotemporal fenestra on postorbital
(1) – covers most of frontal process of the postorbital and extends anteriorly onto dorsal surface of frontal

116.Postorbital, postorbito-lacrimal osteoderm:
(0) – absent
(1) – present

Squamosal

117.Squamosal, anterior extent:
(0) – at or ahead of anterior margin of the fenestra
(1) – posterior to anterior margin of laterotemporal fenestra

118.Squamosal, presence of dorsotemporal fossa:
(0) – absent, fenestra bounded laterally and posteriorly by the squamosal
(1) – present, fossa extends onto dorsal surface of the squamosal

119.Squamosal, web of bone overhangs the posterior border of the dorsotemporal fossa:
(0) – absent
(1) – present

120. Squamosal, orientation of web of bone that overhangs dorsotemporal fossa:
    (0) – dorsal
    (1) – lateral

121. Squamosal, dorsotemporal fossa, surface morphology:
    (0) – flat or concave
    (1) – convex

122. Squamosal, descending process orientation:
    (0) – parallels quadrate shaft
    (1) – oblique to quadrate shaft oriented at about 45 degrees
    (2) – nearly perpendicular to quadrate shaft

123. Squamosal, non-vertical quadratojugal process, extent of constriction of the laterotemporal fenestra:
    (0) – process constricts less than 80%
    (1) – process constricts more than 90%

124. Squamosal, quadratojugal process, morphology of anterior tip of entire process in those taxa with horiziontal processes:
    (0) – tapered point
    (1) – squared off

125. Squamosal, horizontal quadratojugal process, relationship of the articulation with quadratojugal:
    (0) – horizontal process with rod-like ridge above quadratojugal and forming lap joint medial to the quadratojugal
    (1) – process forms a broad lap joint with quadratojugal, but visible portion of horizontal process above quadratojugal is tab-like

126. Squamosal, pneumaticity in the ventral surface of the dorsal portion of bone:
    (0) – absent
    (1) – foramen present
    (2) – foramen and fossa present

127. Squamosal, fossa in ventral surface of the dorsal ceiling of bone, shape:
    (0) – broad with rounded margin
    (1) – rimmed with sharp margins

128. Squamosal, postquadratic process thickness in lateral view measured perpendicular to long axis of the process in the dorsoventral or craniposterior plane in lateral view:
    (0) – absent or thin
    (1) – subequal but not thin
    (2) – thicker than long

129. Squamosal, postquadratic process:
    (0) – short
    (1) – at least as long as quadrate cotylus
    (2) – twice as long as quadrate cotylus
    (3) – three or more times as long as the quadrate cotylus

Jugal

130. Jugal, contribution to antorbital fenestra:
    (0) – absent

(1) – participates along a small surface in the antorbital fenestra
(2) – extensive, forms the caudoventral corner of antorbital fenestra

131. Jugal, pneumatic recess:
(0) – absent
(1) – small and round
(2) – large and elongate

132. Jugal, pneumatic recess orientation of long axis:
(0) – axis of recess is horizontal
(1) – axis of foramen inclined at an angle of 45 degrees to the ventral skull margin

133. Jugal, position of pneumatic recess in antorbital fossa:
(0) – antorbital fossa edge does not extend past the pneumatic recess
(1) – antorbital fossa edge is continues caudoventral to the pneumatic recess

134.Jugal, maxillary process, antorbital fossa position relative to ventral process of lacrimal:
(0) – posterior edge of fossa posterior to or directly ventral to midpoint of ventral process
(1) – posterior edge of fossa anterior to midpoint of ventral process

135.Jugal, maxillary process, dorsoventral depth:
(0) – shallow, not expanded relative to suborbital portion of bone
(1) – deep, expanded relative to suborbital portion of bone

136.Jugal, suture with lacrimal, angle of the posterior half of the contact:
(0) – low, suture sub-horizontal
(1) – steep with posteroventral tab

137. Jugal, suboccular process on ventral part of orbit to accept the suboccular flange of the postorbital:
(0) – absent, postorbital process confluent with suborbital margin
(1) – present, slight notch between postorbital articulation and suborbital margin
(2) – present, pronounced flange corresponding to suboccular flange of postorbital
ORDERED

138.Jugal, postorbital process width at base:
(0) – narrow less than 1/4 length of jugal
(1) – wide, greater than 1/3 length of jugal

139.Jugal, postorbital facet of ascending process:
(0) – absent or shallow
(1) – mediolaterally oriented scarf joint

140.Jugal, postorbital process, orientation relative to ventral margin of jugal in life position:
(0) – approximately perpendicular
(1) – posteriorly inclined 15-25 degrees from perpendicular
(2) – strongly posteriorly inclined to 30 or more degrees

141. Jugal, shape of orbital margin:
(0) – weakly concave, approximately level with lacrimal-jugal suture
(1) – U-shaped, extends ventral to lacrimal-jugal suture

142. Jugal, ventral margin:

(0) – ventral margin relatively straight or gently convex
(1) – ventral margin convex rugose peak

143. Jugal, lateral jugal ornamentation:
(0) – absent
(1) – rugose thickening present

144. Jugal, dorsal prong of quadratojugal ramus, slope in lateral view:
(0) – horizontal
(1) – posterodorsal

145. Jugal, raised rim on the ventrolateral surface, paralleling the ventral margin of the bone and anteriorly confluent with the antorbital fossa rim of the maxilla:
(0) – absent
(1) – present

Quadratojugal

146. Quadratojugal, form of jugal articulation:
(0) – dorsal prong of posterior process of jugal does not approach the base of the quadratojugal
(1) – does approach the base of the quadratojugal (the corner where the anterior and dorsal processes of the quadratojugal meet)

147. Quadratojugal, constriction of lateral temporal fenestra:
(0) – absent, dorsal process is approximately vertical
(1) – present, convex kink along the suture between the quadratojugal and squamosal that projects into the fenestra, constricting it to approximately one half of its maximum anteroposterior length
(2) – present, dorsal region of quadratojugal moderately expanded anteroposteriorly relative to the remainder of the bone, constricting fenestra to approximately one half of its maximum anteroposterior length
(3) – present, dorsal region of quadratojugal expanded anteroposteriorly by at least twice the minimum anteroposterior dimension of the bone, forming a flange that meets the ventral process of the squamosal to nearly divide the fenestra
ORDERED

148. Quadratojugal anterior process, dorsoventrally expanded so majority of process overlaps laterally onto jugal:
(0) – absent
(1) – present

149. Quadratojugal, overall form of jugal process:
(0) – elongate tapered process
(1) – tab-like process with rounded anterior end
(2) – tab-like process with squared-off anterior end
ORDERED

150. Quadratojugal, squamosal-quadratojugal contact:
(0) – at tips or absent
(1) – broad

151. Quadratojugal, anteroposterior breadth of quadratojugal dorsal process:
(0) – narrow
(1) – broad

152. Quadratojugal, dorsal process, ridge along anterior margin of lateral surface:
    (0) – absent
    (1) – present, subtle and fades in strength dorsally
    (2) – present, robust and extends to the dorsal margin of the bone

153. Quadratojugal, presence of posterior process:
    (0) – absent, without horizontal process posterior to ascending process (reversed "L" shape)
    (1) – present, process inverted 'T' or 'Y' shape

154. Quadratojugal, orientation of posterior process:
    (0) – lateral facing process
    (1) –posterior facing process

Quadrate

155. Quadrate foramen size:
    (0) – absent
    (1) – small less than 3% element dorsoventral height
    (2) – more than 5% element height but less than 40% element height
    (3) – more than 45% element height

156. Quadrate foramen conformation:
    (0) – almost completely formed within the quadrate
    (1) – 75% of foramen formed by the quadrate

157. Quadrate foramen orientation:
    (0) – posteriorly, not visible in lateral view
    (1) – caudolaterally, obliquely visible in lateral view
    (2) – laterally, completely visible in lateral view

158. Quadrate foramen position:
    (0) – at midheight or dorsal to midheight
    (1) – ventral, near the quadrate neck

159. Quadrate, pneumaticity:
    (0) – absent
    (1) – present, deep recess on the anterior surface where the pterygoid wing and condyles meet

160. Quadrate, oval fossa on medial surface of pterygoid wing:
    (0) – absent
    (1) – present shallow fossa
    (2) – present deep fossa

161. Quadrate condyles, position relative to occipital condyle when skull is in articulation:
    (0) – anterior to or approximately aligned
    (1) – completely posterior

Supraoccipital

162. Supraoccipital, form of dorsal margin:
    (0) – smoothly convex and undivided
    (1) – divided into two processes ("bilobate")

163. Supraoccipital, distinct dorsal process of supraoccipital:

(0) – absent
(1) – present

164. Supraoccipital, width of dorsal process of supraoccipital:
(0) – narrow
(1) – wide

165. Supraoccipital, dorsal process of supraoccipital form of dorsal surface:
(0) – flat or peaked
(1) – forked

166. Supraoccipital, form of median posterior surface of dorsal process:
(0) – flat
(1) – midline peaked ridge
(2) – midline groove present

167. Supraoccipital, median ridge above dorsal process:
(0) – absent or no differentiation between dorsal process and median ridge
(1) – present; slight, peaked ridge
(2) – present; well-developed, wide ridge
ORDERED

168. Supraoccipital, contribution to dorsal rim of foramen magnum:
(0) – forms entire rim
(1) – makes limited contribution to rim via triangular ventral process
(2) – completely excluded from rim

Prootic

169. Prootic, depression for pneumatic recess:
(0) – absent
(1) – present as dorsally open fossa on prootic/opisthotic

Opisthotic

170. Opisthotic, posterior (caudal) tympanic recess:
(0) – absent
(1) – present

171. Opisthotic, posterior (caudal) tympanic recess position:
(0) – posterior
(1) – anterior

172. Opisthotic, ventral extension:
(0) – notch separates basal tuber from more anteroventral extension of exoccipital-basisphenoid suture
(1) – notch absent

173. Opisthotic, orientation of the paroccipital processes:
(0) – directed laterally, or slightly ventrolaterally
(1) – directed strongly ventrolaterally,

174. Opisthotic, ventral extent of the paroccipital processes:
(0) – above or level with the dorsal border of the occipital condyle

(1) – situated at mid-height of occipital condyle or lower

175. Opisthotic, curvature of the ventral surface paroccipital process:
(0) – straight
(1) – curving ventrally, pendant

176. Opisthotic, paroccipital process length:
(0) – elongate and slender
(1) – process short, thick, 60% or more of dorsoventral height compared to mediolateral length

177. Opisthotic, exoccipital-opisthotic, paroccipital processes, deep fossa on posterior surface dorsolateral to the foramen magnum:
(0) – absent
(1) – present and shallow
(2) – present and deep

178. Opisthotic, exits of cranial nerves X-XII:
(0) – flush with surface of exoccipital
(1) – cranial nerve exits located together in a bowl-like depression

179. Opisthotic, exoccipital-opisthotic, crista tuberalis (= metotic strut), extent in posterior view:
(0) – crista tuberalis absent or extent very limited
(1) – extensive, extends subequal to the length of the paroccipital process

Laterosphenoid

180. Laterosphenoid, transverse scar on lateral surface:
(0) – absent
(1) – present

181. Laterosphenoid, dorsal suture with the parietal
(0) – flat
(1) – raised into a sharp ridge laterally

182. Laterosphenoid, antotic crest separating lateral wall of braincase from orbital and temporal spaces:
(0) – absent or indistinct
(1) – present; robust and rugose

183. Laterosphenoid, antotic crest, form:
(0) – single structure
(1) – bifurcates ventrally

184. Laterosphenoid, fossa on lateral surface that houses head of epipterygoid:
(0) – absent or shallow
(1) – present, deep and rugose

185. Laterosphenoid, ventrolateral shelf:
(0) – absent
(1) – present

Basioccipital

186. Basioccipital, orientation of occipital surface:
(0) – faces directly posteriorly

(1) – faces posteroventrally

187. Basioccipital, occipital condyle constriction of neck:
(0) – lateral constriction of neck
(1) – subspherical without constricted neck

188. Basioccipital, subcondylar recesses:
(0) – absent
(1) – shallow (2) – deep
ORDERED

189. Basioccipital, basicranium in ventral view:
(0) – longer than wide, or with subequal proportions
(1) – clearly wider than long

190. Basioccipital, basal tubera:
(0) – equally formed by basioccipital and basisphenoid and not subdivided
(1) – subdivided by a lateral longitudinal groove into a medial part entirely formed by the basioccipital, and a lateral part, entirely formed by the basisphenoid

191. Basioccipital, basal tubera mediolateral width:
(0) – greater than occipital condyle width
(1) – equal to or less than occipital condyle width

192. Basioccipital, basal tubera, dorsoventral depth:
(0) – less than depth of occipital condyle
(1) –greater than depth of occipital condyle

193. Basioccipital, basicranium,mediolateral width of basal tubera versus the width of the basispterygoid processes:
(0) – subequal or basal tuber wider
(1) – basipterygoids wider

194. Basioccipital, basal tubera in posterior view, concave notch ventrally between opposing tubera, dorsoventral depth:
(0) – shallow, less than 30% depth of tubera
(1) – deep, more than 30% depth of tubera

195. Basioccipital, ventral surface across basal tubera and basisphenoids orientation:
(0) – oriented nearly horizontally
(1) – oriented caudoventrally

196. Basioccipital, pneumatic openings associated with internal carotid artery:
(0) – absent
(1) – present

Parabasisphenoid

197. Parabasisphenoid, with large surfaces of pronounced muscle scars flanking basisphenoid recess:
(0) – no
(1) – yes

198. Parabasisphenoid, basipterygoid recess (pneumatic recess above basipterygoid processes on lateral surface of braincase):
    (0) – absent or very shallow pneumatic fossa
    (1) – present as a deep fossa

199. Parabasisphenoid, basisphenoid recess:
    (0) – undivided
    (1) – divided

200. Parabasisphenoid, orientation of division of basisphenoid recess:
    (0) – transversely divided so that there is an anterior and posterior recess
    (1) – divided by a single midline strut into two laterally separate chambers
    (2) – divided by a "Y" shaped strut of bone forming three recesses

201. Parabasisphenoid, basisphenoid recess, inflation of the dorsal surface of the recess:
    (0) – absent
    (1) – present

202. Parabasisphenoid, basisphenoid recess, orientation of central axis:
    (0) – horizontal, recess obscured in posterior view
    (1) – posteroventral, recess partially visible in posterior view
    (2) – extremely posteroventral, recess compressed anteroposteriorly and widely visible in posterior view, and basipterygoid processes located beneath the basal tubera
    ORDERED

203. Parabasisphenoid, shape of rostrum:
    (0) – anteroposteriorly expanded, ventral margin is a smooth concave arch
    (1) – dorsoventrally expanded, ventral margin is nearly vertical posteriorly and then abruptly transitions to horizontal trend anteriorly

Palate

204. Palate, shelf-like primary palate, presence:
    (0) – absent
    (1) – present

205. Palate, internal choana, shape:
    (0) – anteroposteriorly elongate oval
    (1) – nearly circular

206. Palate, suborbital fenestra, shape:
    (0) – anteroposteriorly elongate oval
    (1) – nearly circular

Vomer

207. Vomer, anterior horizontal expansion:
    (0) – absent
    (1) – present, slight expansion
    (2) – present, expanded to equilateral diamond shape
    ORDERED

Palatine

208. Palatine anterior expansion of dorsal process into a vomerine process:
    (0) – absent

(1) – present

209. Palatine, vomeropterygoid process, anteroposterior length of dorsal margin ratio to length of greatest constriction of process neck:
(0) – long, greater than 2.0
(1) – short, or less than 2.0

210. Palatine posterior expansion of dorsal process:
(0) – absent
(1) – present

211. Palatine, overall orientation of dorsal surface of vomerine process:
(0) – rostrodorsally directed at 45 degrees
(1) – horizontal

212. Palatine, dorsoventral height of the dorsal process:
(0) – tall, 60% or more than narrowest anteroposterior width of the neck of the dorsal process
(1) – short, less than 50%

213. Palatine, overall orientation of neck of dorsal process:
(0) – rostrodorsally directed at nearly 45 degrees
(1) – vertically directed

214. Palatine, posterior expansion of base of the neck of the dorsal process:
(0) – absent
(1) – present

215. Palatine, pneumatic recess, number of external pneumatic openings:
(0) – absent
(1) – present, one opening
(2) – present, two openings

216. Palatine, anterior or primary opening of palatine recess, location of posterior margin:
(0) – posterior to or even with the posterior margin of the neck of the vomeropterygoid process
(1) – anterior to posterior margin of the vomeropterygoid process neck

217. Palatine, position of the posterior edge of the posterior pneumatic recess compared to the posterior edge of the dorsal process:
(0) – anterior to the posterior margin of dorsal process
(1) – extends posterior to the posterior margin of the process

218. Palatine, presence of slot on the articular surface for the maxilla:
(0) – absent
(1) – present

219. Palatine, maxillary process, form of maxillary articulation:
(0) – flat
(1) – deeply excavated as a slot, demarcated dorsally by a pronounced lip of bone

220. Palatine, maxillary articulation, form:
(0) – maxilla abuts lateral surface of maxillary process and anterior region of jugal process

(1) – contact reinforced by a "brace" at the anteroventral corner of the jugal process, which sits within internal antorbital fossa

221. Palatine, morphology of maxillary articulation brace:
(0) – projects ventrally due to a jugal process that extends further ventrally than the maxillary process, such that there is a discrete corner between the two processes in lateral view
(1) – projects laterally, with no discrete corner between the smoothly confluent jugal and maxillary processes in lateral view

222. Palatine, jugal process, location of contact surface for lacrimal:
(0) – posterior ("distal"), separated from opening of palatine recess by wide margin
(1) – anterior ("proximal"), closely approaches opening of palatine recess

223. Palatine, extension of pneumatic recess into jugal process:
(0) – no extension
(1) – yes, process visibly inflated

Epipterygoid

224. Epipterygoid ventral margin:
(0) – undivided
(1) – forked

Ectopterygoid

225. Ectopterygoid, body pneumatic:
(0) – apneumatic
(1) – pneumatic, uninflated
(2) – pneumatic with inflated body

226. Ectopterygoid, external opening of pneumatic recess, shape:
(0) – thin ovoid slot
(1) – larger, round or triangular

227. Ectopterygoid, surface posteriorly adjacent to external opening of pneumatic recess, form:
(0) – flat, recess grades smoothly into the floor of the lateral temporal fenestra (=subtemporal fenestra)
(1) – lip, recess separated from lateral temporal fenestra (=subtemporal fenestra)

228. Ectopterygoid, jugal process, external pneumatic foramina leading into jugal recess:
(0) – absent
(1) – present

229. Ectopterygoid, jugal process inflation:
(0) – uninflated
(1) – inflated by internal pneumaticity

230. Ectopterygoid, mediolateral length of jugal process:
(0) – short
(1) – long

231. Ectopterygoid, dorsoventral thickening of jugal process:
(0) – thin jugal process (1) – thickened

232. Ectopterygoid, dorsal recess form:
(0) – absent
(1) – present forms dorsal lip

Pterygoid

233. Pterygoid, contact between pterygoid and palatine:
(0) – continuous
(1) – discontinuous in the mid-region, resulting in a subsidiary palatal fenestra

Mandible

234. Mandible, mandibular ramus, dorsoventral depth of dentary at level of dentary-surangular contact on the dorsal margin of the lower jaw:
(0) – shallow, less than 20% of the total anteroposterior length of the lower jaw
(1) – deep, greater than 20% of the total anteroposterior length of the lower jaw

235. External mandibular fenestra:
(0) – absent
(1) – present; tiny
(2) – present; large

236. Mandible, internal mandibular fenestra size:
(0) – small and slit-like
(1) – large and rounded
(Currie 1995; Li et al., 2009:73)

237. Mandible, madibular joint, position in lateral view:
(0) – anterior to or even with the paroccipital process
(1) – posterior to the paroccipital process

238. Mandible, lower jaw,articulation, glenoid position relative to level of alveolar margin of dentary with mandible occluded:
(0) – level or ventral
(1) – dorsal

239. Mandible, occlusion in lateral view:
(0) – jaws occlude for their full length
(1) – jaws diverge anteriorly due to kink and downward deflection in dentary buccal margin

Dentary

240. Dentary, dorsal upturn of element at anterior end:
(0) – absent
(1) – present

241. Dentary shape in lateral view:
(0) – with subparallel dorsal and ventral edges
(1) – subtriangular in lateral view, posteriorly expanded

242. Dentary, expansion of posterior dentary:
(0) – posterior height of dentary two times or less than minimum dentary height
(1) – posterior end of dentary more than two times the minimum dentary height

243. Dentary, symphysis, texture:
(0) – generally smooth

(1) – strongly rugose and beveled, with interlocking ridges and convexities for articulation with the opposing symphysis

244. Dentary, primary neurovascular foramina, arrangement:
(0) – distinct foramina or set into a shallow groove posteriorly
(1) – set into a deep and sharp groove across the middle and posterior regions of the dentary

245. Dentary, overall shape of dorsal surface (excluding anterior upturn if present):
(0) – horizontal, straight
(1) – dorsally concave

246. Dentary, ventral margin of bone in lateral view, profile:
(0) – straight
(1) – sigmoidal

247. Dentary, posterior end, presence of posterodorsal process above external mandibular fenestra:
(0) – present
(1) – absent

248. Dentary, posterior end, presence surangular process on the dorsal surface of the mandible:
(0) – absent
(1) – present

249. Dentary, Meckelian groove, dorsoventral depth:
(0) –wide and shallowly inset into medial surface of bone
(1) –narrow and deeply inset into bone, groove appears as a thin, sharp structure

250. Dentary, position of Meckelian groove:
(0) – closer to ventral margin of bone
(1) – roughly at midheight

251. Dentary, anterior extent of lingual bar:
(0) – medial to first alveolus
(1) – medial to second (or further posterior) alveolus

252. Dentary, articular surface for splenial along ventral region of dentary ramus below the Meckelian fossa, form:
(0) – dorsoventrally shallow and smooth
(1) – dorsoventrally deep (nearly as deep as anterior depth of fossa) and rugose

253. Dentary, angle of the anterior end in lateral view:
(0) – anterior end relatively vertical with transition point between dorsal and ventral surfaces below alveoli 1-3 when present
(1) – anterior end angled with transition point between dorsal and ventral surfaces below alveolus 4 or further back

254. Dentary, anteriormost alveoli, size in comparison to alveoli in middle of tooth row:
(0) – approximately same size
(1) – first two alveoli substantially smaller
(2) – first alveolus substantially smaller

255. Dentary, distinct interdental plates:

(0) – present
(1) – absent

Coronoid and Supradentary

256. Supradentary ossification, shape:
(0) – elongate, shallow strip
(1) – deep, crescentic shape

257. Supradentary and coronoid ossifications, form of contact at their zone of fusion:
(0) – smoothly confluent
(1) – offset by a concave notch

Splenial

258. Splenial, anterior margin:
(0) – tapered point
(1) – squared or jagged anterior end

259. Splenial, form of posterior end:
(0) – straight or slightly curved
(1) – distinctly forked

260. Splenial, mylohyoid foramen:
(0) – small, smaller than dentary alveoli
(1) – large, subequal to or larger than dentery alveoli

261. Splenial, myohyoid foramen orientation of long axis:
(0) – horizontal
(1) – dorsoposteriorly inclined in line with intercoronoid process

262. Splenial, mediolateral thickness of intercoronoid process:
(0) – no thickening
(1) – thickened mediolaterally

Angular

263. Angular, exposure in lateral view:
(0) – exposed almost to end of mandible in lateral view, reaches or almost reaches articular
(1) – excluded from posterior end

264. Angular, exclusion from posterior end:
(0) – end of angular stops well short of glenoid
(1) – stops near the anterior end of glenoid

265. Angular posterior process:
(0) – posterior process, point projects dorsally above ventral margin of mandible
(1) – posterior process tip flush with ventral margin of mandible

266. Angular, ventral margin, form:
(0) – smoothly convex
(1) – anterior region “flexed” relative to posterior region, such that there is a discrete step between them

Surangular

267.Surangular, dorsoventral depth:
(0) – shallow, element less than 35% craniocaudal length
(1) – deep, depth 40% or more element anteroposterior length

268.Surangular, lateral surface, wide depression present for dorsal surangular process of the dentary:
(0) – absent or narrow groove
(1) – wide depression

269.Surangular, groove on dorsolateral surface of anterior end:
(0) – absent
(1) – present, shallow groove faintly visible
(2) – present, deep well-demarked groove

270. Surangular, foramen in dorsolateral groove:
(0) – absent
(1) – present, small foramen much smaller than groove
(2) – present, large foramen subequal to groove in diameter

271. Surangular, anteroventral extension:
(0) – extension is absent
(1) – encloses external mandibular fenestra by contacting the angular anteriorly

272. Surangular, surangular shelf on lateral surface, form:
(0) – absent or low ridge
(1) – prominent, shelf present but forms a dorsoventrally thin ridge
(2) – prominent, well-developed shelf that is dorsoventrally deep
ORDERED

273. Surangular, surangular shelf, orientation relative to the long axis of the lower jaw:
(0) – ventrally inclined anteriorly or sigmoidal
(1) – dorsally inclined anteriorly
(2) – horizontal

274. Surangular foramen in lateral surface of surangular anterior to mandibular articulation:
(0) – absent
(1) – tiny foramen, smaller or subequal to glenoid fossa
(2) – large surangular foramen present (bigger than glenoid fossa in diameter)
ORDERED

275.Surangular, position of surangular shelf in relation to surangular foramen:
(0) – placed far dorsal to posterior surangular foramen
(1) – foramen abuts shelf but shelf projects laterally and does not overhang foramen
(2) – shelf projects ventrolaterally to overhang foramen

276.Surangular, pneumatic fossa posterodorsal to posterior surangular foramen:
(0) – absent
(1) – present and shallow sometimes with a small foramen inside foramen
(2) – present and deeply invaginated with large foramen
ORDERED

277.Surangular, adductor muscle attachment site dorsal to surangular shelf, orientation:
(0) – faces primarily dorsally

(1) – faces almost equally dorsally and laterally
(2) – faces primarily laterally

278. Surangular, laterally inclined flange on caudodorsal surface for articulation with lateral process of lateral quadrate condyle:
(0) – absent
(1) – present

Prearticular

279. Prearticular shape:
(0) – dorsally concave sweeping low curve in lateral view
(1) – subcircular in lateral view, "U" shaped

280. Prearticular, anterior process expansion:
(0) – unexpanded
(1) – expanded into a paddle like shape, more than 220% the dorsoventral depth of the midshaft

281. Prearticular, midshaft cross-sectional shape:
(0) – mediolaterally flattened, plate-like
(1) – sub-round with sub-equal width and height
(2) – round
ORDERED

282. Prearticular, ventral process or flange:
(0) – absent
(1) – present

283. Prearticular, ventral bar, series of tall ridges and deep grooves on lateral surface to strengthen articulation with angular:
(0) – absent
(1) – present

284. Prearticular, shape of caudoventral margin:
(0) – sweeping ventrally convex curve
(1) – sigmoidal with downturned articular process

Articular

285. Articular, medial process:
(0) – absent
(1) – present

286. Articular, retroarticular process shape:
(0) –rod-like, sort
(1) – rod-like, elongate and slender
(2) – short, wide, and with distinct posteriorly facing concavity

287. Articular, smooth non-articular region between glenoid and attachment site for depressor mandibular muscles:
(0) – present
(1) – absent

288. Articular, pneumatic foramen posterior to glenoid:

(0) – absent
(1) – present

Dentition

289. Premaxilla, number of teeth:
(0) – 5 or more
(1) – 4
(2) – 3
(3) – edentulous

290. Premaxillary teeth, position of mesial carina:
(0) – symmetrical
(1) – offset mesial to distal carina on all teeth (teeth ziphodont)
(2) – rotated distally on premaxillary teeth 1 and 2 (anterior teeth "D-shaped" and posterior teeth ziphodont)
(3) – rotated distally on all teeth

291. Premaxillary teeth, median vertical ridge on lingual surface:
(0) – absent
(1) – present as subtle structure in anterior (mesial) premaxillary teeth
(2) – present as pronounced structure in all premaxillary teeth
ORDERED

292. Premaxillary teeth, curvature of posterior (posterior) teeth:
(0) – recurved
(1) – straight

293. Premaxillary teeth, size compared to rostal-most maxillary tooth:
(0) – subequal
(1) – significantly smaller

294. Premaxillary teeth, presence of serrations:
(0) – present
(1) – absent on at least the mesial carina or completely absent

295. Maxillary teeth, presence:
(0) – present
(1) – absent edentulous

296. Maxilla, position of carina on anteriormost tooth:
(0) – symmetrical
(1) – asymmetrical so that tooth is D shaped

297. Maxilla, position of the posteriormost tooth:
(0) – nearer to the posterior end of the antorbital fenestra
(1) – posterior to but closer to the midpoint of the antorbital fenestra
(2) – anterior to the midpoint of the antorbital fenestra

298. Maxilla, number of teeth:
(0) – 18 or more alveoli
(1) – 14 to 17 alveoli
(2) – 11 to 13 alveoli

(3) – 10 to 1 alveoli

299. Dentary, portion of dentary with teeth:
(0) – teeth throughout to 65% of the dorsal surface of the dentary
(1) – teeth restricted to the anterior 33% or edentulous

300. Dentary, number of teeth:
(0) – 220 or more alveoli
(1) – 18 to 21 alveoli
(2) – 15-17 alveoli
(3) – 14 or less alveoli

301. Tooth spacing on maxilla and dentary:
(0) – closely appressed
(1) – widely spaced with considerable separation between alveoli

302. Maxillary and dentary, mid position tooth serration symmetry:
(0) – proximal and distal carina serrations similar in size
(1) – clear asymmetry in serrations on proximal and distal carina or without serrations on either surface
(2) – lacking serrations

303. Maxillary and dentary teeth, form:
(0) – ziphodont, transverse width of base less than 60% of mesiodistal length
(1) – thickened, width greater than 60% of length
(2) – thickened, width nearly equal to length
(3) – round

Axis

304. Axis, pleurocoel:
(0) – absent
(1) – present

305. Axis, pleurocoel position:
(0) – midheight of centrum
(1) – dorsally located, directly underneath neurocentral suture and directly posterior to diapophysis

306. Axis, pneumatic foramen, extent of surrounding fossa:
(0) – limited to margins of foramen
(1) – extensive, occupies most of lateral surface of centrum

307. Axis, anteroposterior length of centrum compared to dorsoventral height of posterior centrum face:
(0) – longer than tall
(1) – shorter than tall, or subequal

308. Axis, ridge on ventral surface of centrum:
(0) – absent
(1) – present

309. Axis, axial parapophyses and diapophyses:
(0) – moderate/prominent
(1) – reduced/absent

310. Axis, neural spine form in lateral view:

(0) – sheet-like
(1) – anteroposteriorly reduced and rod-like

311. Axis, neural spine in cranial view:
(0) – flared transversely
(1) – compressed mediolaterally
(2)

312. Axis, pneumatic foramina and fossae on each side of the anterior ridge on the neural spine:
(0) – absent
(1) – present

313. Axis, neural spine, texture of dorsal region of anterior surface:
(0) – generally smooth or with subtle texture
(1) – highly rugose, with series of grooves, ridges, and eminences

314. Axis, epineurapohyseal processes on axis neural spine:
(0) – absent
(1) – present

315. Axis, epipophyses, posterior extent:
(0) – absent or terminates well anterior to postzygapophysis
(1) – extends to, or only slightly posterior to, the posterior margin of the postzygapophysis
(2) – large, rugose flange that extends posterior to postzygapophysis
(3) – elongate flange that extends posteriorly 75% or more than the anteriorposterior length of the postzygapophysis

Cervical Vertebrae

316. Cervical vertebrae, number of pneumatic openings in anterior centra:
(0) – one pneumatic opening per side
(1) – two pneumatic opening per side

317. Cervical vertebrae, form of centra:
(0) – amphiceolous to platycoelous
(1) – strongly opisthocoelous

318. Cervical vertebrae, epipophyses of C3-5, form:
(0) – absent or terminates well anterior to postzygapophysis
(1) – extends to, or only slightly posterior to, the posterior margin of the postzygapophysis
(2) – large, rugose flange that extends posterior to postzygapophysis

319. Cervical vertebrae, position of posterior edge of anterior cervical centra:
(0) – level with or anterior to the posterior extent of neural arch
(1) – extending beyond posterior limit of neural arch.

320. Cervical vertebrae, anterior cervical centra, shape in anterior view:
(0) – subcircular or square
(1) – distinctly wider than high; kidney shaped

321. Cervical vertebrae, anteroposterior length of centrum compared to dorsoventral height of posterior centrum face:
(0) – longer than tall
(1) – shorter than tall, or subequal

322. Cervical vertebrae, neural spine positon:
    (0) – centroid of neural spine positioned on anterior half of vertebrae
    (1) – centroid of neural spine positioned posterior to the midpoint of vertebrae

323. Cervical vertebrae, neural spine anterioposterior minimum length:
    (0) – wide, ½ or more than the length of the centrum
    (1) – narrow, less than ½ the length of the centrum

324. Cervical vertebrae, neural spine dorsoventral height:
    (0) – short, less than the height of the centrum
    (1) – low and centered on neural arch, giving arch an "X" shape in dorsal view
    (2) – approximately the same height as the posterior centrum face
    (3) – tall, 1.5 or more than the height of the centrum face

325. Cervical vertebrae, neural spine mediolateral thickness:
    (0) – thin
    (1) – anteroposterally tapering thin to thick
    (2) – thick, stout rectangle, base is nearly square with nearly equal anteroposterior and transverse dimensions

326. Cervical vertebrae, rugose ligament attachment scars on anterior and posterior surfaces of neural spine:
    (0) – absent or weakly developed
    (1) – present as prominent, flanges visible in lateral view

327. Cervical vertebrae, orientation of posterior centrodiapophyseal lamina in C3-5:
    (0) – nearly horizontal, fossa located primarily dorsal to lamina
    (1) – projects posteroventrally, infrapostzygapophyseal fossa located primarily posterior to lamina

328. Cervical vertebrae, position of prezygapophysis in middle cervicals:
    (0) – slightly overhangs centrum laterally
    (1) – strongly overhangs centrum laterally, entire prezygapophyseal facet placed lateral to centrum

Dorsal Vertebrae

329. Dorsal centra pneumaticity:
    (0) – apneumatic
    (1) – pneumaticity limited to anterior dorsals
    (2) – present throughout dorsal column

330. Dorsal vertebrae, ratio of dorsoventral height of posterior centrum face to anteroposterior length of middleposterior dorsal centra:
    (0) – long and low, less than 75%
    (1) – short and tall greater than 75%

331. Dorsal vertebrae, anterior dorsal neural spines, level of posterior termination:
    (0) – at approximately the same level as the posterior centrum face
    (1) – far posterior to the posterior centrum face

332. Dorsal vertebrae, mid- posterior dorsal neural spines, level of posterior termination:
    (0) – at approximately the same level as the posterior centrum face
    (1) – far posterior to the posterior centrum face

333. Dorsal vertebrae, anterioposterior minimum width of mid-dorsal neural spine in lateral view:
(0) – wide, subequal to centrum length
(1) – narrow, ½ centrum length or less

334. Dorsal vertebrae, dorsoventral height of mid-dorsal neural spine:
(0) – short, subequal to or less than centrum height
(1) – tall, 1.5 x centrum height or more

335. Dorsal vertebrae, rugose ligament attachment scars on anterior and posterior surfaces of neural spine:
(0) – absent or weakly developed
(1) – present as prominent, flanges visible in lateral view

336. Neural spines on posterior dorsal vertebrae, shape in lateral view:
(0) – rectangular or square
(1) – anteroposteriorly expanded distally, fan-shaped

337. Ventral keel in anterior dorsals:
(0) – absent or very poorly developed
(1) – pronounced

338. Posteriormost dorsals, parapophyses position:
(0) – on the same level as transverse process
(1) – distinctly below transverse process

Sacral Vertebrae

339. Sacral vertebrae, number of sacral vertebrae:
(0) – 5 or less
(1) – 6

340. Sacral vertebrae, length of anterior sacrals and posterior dorsal centrum length:
(0) – subequal in length
(1) – sacrals substantively longer than posterior dorsal centra

341. Sacral vertebrae, pleurocoels or foramina on lateral surfaces of centra:
(0) – absent on sacral vertebrae
(1) – present on anterior sacrals only

342. Sacral vertebrae, fenestrae between fused neural spines:
(0) – neural spines unfused
(1) – spines fused but fenestrae absent
(2) – spines fused and fenestrae present

343. Sacral ribs, position of ribs on sacrum:
(0) – span two sacrals
(1) – limited to a single sacral

344. Sacral ribs, position of rib attachment for ribs on individual sacrals:
(0) – span centrum and neural arch
(1) – limited to neural arch only

345. Sacral vertebra five, position of ventral margin of posterior articular face in lateral view:

(0) – at same level as ventral margin of anterior articular face
(1) – positioned ventral to ventral margin of anterior articular face

Caudal Vertebrae

346. Caudal vertebrae: presence of transverse processes:
(0) – on more than 16 posteriors
(1) – on 12 to 16
(2) – on fewer than 12 posteriors

347. Caudal vertebrae, transition point in caudal series at which transverse processes end:
(0) – begins distal to the 10th posterior
(1) – between the 5th and 10th posterior vertebra

348. Caudal vertebrae, anterior caudal centra shape:
(0) – tall, oval or round in cross section
(1) – with box-like centra in posteriors I-V

349. Caudal vertebrae, anterior caudals, position of posterior end of base of neural spine:
(0) – anterior to posterior surface of centrum
(1) – or level with or posterior to posterior surface of centrum

350. Caudal vertebrae, anterior caudals, shape of transverse processes in dorsal view:
(0) – rectangular, with parallel anterior and posterior sides, or slightly ovoid with a gradual expansion in width distally
(1) – distal end expanded into a spatulate bulb

351. Caudal vertebrae, anterior caudals, two laminae linking prezygapophysis and transverse process, between which is a triangular fossa:
(0) – absent
(1) – present, shallow fossa
(2) – present, deep fossa

352. Caudal vertebrae, neural spines:
(0) – simple, undivided
(1) – separated into anterior and posterior alae throughout much of caudal sequence

353. Caudal vertebrae, anterior spur in front of neural spine in mid-caudals:
(0) – absent
(1) – present

354. Caudal vertebrae, distal caudal neural spine shape:
(0) – form a low ridge
(1) – spine absent

355. Caudal vertebrae, mid to distal caudal postzygapophyses length:
(0) – short between 20% to 100% centrum length
(1) – extremely long, between 150% to 1000% centrum length

Chevrons

356. Chevrons, anterior process of chevron base:
(0) – absent/weak
(1) – large

357. Chevrons of anterior caudals, form of distal end:
(0) – short anteroposteriorly, shaft cylindrical
(1) – distal end elongate anteroposteriorly, flattened and plate-like

358. Chevrons, form of mid-caudal chevrons:
(0) – rod-like or only slightly expanded ventrally
(1) – L-shaped

359. Chevrons, form of distal caudal chevrons:
(0) – rod-like or L-shaped
(1) – skid-like or T-shaped

Ribs and Gastralia

360. Pneumatic excavations in cervical or dorsal rib heads:
(0) – absent
(1) – present

Forelimb

361. Scapula, length relative to humerus:
(0) – longer than humerus
(1) – shorter than humerus

362. Radius and ulna separation:
(0) – radius and ulna clearly separate elements
(1) – distinct adherence or syndesmosis distally

Scapula

363. Scapula general form:
(0) – short and broad (ratio length/minimal height of shaft <9)
(1) – slender and elongate (ratio >10)

364. Scapula, dorsal expansion of proximal blade measured from the dorsal surface at the scapulocoracoid suture to the most ventrally displaced dorsal surface of the scapular blade:
(0) – not more than twice the minimum scapular blade width
(1) – twice to 2.5 times the minimum scapular blade width
(2) – expanded more than three times the minimum scapular width
(3) – expanded more than four times the minimum scapular width

365. Scapula, angle between dorsal arcromion process and dorsal surface of scapular blade:
(0) – sweeping curve
(1) – distinct angle greater than 100 degrees
(2) – distinct angle less than 95 degrees

366. Scapula, distal end expansion relative to proximal portion of scapula:
(0) – markedly expanded
(1) – not expanded

367. Scapula, ratio of dorsoventral depth of distal expansion to minimum dorsoventral depth of blade:
(0) – less than 2.5
(1) – greater than 2.5

368. Scapula, acromion margin in rostrodorsal view:
(0) – continuous with blade in anterior aspect
(1) – anterior edge laterally everted relative to plane of scapular blade

369. Scapula, acromion margin length:
(0) – long, either tapering or horizontal triangle
(1) – truncated with deep base but short reach beyond scapular blade and squared-off profile

370. Scapula and coracoid form in posterior and anterior views:
(0) – continuous arc
(1) – coracoid inflected medially, scapulocoracoid 'L' shaped in lateral view

Coracoid

371. Coracoid in lateral view:
(0) – subcircular, with shallow ventral process
(1) – subquadrangular with extensive ventral process
(2) – shallow ventral blade with elongate ventral process

372. Coracoid, anteroposterior length at midpoint:
(0) – long, 200% or greater than the length of the scapular acromion at midheight
(1) – short, less than 150% of the length of the scapular acromion at midheight

373. Posterolateral surface of coracoid ventral to glenoid fossa:
(0) – unexpanded
(1) – posterolateral edge of coracoids expanded to form triangular subglenoid fossa bounded laterally by enlarged coracoid tuber

374. Ventral part of coracoid anterior to the glenoid facet:
(0) – approximately level with the rim of the facet
(1) – with tapering posteroventral process

375. Glenoid fossa orientation:
(0) – faces posteriorly or posterolaterally
(1) – faces laterally

376. Ossified sternal plates in adults:
(0) – ossified sternal plates absent
(1) – plates ossified, but separate in adults

Humerus

377. Humerus, form of shaft:
(0) – straight
(1) – sigmoid

378. Humerus, proximal head, morphology:
(0) – low, poorly differentiated, crescentic shaped in proximal view, overhangs posterior surface and does not overhang anterior surface
(1) – enlarged, occupies the majority of the proximal end, bulbous in proximal view, overhangs both posterior and anterior surfaces

379. Deltopectoral crest form:

(0) – long, makes up more than 40% or more of the element length
(1) – makes up 30-38% of element length
(2) – short, less than 25% element length, deltopectoral crest less pronounced, forming an arc rather than being quadrangular

380. Humerus, rotation along shaft, orientation of long axis of proximal end relative to that of distal end:
(0) – approximately 30-45 degree angle
(1) – approximately parallel, shaft rotation absent

381. Humerus, additional muscle attachment tubera at the corner of the anterior and lateral surfaces distal to the deltopectoral crest:
(0) – absent
(1) – present

382. Humerus, form of distal condyles:
(0) – medial condyle expanded further medially than the lateral condyle is laterally
(1) – lateral and medial condyles expanded equally (offset from shaft in anterior or posterior view is equal)

383. Humerus, length relative to the femur:
(0) – 45% or more
(1) – 40-30%
(2) – 25-30%

Ulna

384. Ulna, shaft axis, form:
(0) – bowed
(1) – straight

385. Ulna, distal articular surface, form:
(0) – convex
(1) – flat

Manus

386. Distal carpal, principal distal carpal shape:
(0) – semilunate in lateral view with trochlear proximal surface
(1) – discoid with flat proximal surface

387. Manus, number of metacarpals present:
(0) – 5
(1) – 4
(2) – 3

388. Manus, number of digits with phalanges:
(0) – 4
(1) – 3
(2) – 2

389. Metacarpal I, medial distal condyle, size:
(0) – well-developed and large
(1) – rudimentary

390. Metacarpal II, ratio of the length of metacarpal II to the length of metacarpal I:
(0) – metacarpal II is 2 or more times the length of metacarpal I
(1) – metacarpal II subequal to the length of metacarpal I
(2) – metacarpal II is less than 1.8 times the length of metacarpal I

391. Metacarpal II, mediolateral width at midpoint:
(0) – equal to or narrower than metacarpal I
(1) – more robust than metacarpal I

392. Metacarpal III, length:
(0) – subequal in length to MC II
(1) – much shorter than MC II

393. Manual phalanx II-1, shaft diameter:
(0) – less than shaft diameter of radius
(1) – greater than shaft diameter of radius

394. Manual phalanx II-1, length:
(0) – longer than metacarpal I
(1) – subequal to metacarpal I
(2) – shorter than metacarpal I

395. Manual unguals, flexor tubercle, form:
(0) – large, robust, rugose, conical structure
(1) – reduced to a small convexity

396. Manual unguals, degree of recurvature:
(0) – extensive, flexor margin deeply concave
(1) – thin and reduced, flexor margin shallowly concave
(2) – robust and reduced, flexor margin shallowly concave

397. Manual unguals, proximodorsal lip on some manual unguals, a transverse ridge immediately dorsal to the articulating surface:
(0) – absent
(1) – present

Ilium

398. Ilium, overall shape of blade:
(0) – sub-quadrangular or trapezoidal in lateral view
(1) – semi-oval outline in lateral view

399. Ilium, dorsal margin, shape:
(0) – smoothly convex or flat across entire length
(1) – convex anteriorly and straightens out posteriorly
(2) – straight anteriorly and transitions to convex posteriorly

400. Ilium, length compared to length of femur:
(0) – ilium significantly shorter than the femur (70-85%)
(1) – almost the same length (95-105%)
(2) – ilium significantly longer (105-115%)

401. Ilium, blade height vs. length:
(0) – low and long
(1) – tall and short

402. Ilium, iliac blade orientation:
(0) – roughly vertical
(1) – dorsomedially inclined, dorsal edges of ilia approach or meet each other above sacrum

403.Ilium, dorsal margin of blade, position relative to sacral neural spines:
(0) – separated by a gap
(1) – lies against neural spines and opposing iliac blades may make contact above neural spines

404.Ilium, postacetabular blade orientation in dorsal view:
(0) – subparallel
(1) – diverge posteriorly

405.Ilium, notch on anterodorsal edge of ilium:
(0) – absent
(1) – notch at rostrodorsal corner

406.Ilium, pronounced anteroventral 'hook' on anterior expansion of ilium:
(0) – absent preacetabular blade subtriangular
(1) – ventral edge pendant projection
(2) – process strongly hooked with recurved posterior margin,
ORDERED

407.Ilium, preacetabular part of ilium length relative to postacetabular ilium:
(0) – preacetabular ilium shorter
(1) – roughly as long as postacetabular part of ilium
(2) – longer than postacetabular ilium

408.Ilium, notch between pubic peduncle and pre-acetabular process:
(0) – wide, with semicircular or tear-drop outline
(1) – narrow and slit-like

409.Ilium, dorsoventrally oriented midline supraacetabular ridge on lateral face of ilium above acetabulum:
(0) – absent
(1) – present posterodorsally inclined
(2) – present and vertical or anterodorsally oriented

410. Ilium, dorsal extent of supraacetabular ridge:
(0) – short, does not extend into the m. iliofibularis scar
(1) – tall, extend onto the m. iliofibularis scar

411.Ilium, postacetabular process shape in lateral view:
(0) – tapering or rounded, posterior margin convex
(1) – squared
(2) – acuminate (pointy)

412.Ilium, supraacetabular crest on ilium as a separate process from antitrochanter:
(0) – present, forms "hood" over femoral head
(1) – reduced, not forming hood

(2) – absent

413.Ilium, acetabular crest, extent on pubic peduncle:
(0) – extensive, extends along most or all of the edge of the peduncle
(1) – limited, discretely offset from acetabular edge of pubic peduncle

414.Ilium, acetabular crest, maximum lateral projection relative to ischial peduncle:
(0) – significantly greater
(1) – subequal

415. Ilium, pubic peduncle articular facet:
(0) – flat or concave
(1) – convex
(2) – flexed with two facets set at obtuse angle to each other

416. Ilium, pubic peduncle articular facet orientation:
(0) – facet is sub-horizontal
(1) – facet faces anteroventrally

417.Ilium, pubic peduncle width in lateral view:
(0) – uniform in width (i.e. unexpanded)
(1) – broadly flared toward pubic articular surface

418.Ilium, pubic and ischial peduncles relative dorsoventral length:
(0) – comparable dorsoventral length
(1) – pubic peduncle expanded and twice or more as long as ischidiac peduncle

419.Ilium, pubic and ischial peduncles, anteroposterior width at dorsal neck:
(0) – pubic peduncle much larger than ischial peduncle
(1) – both peduncles approximately the same length

420.Ilium, cuppedicus fossa ('preacetabular fossa' of Hutchinson, 2001a):
(0) – absent
(1) – present, formed as antiliac shelf anterior to acetabulum, extends posteriorly to above anterior end of acetabulum
(2) – present, posterior end of fossa on anterior end of pubic peduncle, anterior to acetabulum

421.Ilium, brevis fossa lateral exposure:
(0) – entire length of fossa visible in lateral view, including posterior portion
(1) – only the anterior portion of the fossa is visible, the posterior portion of the fossa is hidden by posterior blade of the ilium
(2) – nearly completely hidden by posterior blade of the ilium

Pubis

422. Pubis, orientation:
(0) – propubic
(1) – pubis vertical or pubis posteriorly oriented (opisthopubic)

423. Pubis, shaft curvature:
(0) – shaft curves posteriorly, anteriorly convex curvature
(1) – straight

(2) – distal end curves anteriorly, anterior surface of shaft concave

424. Pubis, pubic boot, posterior expansion:
(0) – present
(1) – little or no posterior process

425. Pubis, pubic boot, anterior expansion:
(0) – absent
(1) – present, short
(2) – present, long

426. Pubis, pubic boot, anterior process, length relative to posterior process, measured from line down the middle of the shaft:
(0) – posterior process much longer
(1) – subequal

427. Pubis, entire pubic boot, anteroposterior length relative to total long axis length of pubis:
(0) – less than 25%
(1) – 30-35%
(2) – 40-55%
(3) – 60-70%
(4) – greater than 75%

428. Pubis, ventral margin of boot in lateral view:
(0) – convex
(1) – straight

429. Pubis, obturator foramen:
(0) – present
(1) – open notch present between pubic shaft and ishciadic peduncle
(2) – neither notch or foramen present

430. Pubis, pubic shaft shape:
(0) – rounded
(1) –mediolaterally flattened

431. Pubis, contact between pubes:
(0) – both pubes meet extensively
(1) – contact disrupted by a slit-like opening

432. Pubis, pubic tubercle on anterior margin just ventral to contact with ilium:
(0) – absent
(1) – present as a convexity on the anterior margin of the pubis
(2) – present as a rugose flange discretely offset from the anterior margin of the pubis and is bordered posteriorly by heavy rugosities on the lateral surface on the obturator region of the pubis

433. Pubis, pubic tubercle, position:
(0) – distally positioned, located ventral to the level of the obturator notch
(1) – proximally positioned, located level with or dorsal to the obturator notch

Ischium

434. Ischium, length compared to the length of the pubis:

(0) – more than two-thirds
(1) – two-thirds or less of pubis length

435.Ischium, midshaft thickness at compared to pubis midshaft thickness:
(0) – about as thick or thicker than pubic shaft
(1) – thin, half the thickness or less than the pubic shaft

436. Ischium, shaft curvature:
(0) – roughly straight or only gently curved
(1) – curved, ventrally concave
(2) – curved, dorsally concave

437. Ischium, ilio-ischiadic contact:
(0) – ischium with slightly concave or flat proximal articular surface that contacts ilium
(1) – with deep socket for reception of peg-like ischial peduncle of ilium

438.Ischium, transverse cross-section of acetabular rim:
(0) – convex or beveled
(1) – broad shelf with longitudinal sulcus or depression

439.Ischium, ischial boot (expanded distal end relative to midshaft):
(0) – present
(1) – absent

440. Ishchium, obturator foramen and flange:
(0) – present
(1) – reduced to notch, flange confluent with pubic peduncle
(2) – notch or foramen absent, U-shaped gap between pubic peduncle and obturator process

441. Ischium, position of apex of obturator flange, distance between apex and proximal end of ischium:
(0) – proximal flange, position at less than 20% of ischum length
(1) – flange positioned at approximately 25-30% of ischium length
(2) – flange position at approximately 35% of ischium length
(3) – distal flange, position further distal than 50% of ischium length

442.Ischium, broad medially deflected apron from obturator flange to distal end of ischium:
(0) – absent
(1) – present, covers 1/3 to 1/2 the ventral surface between obturator flange to distal end of ischium
(2) – present, covers more than 1/2 the ventral surface between obturator flange to distal end of ischium

443. Ischium, scar on posterior edge of the proximal end of the ischium:
(0) – absent
(1) – present

Femur

444.Femur, femoral head orientation:
(0) – directed ventrally
(1) – directed horizontally
(2) – directed dorsally

445.Femur, femoral head orientation relative to the distal femoral condyles:

(0) – directed anteromedially
(1) – directed strictly medially

446. Femur, fossa on the posterior surface of the femoral head, just lateral to the articular surface:
(0) – absent or shallow
(1) – narrow channel
(2) – deep, wide fossa

447. Femur, anterior trochanter, presence and separation from shaft:
(0) – absent
(1) – separated from greater trochanter by deep cleft
(2) – trochanters separated by small groove

448. Femur form of anterior trochanter:
(0) – alariform
(1) – cylindrical in cross section

449. Femur, height of anterior trochanter:
(0) – shorter, terminates further distally ends distal to the height of greater trochanter
(1) – subequal or slightly taller, the two structures extend to approximately the same level proximally

450. Femur, vertical ridge on lateral face of anterior trochanter:
(0) – present
(1) – absent

451. Femur, fourth trochanter, position, measurement from proximal margin of head to midpoint of fourth trochanter relative to total length of the femur:
(0) – proximally located, distance 25% or less femoral length
(1) – distally located, distance 30% of greater femoral length

452. Femur, circular scar (*M. adductor femoralis 1*) on posterior surface of shaft distal to fourth trochanter, mediolateral position:
(0) – scar absent
(1) – positioned closer to the medial edge of shaft
(2) – positioned closer to the shaft midline

453. Femur, anteromedial crest on anterior surface proximal to medial distal condyle:
(0) – without longitudinal crest
(1) – crest present extending proximally from medial condyle on anterior surface of shaft

454. Femur, depression (for *M. extensor digitalum longus*) on anterior surface of distal femur.
(0) – absent or extremely shallow, anterior surface relatively flat
(1) – shallow depression present
(2) – deep depression present

455. Femur, well-developed extensor groove (for *M. extensor digitalum longus*) present on the distal end of anterior surface of the distal femur constricting distal end of the EDL depression:
(0) – groove absent, expressed as a broad concave anterior margin
(1) – groove present and constricted to a wide, deep, U-shaped cleft in distal view
(2) – groove present and constricted to a narrow, deep, U-shaped cleft in distal view and present as an extensive depression on the anterior surface of the femur

456. Femur, depression between distal condyles in anterior view:
    (0) – relatively flat between condyles
    (1) – shallow depression between condyles
    (2) – deep depression confluent with extensor groove on anterior surface

457. Femur, deep channel between condyles for *M. gastrocnemius* and *flexor digitorum longus* group in distal view:
    (0) – no discrete channel present between condyles
    (1) – wide channel, wider than deep
    (2) – channel deeper than wide

458. Femur, crista tibiofibularis on lateral condyle in distal view:
    (0) – no distinct lateral separation in lateral condyle
    (1) – distinct lateral constriction into crista tibiofibularis larger than half the mediolateral width of the lateral condyle
    (2) – crista tibiofibularis restricted to medial half lateral condyle

Tibia

459. Tibia, length relative to the femur:
    (0) – tibia longer (1.05 or greater)
    (1) – tibia subequal or shorter (less than 1.00)

460. Tibia, proximal end, anterior process of lateral condyle:
    (0) – absent
    (1) – present

461. Tibia, lateral ridge on the lateral side of the tibia for connection with fibula:
    (0) – extending from the proximal articular surface distally
    (1) – clearly separated from proximal articular surface

462. Tibia, lateral condyle on proximal end of tibia:
    (0) – confluent with cnemial crest anteriorly in proximal view, or only slightly offset
    (1) – strongly offset from cnemial crest

463. Tibia, lateral malleolus, lateral extent:
    (0) – limited, mediolateral measure is less than 40% of mediolateral width of adjacent shaft
    (1) – extensive, mediolateral measure greater than 40% of mediolateral width of adjacent shaft

464. Tibia, lateral malleolus, position relative to medial malleolus:
    (0) – extend to approximately the same level distally
    (1) – lateral malleolus extends significantly further distally than medial malleolus

Fibula

465. Fibula, excavated medial fossa on the proximal end of the fibula:
    (0) – absent
    (1) – present, shallow
    (2) – present, deep

466. Fibula, position of medial fossa:
    (0) – not extensive, proximal border starts about 1/3 the distance between the proximal surface and the iliofibularis tubercle
    (1) – fills most of the proximal end of the fibula

467. Fibula, proximodistal cleft in the iliofibularis tubercle:
(0) – absent
(1) – present, resulting in two crests separated by a depressed fossa

468. Fibula, elongate groove on medial surface distal to iliofibularis turbercle:
(0) – absent
(1) – present, distal fibula medially concave

Astragalus

469. Astragalus, ascending process, form of base:
(0) – confluent with condylar portion
(1) – separated by deep transverse groove
(2) – separated by fossa across base

470. Astragalus, height of ascending process of astragalus (height vs. height of body):
(0) – lower than astragalar body
(1) – higher than the astragalar body, typically covering only lateral half of anterior surface of distal tibia
(2) – more than twice the height of astragalar body

471. Astragalus, ascending process height (height vs. width):
(0) – less than half the width of the bone
(1) – half the width of the bone to equal to the width of the bone
(2) – greater than the width of the bone

472. Astragalus, basal extent of ascending process:
(0) – arising out of the lateral part of the astragalar body
(1) – arising out of the complete breadth of the astragalur body

473. Astragaus, anteroposterior thickness of ascending process:
(0) – wedge-shaped/blocky
(1) – plate-like/laminar

474. Astragalus, ascending process contact with fibula:
(0) – absent or limited
(1) – extensive

475. Astragalus, , fibular facet on body of astragalus:
(0) – large and facing partially proximally
(1) – reduced and confined to anterior half of lateral side of astragalus
(2) – strongly reduced, facing laterally or absent

476. Astragalar condyles:
(0) – almost entirely below tibia and face distally
(1) – significantly expanded proximally on anterior side of tibia and face anterodistally

477. Astragalus, horizontal groove across astragalar condyles anteriorly:
(0) – absent
(1) – present

478. Astragalus, posterior process:

(0) – completely caps distal tibia
(1) – curves only slightly proximally, but not strongly covering the posterior side of the tibia
(2) – significant portion of distal surface exposed on articular facet so that astragalus and calcanium do not cover entire distal tibia

Calcaneum

479. Calcaneum, articulation with tibia:
(0) – without facet for tibia
(1) – with tibial facet on posteromedial corner or posterior surface

Distal tarsals

480. Distal tarsal fusion:
(0) – separate, not fused to metatarsals
(1) – fused, forming metatarsal cap with intercondylar prominence that fuses to metatarsal early in postnatal ontogeny

Metatarsals

481. Metatarsals, appression of major metatarsal shafts:
(0) – not appressed against each other beyond proximal half of shaft
(1) – appressed throughout most or all of metatarsus, adjacent surfaces of shafts flattened for contact between metatarsals metatarsals closely appressed and distance between II-III and III-IV is approximately equal
(2) –distance between mt III- mt IV greater than that between mt II- mt III

482. Metatarsals II and IV, relative length when in articulation:
(0) – metatarsals II and IV subequal in length
(1) – mt II longer than mt IV
(2) – mt II shorter than mt IV

483. Metatarsal II, articular scar for metatarsal III on distal portion of lateral surface of shaft, form:
(0) – smooth or subtle texture
(1) – heavily rugose fossa

484. Metatarsal II, tear drop shaped articular surface for metatarsal III:
(0) – absent
(1) – present

485.Metatarsal II, relative size of midshaft compared to metatarsal IV:
(0) – subequal
(1) – metatarsal II more robust than metatarsal IV

486.Metatarsal II, lateral surface in proximal view, shape:
(0) – flat or weakly concave
(1) – strongly concave

487.Metatarsal III, outline of proximal articular surface:
(0) – rectangular
(1) – hourglass-shaped
(2) – wedge-shaped with no exposure on plantar surface

488.Metatarsal III, form of midshaft shaft medial border:
(0) – straight or subtly convex medial border in anterior view

(1) – medial expansion forming a convexity or bulge along the distal part of the shaft

489. Metatarsal III, proximal shaft exposure:
(0) – prominently exposed between MT II and MT IV along entire metapodium
(1) – MT III proximal shaft constricted and much narrower than either II or IV, but still exposed along most of metapodium, subarctometatarsal
(2) – very pinched, poorly exposed exposed along proximal section of metapodium, arctometatarsal condition, mt III wedge-shaped with proximal end covered anteriorly by contact between metatarsals II and IV
ORDERED

490. Metatarsal III, ventral non-articular surface immediately proximal to the distal condyles:
(0) – concave
(1) – raised subtriangular platform

491. Metatarsal IV, proximal end, medial notch for articulation with metatarsal III:
(0) – absent
(1) – present, shallow notch
(2) – present, deep notch
ORDERED

492. Metatarsal IV, well-developed posteromedial flange on proximal end for articulation with metatarsal III:
(0) – absent
(1) – present

493. Metatarsal IV, midshaft, articular surface for metatarsal III:
(0) – flat
(1) – concave

494. Metatarsal IV, articular surface for metatarsal III tear drop shaped:
(0) – absent
(1) – present

495. Metatarsal IV, scar for the insertion of *M. gastrocnemius lateralis* covering medial third of posterior surface on metatarsal IV: articular surface for metatarsal III tear drop shaped:
(0) – absent or elongate scar
(1) – narrow oval rugosity

496. Metatarsal IV, surface between metatarsal III articulation and scar for *M. gastrocnemius lateralis*:
(0) – flat
(1) – concave
(2) – slender plantar ridge between metatarsal III articulation and *M. gastrocnemius lateralis* scar

497. Metatarsal IV, depth of medial collateral ligament fossa:
(0) – shallow, not rimmed
(1) – deep and rimmed

Pedal Phalanx

498. Pedal phalanges, proximal phalanges of digit II and III, ratio of length to midshaft width:
(0) – greater than 3.0
(1) – 2.0 to 3.0
(2) – less than 2.0

499. Pedal unguals, relative size of unguals II and III:
    (0) – subequal
    (1) – II much larger forming sickle claw

500. Pedal unguals, lip overhanging proximal articular surface dorsally (on extensor surface):
    (0) – present
    (1) – absent or reduced to a subtle tuber

501. Pedal unguals, curvature of flexor surface:
    (0) – curved
    (1) – relatively straight

Added characters

502. Postorbital, anteroposterior width of jugal flange:
    (0) – anteroposteriorly narrow
    (1) – anteroposteriorly expanded to subequal the length of the orbit

503. Postorbital, posterior extent of cornual boss:
    (0) – extends only to midpoint of ventral process
    (1) – extends well beyond the midpoint of the ventral process

504. Frontal, scar for posterior process of prefrontal:
    (0) – broad embayment
    (1) – narrow notch, part of frontal wraps lateral to prefrontal
    EXCLUDED

505. Dentary, shape in dorsal/ventral view:
    (0) – straight
    (1) – concave laterally, mandible bowed outward

506. Dentary, dorsoventral height of symphysis vs mid element height:
    (0) – subequal in height
    (1) – much deeper symphysis, 125% middentary height Dentary, dorsoventral minimum thickness of lingual bar in posterior third of tooth row:

507. Dentary, dorsoventral minimum thickness of lingual bar in posterior third of tooth row:
    (0) – deep; more than half of the height of the lingual bar anteriorly
    (1) – shallow, half or less the height of the lingual bar anteriorly

508. Dentary, modal number of alveoli:
    (0) – 14 or more
    (1) – 13 or less

509. Dentary, posterior alveolar dorsal margin:
    (0) – straight or gently rising upwards
    (1) – strongly concave and rising up steeply posteriorly

510. Angular, posteroventral edge:
    (0) – straight or convex
    (1) – concave

NEW CHARACTERS

511. lacrimal-frontal contact behind prefrontal
    (0) – absent
    (1) – broad, transverse suture between frontal and lacrimal
    (2) – slightly oblique suture between frontal and lacrimal
    (3) – strongly oblique suture between frontal and lacrimal, with strong anteromedial flange of frontal extending forward to contact lacrimal
    ORDERED

512. Lacrimal, suborbital tubercle:
    (0) – absent
    (1) – suborbital tubercle or flange developed on lacrimal along anteroventral margin of orbit

513. Antorbital fossa development on ventral ramus of lacrimal:
    (0) – weakly developed
    (1) – developed below lacrimal and extending to or beneath orbit

514. Maxilla, surface texture:
    (0) – weakly sculptured
    (1) – extremely rugose sculpture on anteroventral surface of maxilla

515. Lateral teeth, labial / lingual grooves:
    (0) – absent, or weak and developed basally
    (1) – very strong pinching of the root with deep gutters extending up crown

516. Pubic peduncle:
    (0) – anterior margin slopes anteroventrally, pubic peduncle trapezoidal in shape
    (1) – anterior margin relatively vertical, pubic peduncle subrectangular in shape

517. frontals, ventral surface flat, or weakly convex (0) or strongly convex in medial view (1)
    (0) – flat, or weakly convex
    (1) – frontals strongly convex in medial view, with ventral surface of frontals strongly depressed relative to the frontoparietal suture between the postorbital processes

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