

APPENDIX 1: List of characters used in the phylogenetic analysis.

1. Basicranial articulation: Pterygoid and/or epipterygoid for a mobile articulation with the basiptyergoid process (0); articulation is immobile (1). (Lee 1997 #2; de Braga & Rieppel 1997 #72; Jalil & Janvier 2005 #1)
2. Sphenethmoid ossification: absent (0); present (1). (Modified from Lee 1995 #10; Lee 1997 #3; de Braga & Rieppel 1997 – see discussion about sphenethmoid vs. pleurosphenoid therein; Jalil & Janvier 2005 #2)
3. Ossified medial wall of the prootic: absent (0); present (1). (Lee 1993 A6; Lee 1995 #1; Lee 1997 #4; de Braga & Rieppel 1997 #68; Jalil & Janvier 2005 #3)
4. Lateral flange of the exoccipital: absent (0); small flange present (1); lateral flange of the exoccipital well-developed and extends well along the paroccipital process of the opisthotic (2). (Lee 1993 #A4; Lee 1995 #2; Lee 1997 #5; Laurin & Reisz 1995 #64; Jalil & Janvier 2005 #4)
5. Paroccipital process suture: not sutured to the squamosal and supratemporal (0); paroccipital process of the opisthotic is antero-posteriorly expanded and sutured to ventrally-directed flange from the squamosal and supratemporal (1). (Modified from Lee 1993 #A3; Lee 1995 #4; Lee 1997 #6; de Braga and Rieppel 1997 #61&66; Jalil & Janvier 2005 #5)
6. Paroccipital process direction and orientation: projects laterally from the neurocranium (0); is U-shaped in occipital view (1). (Lee 1997 #7; Jalil & Janvier 2005 #6)
7. Ventral otic fissure: present (0); absent (1). (Lee 1993 #A5; Lee 1995 #5; Lee 1997 #8; deBraga & Rieppel 1997 #63; Jalil & Janvier 2005 #7)
8. Floor of the braincase formed by the parabasisphenoid and basioccipital: not thickened (0); thickened (1). (Lee 1995 #6; Lee 1997 #9; Jalil & Janvier 2005 #8)
9. Cultriform process length: relatively long, more than the half of the distance between the anterior extent of the rostrum of the basiptyergoid tubercles (0); short, less than a third of this distance (1); absent (2). (Lee 1993 #C2; Lee 1995 #7; Lee 1997 #10; Jalil & Janvier 2005 #9)
10. Tip of cultriform process: pointed (0); blunt (1). (Lee 1995 #8; Lee 1997 #11; Jalil & Janvier 2005 #10)
11. Body of the basisphenoid: strongly constricted, giving it an hourglass shape in ventral

- view (0); body of the basisphenoid not strongly laterally constricted (1). (Lee 1997 #12; de Braga & Rieppel #64; Jalil & Janvier 2005 #11)
12. Ventral surface of the basisphenoid: featureless, lacking tubercles (0); tubercles present on the ventral surface of the neurocranium just behind the basiptyergoid processes (1). (Lee 1997 #13; Jalil & Janvier 2005 #12)
 13. Ventral surface of the basioccipital: absence of a central boss (0); presence of a boss on the ventral surface of the basioccipital (1). (Jalil & Janvier 2005 #13)
 14. Hemispherical basal tubera: absent (0); present (1). (Lee 1995 #9; Lee 1997 #14; Jalil & Janvier 2005 #14)
 15. Basal tubera position: situated posteriorly, closer to the occipital condyle than the basiptyergoid process (0); basal tubercles situated approximately midway between the occipital condyle and the basiptyergoid processes, or even further anteriorly (1). (Lee 1997 #15; Jalil & Janvier 2005 #15)
 16. Choana shape: situated in a lateral position, bounded laterally by the maxilla, diverge posteriorly, parallel to tooth row throughout (0); parallel, positioned more medially, delimited posterolaterally by the palatine (1); choanae even more medially positioned, with the palatine constituting more than 50% of the lateral border, medial border formed entirely by the vomer (2). (Modified from Lee 1993 #A1; Lee 199a #11; Lee 1997 #16; Laurin & Reisz 1995 #40; de Braga & Rieppel 1997 #8; Jalil & Janvier 2005 #16)
 17. Alar flange of the vomer: lateral flange of the vomer (alar flange) absent (0); present (1). (Modified from Damiani & Modesto 2001; Jalil & Janvier 2005 #17)
 18. Foramen palatinum posterius size: small or absent and delineated by the bones of the skull roof (?) (0); large, medially positioned and defined by the palatine and the ectopterygoid without participation of the bones of the skull roof (1). (Modified from Lee 1993 #A2; Lee 1995 #12; Lee 1997 #17; Laurin & Reisz 1995 #41; de Braga & Reisz 1996 # 74; Jalil & Janvier 2005 #18)
 19. Medial prepalatal foramen bordered by the premaxillary and the vomer: absent (0); present (1). (Jalil & Janvier 2005 #19)
 20. Interptyergoid vacuity: long, at least 15% of skull length (0) short, less than 15 % of skull length (1). (Laurin & Reisz 1995 #39)

21. Interpterygoid vacuity shape: extends far anteriorly and is V-shaped (0); anterior border is U-shaped (1); no vacuity, or very small, pterygoids are sutured along their entire length closing the interpterygoid vacuity (2). (Lee 1997 #18; de Braga & Rieppel 1997 #73; Jalil & Janvier 2005 #20)
22. Transverse flange of the pterygoid shape: large and directed laterally (0); reduced, directed more anteriorly than laterally, without contact with the cheek (1). (Modified from Lee 1993 # A7; Lee 1995 #13; Lee 1997 #19; deBraga & Rieppel 1997 # 80; Jalil & Janvier 2005 #21)
23. Transverse flange of the pterygoid orientation: extends ventrally below the level of the alveolar ridge (0); oriented primarily horizontally, so the level of the palate is higher, not reaching the level of the alveolar ridge (1). (Lee 1993 #A9; Lee 1995 #14; Lee 1997 #20; Jalil & Janvier 2005 #22)
24. Supraoccipital: large, with longitudinal contact with the postparietal (0); high and narrow, forming along all of its length a solid sagittal suture with a ventral projection of the postparietal (1). (Modified from Lee 1993 # A8; Lee 1995 #3; Lee 1997 #21; Jalil & Janvier 2005 #23)
25. External nares: round and small (0); very anteroposteriorly elongate (1). (Lee 1995 #16; Lee 1997 #23; Jalil & Janvier 2005 #25)
26. Maxillary boss: a boss or horn on the maxilla immediately behind the external naris feebly developed or absent (0); prominent boss or horn present (1). (Lee 1997 #25; deBraga & Rieppel 1997 #12; Jalil & Janvier 2005 #27)
27. Dorsal process of the maxilla: reduced, not reaching the nasal with a contribution of the lacrimal to the ventral border of the naris (0); large anterodorsal extension of the maxilla, excluding the lacrimal from the external naris (1). (Modified from Laurin & Reisz 1995 #19; Lee 1997 #26; deBraga & Rieppel 1997 #17; Jalil & Janvier 2005 #28)
28. Snout dimensions (anteriorly): broader than high (0); as high as wide (1). (Lee 1997 #30; Jalil & Janvier 2005 #31)
29. Postfrontal shape: narrow, more than 2 times as long as wide, contributes to the orbital margin (0); widened mediolaterally, around 2 times as wide as long or less, no or only feeble contribution to the orbital rim (1). (Modified from Lee 1995 #25;

Lee 1997 #31; Jalil & Janvier 2005 #32). Modified.

30. Orbit shape: circular, no posterior emargination (0); posterior emargination of orbits (1). (Lee 1995 #23; Lee 1997 #32; Jalil & Janvier 2005 #33)
31. Pineal foramen position: pineal foramen situated about halfway along the interparietal suture (0); placed more anteriorly, close to the frontal-parietal suture (1). (Modified, combined 2 characters from Lee; Lee 1995 #17; Lee 1997 #33; Lee 1993 #C2; Lee 1995 #18; Lee 1997 #34; Laurin & Reisz 1995 #3; Jalil & Janvier 2005 #34 & 35)
32. Supernumerary elements: 'supernumerary elements' (tabular): small, largely an occipital element (0); absent (1); integrated into skull table (2). (Modified from Lee 1997 #36; Jalil & Janvier 2005 #37)
33. Supernumerary element (tabular) contact: do not contact each other posteriorly (0); very well-developed, make contact posteriorly, excluding the postparietals from the posterior edge of the skull table (1). (Modified from Jalil & Janvier 2005 #38)
34. Postparietal morphology: small, largely an occipital element (0); absent (1); integrated into skull table (2). (Modified from Lee 1995 #20; Lee 1997 #37; Jalil & Janvier 2005 #39)
35. Postparietal form: paired (0); fused into a single element and exposed well dorsally (1). (Modified from Laurin & Reisz 1995 #4 & 5; Lee 1997 # 38; deBraga & Rieppel 1997 #52; Jalil & Janvier 2005 #40)
36. Junction of skull table and cheek: both flat surfaces form a distinct angle where they meet, particularly behind the orbits (0); postorbital portion of this junction is rounded, no clear edge between these two surface behind the orbit (1). (Lee 1997 #41; Jalil & Janvier 2005 #43)
37. Temporal emargination (otic notch): absent or very small (0); emargination present on the posterior border of the cheek, formed by the squamosal and the quadratojugal (1). (Lee 1995 #29; Lee 1997 #43; Jalil & Janvier 2005 #45)
38. Jugal flange: no flange present on the jugal, the ventral surface of the cheek is continuous with that of the maxilla (0); jugal flange present, extends below the level of the maxillary teeth (1); jugal flange well-developed, forms an angle of greater than or equal to 140 degrees with the ventral surface of the cheek (2). (Lee 1997 #45; Jalil & Janvier 2005 #46)

39. Cheek ornamentation: no ornamentation on the ventral surface of the cheek (0); cheek ornamentation present in the form of low rounded bosses (1); cheek bosses well-developed with well-defined tubercles (2); cheek ornamentation in the form of prominent conical horns (3). (Modified from Lee 1995 #27; Lee 1997 #46; deBraga & Rieppel 1997 #43; Jalil & Janvier 2005 #47)
40. Quadratojugal ornamentation: no ornamentation, continuous with the jugal (0); dermal ornamentation and bosses present also on the posteroventral surface of the quadratojugal (1). (Lee 1997 #47; Jalil & Janvier 2005 #48)
41. Ventral temporal emargination: absent (0); present and bounded ventrally, forming a lower temporal fenestra (1); present and open ventrally (2). (Modified from Laurin & Reisz 1995 #30)
42. Postorbital region of skull: length at least equals anteroposterior extension of orbit (0); postorbital region shorter than anteroposterior extension of orbit (1). (Modified from Laurin & Reisz 1995 #32)
43. Frontal contribution to the orbit: present (0); frontals excluded from the orbit by contact between the prefrontal and postfrontal (1). (Laurin & Reisz 1995 #2; modified from Lee 1997 #48; de Braga & Rieppel 1997 #22; Jalil & Janvier 2005 #49)
44. Frontal shape: slim and long, four times as long as wide (0); frontals short, with a length not more than two times the width (1). (Lee 1995a #24; Lee 1997a #49; deBraga & Rieppel 1997 #26; Jalil & Janvier 2005 #50)
45. Boss ornamentation: dermal bosses of skull bones have no central pointed horn (0); dermal bosses of cranial bones have a central long, pointed horn (1). (Jalil & Janvier 2005 #51)
46. Mandibular symphysis: splenial is excluded from the mandibular symphysis (0); splenial forms the ventral portion of the mandibular symphysis (1). (Lee 1997 #51; Jalil & Janvier 2005 #52)
47. Angular boss: ventral surface of the angular smooth, no boss present (0); low, rounded boss present (1); boss present and well developed, forms a prominent, pointed tubercle (2). (Lee 1997 #52; Jalil & Janvier 2005 #53)
48. Retroarticular process dorsal projection: without a projection, tapers gradually to end

- (0); small projection (“dorsal lump” of Lee 1997) present at the very posterior end of the retroarticular process (1). (Lee 1997 #54; Jalil & Janvier 2005 #55)
49. Lateral shelf of the articular region: absent, the lateral surface of the articular region is smooth (0); present, there is a lateral extension of the surangular or articular, the lateral surface of the effected element extends dorsolaterally (1) (Laurin & Reisz 1995 #78) – (Modified slightly from Jalil & Janvier 2005 #56).
50. Maxillary dentition orientation: maxillary teeth oriented vertically, teeth point directly downwards (0); alveolar ridge inflected towards the palate, teeth oriented ventromedially (1). (Lee 1997 #27; Jalil & Janvier 2005 #57)
51. Number of maxillary teeth in each maxilla: more than or equal to 10 (0); less than or equal to 9 (1). (Modified from Lee 1997 #55; Jalil & Janvier 2005 #58)
52. Teeth labiolingually compressed: teeth not labio-lingually compressed (0); teeth labio-lingually compressed, leaf-shaped, with small denticles on the tooth crown (1); labio-lingual compression very pronounced, giving the marginal teeth a fan shape (2). (Modified from Lee 1997 #58; Jalil & Janvier 2005 #60)
53. Cusp arrangement: three central cusps close together, more lateral cusps farther apart and spaced farther apart from each other than these central 3 (0); cusps regularly spaced along the tooth crown (1). (Lee 1997 #61; Jalil & Janvier 2005 #61)
54. Maxillary tooth cusp number: maxillary teeth conical, single cusp (0); 2–7 cusps on each maxillary tooth (1); 7–9 cusps (2); 9–11 cusps (3); more than 11 cusps (4). (Lee 1997 #59; Jalil & Janvier 2005 #62)
55. Mandibular tooth cusp number: conical, without cusps (0); 2–7 cusps on each mandibular tooth (1); 7–9 cusps (2); 9–11 cusps (3); more than 11 cusps (4). (Modified from Lee 1997 #60; Jalil & Janvier 2005 #63)
56. Shape of lingual surface of mandibular teeth: smooth (0); has a distinct, triangular ridge, narrowing towards the crown of the tooth (1). (Lee 1997 #63; Jalil & Janvier 2005 #64)
57. Cingulum: no cingulum on the lingual surface of the marginal teeth (0); cingulum present, with small cuspules (1). (Lee 1997 #64; Jalil & Janvier 2005 #65)
58. Pterygoid transverse flange dentition: teeth present on the transverse flange of the pterygoid (0); no dentition on the transverse flange of the pterygoid (1). (Lee 1997

#65; Jalil & Janvier 2005 #66)

59. Palatal teeth: medial rows of palatal denticles parallel and close together and to the medial axis of the skull (0); medial rows of palatal denticles widely separated, converging anteriorly (1). (Modified from Lee 1997 #66; Jalil & Janvier 2005 #67)
60. Presacral vertebral count: more than 20 presacral vertebrae (0); 20 presacral vertebrae (1); 19 or fewer presacral vertebrae (2). (Modified from Lee 1993 #B1; Lee 1995 #35; Lee 1997 #67; Laurin & Reisz 1995 #81; de Braga & Rieppel 1997 #97; Jalil & Janvier 2005 #68)
61. Atlas-axis fusion: pleurocentrum of the atlas and axial intercentrum fused (0); atlas pleurocentrum separate from the axial intercentrum (1). (Laurin & Reisz 1995 #85; Jalil & Janvier 2005 #69)
62. Lumbar vertebrae: absent (0); present (1). (Lee 1995 #36; Lee 1997 #68; Jalil & Janvier 2005 #70)
63. Sacral vertebrae number: two (0); three (1); four (2); five (3). (Lee 1997 #93; Jalil & Janvier 2005 #71)
64. Tail length: long, with more than 25 caudal vertebrae (0); short, less than 25 caudal vertebrae (1). (Lee 1997 #70; Jalil & Janvier 2005 #73)
65. Lateral projections (“transverse processes”) of anterior caudal vertebrae: generally present on the first five but never on more than 9 of the first (most anterior) caudal vertebrae (0); prominent lateral projections on at least the first 9 caudal vertebrae (1). (Modified from Lee 1993 #A10; Lee 1995 #37; Lee 1997 #71; Laurin & Reisz 1995 #90; de Braga & Rieppel 1997 #110; Jalil & Janvier 2005 #74)
66. Shape of lateral projections ('caudal ribs'): projections form an 'L', as their distal portions are recurved posteriorly parallel to the axis of the body (0); projections almost straight and directed laterally (1). (Lee 1997 #72; de Braga & Rieppel 1997 #111; Jalil & Janvier 2005 #75)
67. Haemal arch insertion: between two caudal vertebrae (0); articulate with only one centrum via a facet of articulation found on posteroventral projections of the centra (1). (Lee 1993 #A11; Lee 1995 #39; Lee 1997 #73; Laurin & Reisz 1995 #91; deBraga & Rieppel 1997 #112; Jalil & Janvier 2005 #76)
68. Acromion process of the scapula: absent (0); acromion process present on the anterior

- surface of the scapula (1). (Lee 1993 #A12; Lee 1995 #40; Lee 1997 #74; Laurin & Reisz 1995 #91; deBraga & Rieppel 1997 #112; Jalil & Janvier 2005 #77)
69. Scapular blade length: short, with a length less than two times the diameter of the glenoid fossa (0); long, with a length at least two times longer than the maximum diameter of the glenoid fossa (1); very long, with a length at least three times the diameter of the glenoid fossa (2). (Lee 1993 #B2; Lee 1995 #41; Lee 1997 #75; Laurin & Reisz 1995 #96; Jalil & Janvier 2005 #78)
70. Dorsal edge of posterior coracoid: almost horizontal, meets the posterior border of the scapula at an angle of less than 135 degrees (0); dorsal edge of the posterior coracoid is oriented posteroventrally, forms an angle of more than 135 degrees with the posterior border of the scapula (1). (Lee 1997 #77; Jalil & Janvier 2005 #80)
71. Cleithrum: present (0); absent (1). (Laurin & Reisz 1995 #94; de Braga & Rieppel 1997 #113; Lee 1997 #79; Jalil & Janvier 2005 #81)
72. Torsion of the humerus: the plane of proximal expansion makes an angle of 60 degrees or more with the plane of proximal expansion (0); the two planes form an angle of less than or about equal to 45 degrees (1); the two planes form an angle less than or equal to 20 degrees (2). (Lee 1997 #81; de Braga & Rieppel 1997 #123; Jalil & Janvier 2005 #83)
73. Ectepicondyle: ectepicondyle narrow and rounded (0); expanded, forming a wide rectangular flange that projects in front (preaxially) of the radial condyle (1). (Lee 1997 #82; Jalil & Janvier 2005 #84)
74. Ectepicondylar foramen: absent (0); present (1). (Modified from Lee 1993 #A13; Lee 1995 #43; Lee 1997 #83; Laurin & Reisz 1995 #102; de Braga & Rieppel 1997 #127; Jalil & Janvier 2005 #85)
75. Entepicondyle: forms a wide, rectangular flange that projects posteriorly behind (postaxially) the radial condyle (0); rounded, narrower, with a very reduced distal expansion (1). (Lee 1997 #84; Jalil & Janvier 2005 #86)
76. Entepicondylar foramen: present and completely enclosed (0); present in the form of an 'open groove' (1); absent, no foramen or groove (2). (Lee 1995 #44; Lee 1997 #85; Jalil & Janvier 2005 #87)
77. Entepicondylar foramen position: exposed in dorsal view (when distal expansion of

the humerus is viewed dorsally) (0); situated on the side of the epicondyle and feebly exposed in dorsal view, foramen has migrated around the edge of the humerus (1). (Lee 1997 #86; Jalil & Janvier 2005 #88)

78. Ent- and Ectepicondyle projection: entepicondyle and ectepicondyle do not project distally beyond the epicondylar region (0); project beyond the epicondylar region, distal end of the humerus appears 'forked' (1). (Lee 1997 #87; Jalil & Janvier 2005 #89)
79. Intercondylar depression on the dorsal surface of the distal end of the humerus: without a transverse ridge (0); transverse ridge present on the intercondylar depression, it is found on the distal surface of the intercondylar depression and is defined dorsally by the ulnar articular surface (1). (Lee 1997 #88; Jalil & Janvier 2005 #90)
80. Ulnar articulation surface of the humerus: takes the form of a groove bordered posteriorly by a faint ridge (0); this postaxial ridge is elaborated into a prominent tubercle (1). (Lee 1997 #89; Jalil & Janvier 2005 #91)
81. Radial condyle of the humerus: hemispherical, located entirely on the ventral surface of the humerus (0); condyle positioned more terminally, encroaches onto the distal end of the humerus (1). (Lee 1997 #90; Jalil & Janvier 2005 #92)
82. Olecranon process of the ulna: well-developed, articulation surface for the humerus oriented medially (0); olecranon process very reduced, articular surface for the humerus faces terminally, trochlea on the humerus lies on the ventral surface (1). (Lee 1997 #91; Jalil & Janvier 2005 #93)
83. Manual phalangeal formula: 23452, not reduced (0); 23332 reduced (1). (Lee 1993 #B5; Lee 1995 #45; Lee 1997 #92; Laurin & Reisz 1995 #106; Jalil & Janvier 2005 #94)
84. Morphology of the 2nd and 3rd sacral ribs: only slight dorsoventral compression of the second and third sacral ribs (0); significant dorsoventral compression of the second and third sacral ribs, which take on a thin sheet-like appearance (1). (Lee 1997 #94; Jalil & Janvier 2005 #95)
85. Crista sacralis of the ilium: weak ridge on the medial surface of the iliac blade for articulation with the first sacral rib weakly developed (0); ridge well developed (1).

(Lee 1997 #95; Jalil & Janvier 2005 #96)

86. Iliac shaft: vertical or oriented posterodorsally (0); inclined anterodorsally, forming an angle with the vertical of more than 20 degrees (1); inclined even further anteriorly, forming an angle of more than 45 degrees with the vertical (2). (Lee 1997 #96; Jalil & Janvier 2005 #97)
87. Iliac blade: not or only very slightly expanded in front of the iliac shaft (0); expanded well anterior of the iliac shaft (1). (Lee 1997 #97; Jalil & Janvier 2005 #98)
88. Eversion of anterior extent of the ilium: the lateral surface of the anterior expansion of the iliac blade almost completely flat (0); this surface concave along the vertical dimension, anteroventral margin slightly everted (1); surface strongly everted, even pointed looking, oriented almost horizontal (2). (Lee 1997 #98; Jalil & Janvier 2005 #99)
89. Posterior process of the ilium: long, extending the blade of the ilium posteriorly (0); strongly reduced (1). (Lee 1995 #48; Lee 1997 #99; Jalil & Janvier 2005 #100).
90. Dorsal buttress on the acetabulum: not well developed (0); strongly developed (1). (Lee 1993 #A16; Lee 1995 #47; Lee 1997 #100; Laurin & Reisz 1995 #109; Jalil & Janvier 2005 #101)
91. Acetabular shape: edge of the acetabulum anteriorly rounded or slightly oval (0); presence of a distinct notch in the anterior rim of the acetabulum (1). (Lee 1997 #101; Jalil & Janvier 2005 #102)
92. Pelvic symphysis: long and thin (0); shorter and thick (1). (Lee 1997 #103; Jalil & Janvier 2005 #104)
93. Anterior border of the pubis: smooth, without a ventral process (0); ventrally oriented process present on the anterior of the pubic plate ('lateral pubic process' of Walker 1973; Gaffney 1990) (1). (Lee 1997 #104; Jalil & Janvier 2005 #105)
94. Median pubic process: anterior margin of the pubis smooth edge (0); medial process on the anterior margin of the pubis (1). (Lee 1997 #105; Jalil & Janvier 2005 #106)
95. Preaxial curvature of the femoral head: no curvature (0); proximal head of the femur curved slightly anteriorly (preaxially) (1); strong curvature preaxially, giving the bone a boomerang shape in dorsal or ventral view (2). (Lee 1997 #107; Jalil & Janvier 2005 #107)

96. Trochanter major: no major trochanter present on the posterior (postaxial) side of the femur (0); major trochanter present but small, forms a slight thickening of the postaxial edge of the femur (1); major trochanter present and large, a distinct thickening on the postaxial edge of the femur (2). (Lee 1993 #A14; Lee 1995 #50; Lee 1997 #109; Jalil & Janvier 2005 #109)
97. Postaxial flange of the femur size: reduced, limited to the proximal region of the femur (0); present, extends the entire length of the femur, but is narrower in the middle, so femur looks concave in dorsal or ventral view (1); well-developed, runs the entire length of the femur, keeping the same length for its entire length, so femur appears extremely wide with postaxial border appearing a straight edge (2). (Lee 1997 #112; Jalil & Janvier 2005 #112)
98. Minor (internal) trochanter shape: long and straight in ventral view (0); long and curved on its proximal region in ventral view, preaxial (anterior) side concave and postaxial (posterior) being convex (1). (Lee 1997 #114; Jalil & Janvier 2005 #114)
99. Cnemial crest: cnemial crest of the tibia (longitudinal ridge on the dorsal (lateral or external) surface of the tibia) well developed and prominent (0); ridge and accompanying groove much reduced (1). (Lee 1997 #115; Jalil & Janvier 2005 #115)
100. Astragalus and calcanium: separate or sutured (0); fused, with the presence of the obturator foramen (1). (Modified from Lee 1993 #B6; Lee 1995 #51; Lee 1997 #116; Laurin & Reisz 1995 #117; de Braga & Rieppel 1997 #149; Jalil & Janvier 2005 #116)
101. Pedal phalangeal formula: 23454 or 23453 (0); 23343 (1). (Lee 1993 #B7; Lee 1995 #53; Lee 1997 #118; Laurin & Reisz 1995 #122; de Braga & Rieppel 1997 #161; Jalil & Janvier 2005 #118)
102. Fifth pedal digit: large, always longer than the first pedal digit (0); reduced, slender, shorter than the first pedal digit (1). (Lee 1993 #A15; Lee 1995 #54; Lee 1997 #119; Laurin & Reisz 1995 #120; de Braga & Rieppel 1997 #159; Jalil & Janvier 2005 #119)
103. Metapodial (metacarpal and metatarsal) shape: slender, close to two times as long as wide (0); robust, approximately as wide as long (1). (Lee 1997 #120; Jalil & Janvier

2005 #120)

104. Non-terminal phalanges shape: slender, 50 % longer than wide (0); short, as long as wide (1); even shorter and more massive, about two times as wide as long (2). (Lee 1995 #46; Lee 1997 #121; Jalil & Janvier 2005 #121)
105. Osteoderms on the body: absent (0); present, forming only a longitudinal band closely overlying the vertebral column (1); present over the entire dorsal surface of the body including the flanks (2). (Lee 1997 #122; de Braga & Rieppel 1997 #165; Jalil & Janvier 2005 #122)
106. Osteoderm boss appearance: dorsal surface of the osteoderms smooth, convex, without a central boss (0); possess a distinct rounded central boss (1); central boss on osteoderm capped by a small conical spine (2). (Lee 1997 #123; Jalil & Janvier 2005 #123)
107. Osteoderm ornamentation: external surface of the osteoderms smooth and without ornamentation (0); osteoderms ornamented with fine, straight, regularly spaced ridges radiating out from a central boss to the edge (1); ridges fewer, larger, lumpier, and less regularly spaced (2). (Lee 1997 #124; de Braga & Rieppel 1997 #166; Jalil & Janvier 2005 #124)
108. Osteoderm dimension: round and small, with a dimension no larger than diameter of the centra of the dorsal vertebrae (0); osteoderms large, with a maximal length the same as or larger than the dorsal vertebral centra (1). (Lee 1997 #125; Jalil & Janvier 2005 #125)
109. Osteoderm position: osteoderms do not touch, separated by a space (0); osteoderms more densely packed, often touching one another, but touching only on the shoulder and pelvic regions, never sutured or articulated over the trunk (1); osteoderms overlapping, articulated or sutured, forming a continuous layer on the dorsal surface of the body (2). (Modified from Lee 1997 #126; Jalil & Janvier 2005 #126)
110. Osteoderms on appendages: no osteoderms over the appendages (0); fore and hind limbs covered with numerous conical osteoderms (1). (Lee 1997 #127; de Braga & Rieppel 1997 #167; Jalil & Janvier 2005 #127)
111. Gastralia: present (0); absent (1). (Lee 1995 #56; Lee 1997 #128; de Braga & Rieppel 1997 #168; Jalil & Janvier 2005 #128)

112. Fully enclosed lateral temporal fenestra: absent (0); present (1).
113. Pterygoid anterior extent: reaches level of choana (0); posterior to choana (1).
(Laurin & Reisz 1995 #44)
114. Circumorbital tubercities: circumorbital skull elements lacking tubercles or bosses (0); circumorbital tubercles present (1). (Modified from Tsuji 2006 #45)
115. Radiating ridges: dermal sculpturing in the form of relatively straight ridges radiating from the centre of dermal skull roof bones absent (0); regular ridges present (1).
116. Circular pits: cranial sculpture in the form of circular pits absent (0); present (1).
117. Jugal anterior process: does not extend to anterior orbital rim (0); extends at least to level of orbital rim (1). (Laurin & Reisz 1995 #11)
118. Quadratojugal anterior extent: does not reach level of posterior border of orbit (0); reaches posterior border of orbit (1). (Modified from Laurin & Reisz 1995 #23)
119. Caniniform region: present (0); absent (1). (Laurin & Reisz 1995 #24)
120. Jaw articulation position: anterior to occiput (0); even with occiput (1). (Laurin & Reisz 1995 #36)
121. Posterior margin of skull roof: with single, median embayment (0); roughly straight (1). (Modesto 1999 #125)
122. Quadrate ramus of pterygoid: merges smoothly into transverse flange without distinctive excavation (0); deep excavation on posterolateral surface (1). (deBraga & Reisz 1996 #33)
123. Suture between jugal and maxilla: straight, jugal thins out smoothly towards anterior, or upright, but no dramatic vertical 'step' (0); "stepped", anteriormost tip of jugal very narrow but expands broadly posteriorly along with a dramatic thinning of the posterior process of the maxilla (1). (Modified from Müller & Tsuji 2007 #133)
124. Temporal (otic) notch morphology: restricted to posterior half of cheek (0); closely approaches the orbital margin (1). (Müller & Tsuji 2007 #135)
125. Contribution of maxilla to external naris: maxilla either excluded from naris or forms only its ventral/posterior edge (0); maxilla extends also to the posterodorsal margin of naris (1). (Müller & Tsuji 2007 #137).

References

- Damiani, R. & Modesto, S. P. 2001. The morphology of the pareiasaurian vomer. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte* **2001**, 423–34.
- deBraga, M. & Reisz, R. R. 1996. The Early Permian reptile *Aceistorhinus pteroticus* and its phylogenetic position. *Journal of Vertebrate Paleontology* **16**, 384–95.
- deBraga, M. & Rieppel, O. 1997. Reptile phylogeny and the interrelationships of turtles. *Zoological Journal of the Linnean Society* **120**, 281–354.
- Gaffney, E. S. 1990. *Dinosaurs: A Golden Guide*. Western Publishing Company, Inc. 160 pp.
- Jalil, N.-E. & Janvier, P. 2005. Les pareiasaures (Amniota, Parareptilia) du Permien supérieur du Bassin d'Argana, Maroc. *Geodiversitas* **27**, 35–132.
- Laurin, M. & Reisz, R. R. 1995. A reevaluation of early amniote phylogeny. *Zoological Journal of the Linnean Society* **113**, 165–223.
- Lee, M. S. Y. 1993. The origin of the turtle body plan: bridging a famous morphological gap. *Science* **261**, 1716–20.
- Lee, M. S. Y. 1995. *Evolutionary morphology of pareiasaurs*. Unpublished PhD Thesis, Cambridge University, UK.
- Lee, M. S. Y. 1997. Pareiasaur phylogeny and the origin of turtles. *Zoological Journal of the Linnean Society* **120**, 197–280.
- Modesto, S. P. 1999. *Colobomycter pholeter* from the Lower Permian of Oklahoma: a parareptile, not a protorothyridid. *Journal of Vertebrate Paleontology* **19**(3), 466–72.
- Müller, J. & Tsuji, L. A. 2007. Impedance-matching hearing in Paleozoic reptiles: evidence of advanced sensory perception at an early stage of amniote evolution. *PloS ONE* **2**, e889.doi:10.1371/journal.pone.0000889.
- Tsuji, L. A. 2006. Cranial anatomy and phylogenetic affinities of the Permian parareptile *Macroleter poezicus*. *Journal of Vertebrate Paleontology* **26**, 849–65.
- Walker, W. F., Jr. 1973. The locomotor apparatus of testudines. In Gans, C. & Parsons, T. S. (eds) *Biology of the Reptilia*, 1–100. New York: Academic Press. 539 pp.

			1	1	1	1
	8	9	0	1	2	2
	1234567890	1234567890	1234567890	1234567890	1234567890	12345

Millerettidae	0000000000	0000000?00	0000000000	00000????0	0A0000000A	0000?0
Owenetta	000012?00?	?000000110	?0??100??0	??000????0	?01000010	001100
Ba. bashkyricus	??????????	??????????	??????????	??????????	?00001???	?11110
'Ba.' mesensis	??????????	??????????	??????????	??????????	?00001A00	?00111
Rhipaeosaurus	?010?00?00	?0??000100	0?0?100001	0000??????	??????????	??0???
Nycteroleter	??????????	??????????	??????????	??????????	?00001001	101010
Emeroleter	0??0?0????	?100?0????	?????10??11	0000??????	00?001001	100011
Macroleter	00?1?00000	0?00?01???	0???1???01	0?110????0	110101100	100000
'Br.' baini	0?11000000	00?0101111	0011112?01	??12100000	101111111	001000
Br. seeleyi	0011000000	0010101111	0000112001	1112100000	101111111	001000
Nochelesaurus	0111000000	00????????	?????11200?	?????100000	101111111	00?000
Embrithosaurus	0111000000	0010101011	0111121101	1112110000	?01111111	00?000
Deltavjatia	11110000?0	0010?11111	?????122001	1012110000	101101111	001000
Shansisaurus	1111?00???	?0????????	?????1?1???	????????????	????????????	???????
Shihtienfenia	1111?10010	0??0?11211	0??????????	????????????	????????????	???????
P. peringueyi	1101110110	00?1121211	111122110?	??12212111	101101111	001000
P. nasicornis	?10?1??1?0	0011121211	11112?1101	??12212111	101101111	001000
Pareiasaurus	1111000010	0010111211	0111121101	?????212111	?01101111	00?000
Scutosaurus	1111000010	0010111211	0111121101	??12222111	101111111	001000
Sanchuansaurus	????????????	????????????	????????????	????????????	????????????	???????
Parasaurus	????????????	???0?11?11	1?1?12??01	??11???????	10??01???	?0??0?
Elginia	1??1?0001?	?????111211	?????1?110?	??12222111	10?101111	00??00
Provelosaurus	120??01??1	10?0?0011?	?????1?1?0?	?????21111?	?0?111111	00?000
Anthodon	1201001011	11?0100111	011102011?	?????21112?	101101111	00?000
Pumiliopareia	????????????	????????????	????????????	?????21112?	101100111	00?000
Nanoparia	????????????	????????????	????????????	????????????	?01101111	001000
Bunostegos	????????????	????????????	????????????	????????????	?01101?11	00??00
Arganaceras	????????????	????????????	????????????	????????????	?01101111	00?000
Obirkovia	????????????	????????????	????????????	????????????	?????01???	???????

Note: polymorphism is indicated by letters, such that A = 0 & 1; B = 1 & 2; C = 0 & 2; D=0 & 1 & 2; E = 0/1; F = 1/2.

APPENDIX 3: List of autapomorphic characters for taxa involved in phylogenetic analysis.

Millerettidae

-no known autapomorphies

Bashkyroleter bashkyricus

-no known autapomorphies

'Bashkyroleter' mesensis

-no known autapomorphies

Rhipaeosaurus tricuspidens

1. Tricuspid teeth

Nycteroleter ineptus

-no known autapomorphies

Emeroleter levis

2. Closely-spaced small round pits on otherwise smooth skull
3. Posteriorly strongly elongated supratemporals that form narrow and long horns
4. Enlarged unsculptured otic notch that reaches anteriorly almost to orbit
5. Posterior end of quadratojugal curves upward forming small horn
6. Middle pterygoid denticle ridge stretches from area of basipterygoid joint to posterior edge of choana and does not adjoin vomeropalatine ridge

Macroleter poezicus

7. Maxilla vomer anterior contact
8. Basicranial articulation and basipterygoid processes facing anteriorly
9. Pterygoids meeting anterior to basipterygoid articulation
10. Sculptureless indentation just anterior to fronto-parietal suture

11. Skull roof v-shaped in posterior view

Bradysaurus seeleyi

-no known autapomorphies

Bradysaurus baini

12. Distal portion of paroccipital process greatly swollen

13. Huge, rounded lump on the maxilla immediately behind the naris

Nochelesaurus alexanderi

14. Groove on internal surface of scapulocoracoid located very close to the anterior margin of the scapula blade

15. Distinct tubercle on centre of dorsal surface of entepicondyle

16. Flange on the dorsal surface of the femur that projects distally beyond the postaxial tibial facet

Embrithosaurus schwarzi

17. Anterior expansion of the iliac blade is flat rather than everted

18. Two iliac blades not parallel but diverge anteriorly (making an angle of approximately 40 degrees with the sagittal plane)

19. Pelvic symphysis extremely thick, almost half as deep as long

Deltavjatia rossicus

20. Occipital condyle projects far behind posterior border of postparietal

21. Sculpturing consists of irregular 'pustule-like' bosses scattered among circular pits

Shansisaurus xuecunensis

-no known autapomorphies

Shihtienfenia permica

22. Rounded expansion on the anterior margin of the scapular blade near the dorsal end

23. Acromion process is a smoothly-contoured, semi-circular flange

Pareiasuchus peringueyi

24. Lateral flange of the exoccipital forms a distinct, dorsally-oriented crest along the posterior margin of the paroccipital process

25. Small median tubercle on the internal surface of the mandible immediately above the symphyseal 'hook'

26. Angular boss is a large, blunt knob

Pareiasuchus nasicornis

27. Boss on nasal a discrete ossification

28. Cultriform process extremely wide, occupying entire width of interpterygoid vacuity

29. Large descending cheek flanges project backwards, making the skull appear 'delta-shaped' in dorsal view

Pareiasaurus serridens

30. Cranial sculpturing consists of a reticulate network of very fine pits and grooves, no boss on centre of each element

31. Dorsal flange on the anterior margin of the proximal end of the paroccipital process

32. Large descending cheek flanges project ventrally (doubtful)

Scutosaurus karpinskii

33. Small median boss on the basioccipital between the basal tubera

34. Teeth on upper jaw point slightly outwards

35. Radiating ridges covering skull very coarse

Sanchuansaurus pygmaeus

36. Two exits for infraorbital canal further apart than in any other pareiasaurs

37. The marginal surface of every tooth has a cusped cingulum

Parasaurus geintzi

- 38. Reduced small spike-like horns on the quadratojugal and supratemporal

Elginia mirabilis

- 39. Long conical horns present over the skull and cheek margins
- 40. Distinct median “crater-like” depression just behind the nasal bosses
- 41. Posteroventral embayment of the orbital margin

Provelosaurus americanus

- 42. Quadratojugal with long smooth ventrolateral surface, with two prominent cylindrical bosses located distally
- 43. Squamosal dorsoventrally expanded

Anthodon serrarius

- 44. Marginal teeth separated by small gaps – no continuous cutting surface
- 45. Olecranon process lost
- 46. Capitellum of femur extends onto dorsal surface
- 47. Proximal end of tibia bears huge ridge
- 48. Large dorsally-projecting flange on posterolateral corner of ischium

Pumiliopareia pricei

- 49. Skull table and cheeks completely covered in densely-spaced, conical bosses
- 50. Orbits perfectly round
- 51. Only nine teeth on upper jaw, seven on lower jaw
- 52. Ribs very wide, no intercostal spaces

Nanoparia luckhoffi

- 53. Snout very pointed in dorsal view
- 54. Small, superficial element between squamosal and quadratojugal
- 55. External nares proportionately larger than any other pareiasaur taxon

Bunostegos akokanensis

56. Three hemispherical processes at the anterior end of the snout
57. Elongate, laterally-projecting bosses overhanging orbit
58. Hemispherical boss at posterolateral corner of skull roof
59. Postfrontal and supratemporal bosses with neck separating globular head from skull roof

Arganaceras vacanti

60. Anterior process of maxilla inclined posteriorly (ventral surface of the naris horizontal)
61. Well-developed S.E. (tabular), with a large flange applied to the internal side of the supratemporal
62. Internal flange of the supernumerary element continues dorsally the internal flange of the squamosal and supratemporal, so probably made contact with the paroccipital process of the braincase
63. The medial process of the exoccipital meets its pair at the midline, excluding the supraoccipital from the foramen magnum
64. Neurocranium extremely elongated with a lateral constriction of the parabasisphenoid
65. Basipterygoid processes laterally restricted and very elongate
66. Sella turcica
67. Two additional lateral tubercles present in addition to the single median tubercle on the ventral surface of the basioccipital
68. Articular and angular form a large retroarticular process
69. Prominent bony flange formed by the articular defines the medial edge of the glenoid fossa?
70. Maxillary teeth point forwards

Obirkovia gladiator

71. Quadratojugal with three osteoderms on occipital flank
72. Anterior projection of quadratojugal with three osteoderms