Appendices

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Appendix 1. Character list used in this study's phylogenetic analysis

Annotations provided with the original character are retained immediately after the character description, while novel annotations provided by us are appended as a subpoint. When a character was taken from a previous metoposaurid matrix, the equivalent numbering is given following an abbreviation derived from the authors' names (BJS = Buffa, Jalil & Steyer; CS = Chakravorti & Sengupta; GPM = Gee, Parker & Marsh). A color-coded table showing character equivalency between these three matrices is provided at the end of this appendix. Character ordering status is listed after relevant multistate characters.

Character list

1. **Skull (proportions)**. longer than wide (0); wider than long (1). [Pardo et al., 2017 – 215]
2. **Preorbital-postorbital (length ratio)**: ratio of preorbital to postorbital length < 1 when measured along midline (0); ratio between 1 and 2 (1); ratio >2 (2). [modified from GPM – 4; adapted from Schoch, 2013] - *ordered*

3. **Orbit location**: medial, framed by wide jugals laterally (0); lateral emplacement, framed by very slender jugals (1). [GPM – 11; adapted from Schoch, 2013]
4. **Orbits in interpterygoid fenestrae**: posterior (0); second anterior quarter of interpterygoid fenestrae (1); anterior quarter of interpterygoid fenestrae (2). [BJS – 30] - *ordered*
5. **Ornamentation (prepineal region):** elongate grooves present (0); absent (1). [Schoch, 2013 – 6]
6. **Lateral line sulci:** throughout skull roof (0); confined to circumorbital region (1); absent (2). [adapted from Schoch, 2013 – 34] - *unordered*
7. **Number of premaxillary teeth:** > 15 (0); 10-15 (1); < 10 (2). [Pardo et al., 2017 – 242] – *ordered*
    a. The original states only differentiated among taxa with fewer than 11 premaxillary positions, reflecting that many early tetrapods and non-stereospondyl temnospondyls have low tooth counts. This character was revised to differentiate among the higher counts observed in stereospondyls.
8. **Number of maxillary teeth:** < 30 (0); 30-50 (1) >50 (2). [modified from Pardo et al., 2017 – 243] – *ordered*
    a. The original states only differentiated among taxa with fewer than 31 maxillary positions, reflecting that many early tetrapods and non-stereospondyl temnospondyls have low tooth counts. This character was revised to differentiate among the higher counts observed in stereospondyls.
9. **Premaxilla (alary process)**: absent, premaxilla and nasal share a transversely oriented suture (0); present, forming a posterior indentation along the medial narial margin (1); present, forming a posterior triangular process fully separated from the naris (2). [GPM – 5; adapted from Milner, 1993; Schoch, 2013] – *unordered*
    a. We modified the character here to capture additional nuance in the nature of the alary process and to more clearly specify how this feature is identified. It is unordered because state 1 cannot be inferred to be intermediary to the other two states.
10. **Premaxilla (mandibular apertures):** openings in premaxilla for symphyseal fangs absent (0); present (1). [NEW]
11. **Maxilla-orbital margin**: contact absent (0); contact present (1). [BJS – 6; adapted from McHugh, 2012]
12. **Nasal (width)**: nasal longer than wide (0); as wide as long (1). [Schoch, 2013 – 16]
13. **Lacrimal:** present (0); absent (1). [Schoch, 2013 – 21]
14. **Lacrimal-nasal**: contact absent (0); contact present (1). [BJS – 7]
15. **Lacrimal (length)**: compact, less than half of the distance between the naris and the orbit (0); elongate, at least 50% of the distance between the naris and the orbit (1). [modified from BJS– 8; adapted from Schoch and Milner, 2000]
    a. We modified the character here to remove a little ambiguity regarding what warrants ‘compact’ versus ‘elongate’ based on BJS’s corresponding figure (S3 therein).
16. **Lacrimal-orbit**: contact absent (0); contact narrow (1); contact broad (2). [BJS – 9; adapted from McHugh, 2012] - *ordered*
17. **Lacrimal-naris:** contact present (0); contact absent (1). [BJS – 10; adapted from Hunt 1993]

18. **Palatine (laterally exposed palatine, LEP)**: absent (0); present (1). [Schoch, 2013 – 127]
19. **Prefrontal (anterior end)**: pointed (0); wide and blunt (1). [GPM – 16; adapted from Schoch, 2013]
20. **Prefrontal (anterior contacts)**: nasal and lacrimal (0); nasal and maxilla (1); lacrimal and maxilla (2). [BJS – 11; adapted from McHugh, 2012]
    a. The second derived state (maxilla and lacrimal) was found only among *Almasaurus habazzi* and was previously 'frontal and lacrimal'; in this taxon, the frontal is only medial to the prefrontal, even though it extends past it with respect to the anterior level.
21. **Prefrontal, frontal (anterior extent)**: prefrontal terminating anterior to the anterior terminus of the frontal (0); terminating at same level as terminus (1); terminating posterior to terminus (2). – *ordered* [adapted from Schoch, 2013 – 39]
22. **Prefrontal-postfrontal**. sutured (0); separated by frontal (1). [Schoch, 2013 – 42]
23. **Prefrontal-jugal**: contact absent (0); contact present (1). [BJS – 12; adapted from McHugh, 2012]
24. **Frontal**: paired (0); fused (1) [GPM – 101; adapted from Huttenlocker et al., 2013]
25. **Frontal-nasal (suture)**. anterior to the orbit margin (0); level with margin (1); posterior to margin (2). [adapted from Schoch, 2013 – 32] - *ordered*
26. **Frontal, nasal (length)**: frontal as long or longer than nasal (0); shorter (1). [Schoch, 2013 – 31]
27. **Postfrontal contribution to orbital margin**: broad (0); reduced (1). [BJS – 13]
28. **Postorbital (lateral process)**: not wider than orbit (0); with substantial lateral process projecting into jugal (1). [Schoch, 2013 – 49]
29. **Postorbital, postfrontal**: shorter than supratemporal and parietal (0); as long or longer (1). [GPM 20; adapted from Schoch, 2013]
30. **Jugal (anterior margin)**: posterior to the anterior orbital margin (0); level with anterior orbital margin (1); anterior to anterior orbital margin (2). [BJS – 14; adapted from McHugh, 2012] - *ordered*
    a. State 1 and state 2 were reversed from the original character as they likely occur along a morphocline.
31. **Parietal (width relative to frontal)**: greater (0); less than or equal to (1). [Pardo et al., 2017 – 312]
32. **Parietal (length relative to frontal):** less than (0); greater than or equal to (1). [NEW].
33. **Parietal-supratemporal (suture)**: suture straight (0); suture angled (1) [BJS – 15]
34. **Parietal-postorbital**. contact absent (0); present (1). [Pardo et al., 2017 – 232]
35. **Parietal-tabular:** absent (0); present (1). [Pardo et al., 2017 – 234]
36. **Pineal foramen (position)**: within anterior half of the parietals (0); within posterior half of parietals (1). [NEW]
37. **Supratemporal (proportions)**: longer than wide (0); quadrangular (1). [Schoch, 2013 – 53]
38. **Squamosal (shape)**: (0) pentagonal; (1) sub-triangular. [NEW]
39. **Squamosal (falciform crest)**: posterior rim of squamosal straight (0); with convex projection, referred to as falciform crest (1). [GPM – 26; adapted from Schoch, 2013]
40. **Squamosal-tabular (dorsal)**: separated by supratemporal (0); sutured (1). [GPM – 25 ; adapted from Schoch, 2013]

41. **Quadratojugal-maxilla**: contact present (0); contact absent (1). [GPM – 28; adapted from Schoch, 2013]
42. **Quadrate-squamosal**: present (0); excluded by the quadratojugal (1). [BJS – 32; adapted from McHugh, 2012]
43. **Otic notch**: enclosed otic notch (0); semicircular embayment (1); straight transverse posterior skull margin without embayment between cheek and table (2). [adapted from Schoch, 2013 – 51] - *ordered*
44. **Otic notch (position)**: lateral, expanding along entire cheek to form continuous unornamented area up to quadrate (0); slit-like (1); small and rounded, confined to dorsomedial part of squamosal (2). [GPM – 21; adapted from Schoch 2013]
45. **Postparietal (proportions)**: longer than wide (0); wider than long (1). [adapted from Pardo et al., 2017 – 237]
46. **Tabular (horn)**: well-developed (0); moderately developed (1); or absent (2). [modified from BJS – 35 and GPM – 27; adapted from McHugh, 2012; Schoch, 2013]
47. **Tabular (laterally directed parotic flange)**: (0) absent, (1) present. [NEW]
48. **Occipital flange**: descending flange of occipital portion of postparietals forming a bulge (0); long smooth blades as long as the dermal portion of the postparietal (1). [GPM – 30; adapted from Schoch, 2013]
49. **Paraquadrate foramina (borders):** entirely within quadratojugal (0); framed by quadrate and quadratojugal (1); framed by squamosal and quadratojugal (2); framed by quadrate, squamosal, and quadratojugal (3). [NEW] - *unordered*
50. **Paraquadrate foramina**: absent (0); small circular opening with maximum diameter less than that of the exoccipital condyle (1); large oval opening with maximum diameter greater than that of the exoccipital condyle (2). [modified from BJS – 37 and GPM – 102; adapted from McHugh, 2012, and Hunt 1993] – *ordered*
    a. The revised version of this character omits any reference to which elements frame the opening to avoid a compound character; this is added in a new character (above).
51. **Posttemporal foramina (size)**: large opening, larger than foramen magnum (0); small round foramen (1); small polygonal foramen (2). [modified from BJS – 39; adapted from McHugh, 2012]
    a. This character was split into two characters (with the subsequent new character) to avoid the compound nature of both shape and size being included in a single character.
52. **Posttemporal foramina (shape):** circular (0); oval (1); polygonal (2). [NEW] - *unordered*
53. **Foramen magnum (proportions)**: dorsal portion dorsoventrally deeper (0); ventral portion dorsoventrally deeper (1); both portions equal in dorsoventral depth (2). [BJS – 41]
54. **Posteriorly projecting occiput**: absent (0); occiput partially exposed in dorsal view (1); occiput fully exposed, with foramen magnum largely visible in dorsal view. [BJS – 31; adapted from Hunt 1993] - *ordered*
55. **Skull (level of jaw articulation)**: quadrate trochlea posterior to tabular horns (0); at one level or anterior (1). [GPM – 29; Schoch, 2013]

56. **Quadrate and occipital condyles**: quadrate condyles posterior to occipital ones (0); or at same level (1); or well anterior (2). [GPM – 31; adapted from Yates & Warren, 2000; Schoch, 2013] - *ordered*
57. **Infraorbital sulcus:** straight or gently curved (0); step-like (1); Z-shaped (2). [modified from BJS – 16; adapted from McHugh 2012] - *unordered*
    a. A third state is added to capture the condition found in some capitosaurs.
58. **Supraorbital sulcus**: sulcus passes medial to lacrimal (0); sulcus enters lacrimal (1). *Koskinonodon perfectus*, *Apachesaurus gregorii* and *Callistomordax kugleri* are the only metoposauroid taxa in which the supraorbital sulcus passes medial to the lacrimal. [BJS – 17; adapted from McHugh, 2012]
59. **Postorbital sulcus:** does not terminate on the supratemporal (0), terminates on the supratemporal (1) [modified from CS – 7]
60. **Postorbital sulcus-posterior skull margin contact:** absent (0); present (1). [BJS – 18]
61. **Postorbital-infraorbital sulci:** sulci remain distinctly separated posteriorly (0), sulci merge together on the jugal (1). [CS – 8]
62. **Palate structure**: in occipital view, pterygoids either sloping continuously ventrolaterally or flat horizontal (0); vertically curved ventrally at right angle with basicranium (1). [Schoch, 2013]
63. **Choana (shape):** oval (0); circular (1). [adapted from Schoch, 2013 – 101]
64. **Maxilla-choana:** forming most of the lateral border of choanae (0); lateral processes of vomer and palatine approach one another so as to reduce the maxillary contribution (1); vomer-palatine suture lateral to the choanae excludes maxilla entirely (2). [Yates & Warren (2000: character 76)] - *ordered*
65. **Choana, interpterygoid vacuity:** posterior margin of choana is anterior to the anterior margin of the vacuity (0); posterior margin of choana is at or posterior to the anterior margin of the vacuity (1). [NEW]
66. **Anterior palatal opening(s)**. vomer and premaxilla with continuous suture (0); single perforation for symphyseal fangs (1); paired perforations for symphyseal fangs (2). [adapted from Schoch, 2013] - *unordered*
67. **Palatal tusks (cross-section)**: round or oval (0); laterally compressed and keeled at least on one side (1). [Schoch, 2013 – 80]
68. **Maxilla-vomer**: absent (0); present (1). [BJS – 20; adapted from McHugh, 2012]
69. **Vomer (denticles):** present (0) ; absent (1). [modified from GPM – 35; adapted from Schoch, 2013]
70. **Vomer (transvomerine tooth row)**: absent (0); present and transverse (1); V-shaped (2). [GPM – 36; adapted from Schoch, 2013] - *unordered*
71. **Vomer (parachoanal tooth row):** absent (0); present (1). [BJS – 21; adapted from McHugh, 2012]
72. **Palatine (denticles):** present (0); absent (1). [Pardo et al., 2017 – 252]
73. **Ectopterygoid (denticles):** present (0); absent (1). [NEW]
74. **Ectopterygoid (fangs)**: present (0); absent (1). (Yates & Warren 2000). [GPM – 38; Schoch, 2013 – 88]
75. **Jugal (ventral process)**: no ventral outgrowth (0); ventral outgrowth (insula jugalis) framing subtemporal window (1). [CS – 17]

    a. This can be a difficult feature to see in person let alone photos. If it was not explicitly stated to be present or absent by the author or from previous phylogenetic matrices, it was coded as unknown.
76. **Palatine, ectopterygoid (suture):** straight or very slightly convex (0); sinuous or markedly convex (1). [modified from Schoch, 2013 – 125]
77. **Pterygoid (denticles):** present (0); absent (1). [Pardo et al, 2017 – 249]
78. **Pterygoid (anterior sutures)**. Contacts both vomer and palatine (0); only contacts palatine (1); does not contact vomer or palatine (2). [adapted from Schoch, 2013 – 97] - *ordered*
79. **Pterygoid-exoccipital**. contact absent (0); present (1). [Schoch, 2013 – 118]
80. **Pterygoid, ectopterygoid**. palatine ramus exclusively formed by pterygoid (0); with posteromedial projection of ectopterygoid. [Schoch, 2013 – 123]
81. **Pterygoid (posterolateral flange)**: absent (0); present (1). [BJS – 23]
    a. The name of this character is modified as the transverse flange is only considered to be present in dissorophoids, in which it often forms a prominent projection with a right angle margin; in metoposaurids, the flange is much smaller.
82. **Pterygoid (palatine ramus)**: medial margin is curved, concave medially (0); margin is straight (1); margin is curved, convex medially (2). [BJS – 24] - *ordered*
    a. Modified character states to reflect difference in curvature of the palatine ramus of *Callistomordax* as convex medially as opposed to concave medially in relation to the other outgroups.
83. **Pterygoid (oblique crest/otic ridge)**: absent (0); present (1). [modified from BJS – 42; adapted from McHugh, 2012]
    a. Modified wording to be more specific
84. **Parasphenoid-pterygoid (suture)**: suture of the parasphenoid is not oblique (curved / straight) to the long axis of the skull (0); oblique to the long axis of the skull (1). [modified from CS – 53]
85. **Basicranium (suture)**. Suture much shorter than basal plate, reaching at best 40% its length (0); suture between 40% and 67% as long as the basal plate (1); suture almost as long as basal plate (2). [adapted from Schoch, 2013 – 107] - *ordered*
86. **Parasphenoid (ornamentation)**: absent (0); confined to basal plate (1); extends on the cultriform process (2). [BJS – 25] - *ordered*
87. **Parasphenoid (central depression)**: depression on ventral surface of basal plate is absent (0); depression is present (1). [BJS – 26; adapted from McHugh, 2012]
88. **Parasphenoid (shagreen)**: tooth patches present (0); teeth entirely absent (1). [GPM – 37; adapted from Yates & Warren, 2000; Schoch, 2013]
89. **Parasphenoid (plate, proportions)**. longer than wide (0); equant or slightly wider than long (1); much wider than long (2). [adapted from Schoch, 2013 – 110] - *ordered*
90. **Parasphenoid (cultriform process, shape)**: ventrally flat (0); with ridge emplaced on broader base (1); knife-edged and keel-shaped (2). [BJS – 29; adapted from McHugh, 2012]
91. **Parasphenoid (cultriform process, relative width)**: narrow (0); broad (1). [BJS – 27; adapted from McHugh, 2012]
92. **Parasphenoid (cultriform process, post-vomerine width)**: uniform width between base and posteriormost contact with vomers (0); continuously narrowing from base (1);

continuously broadening from base (2); constricted in medial third (3); constricted in posterior third (4). [BJS – 28; adapted from McHugh, 2012] - *unordered*

93. **Parasphenoid (cultriform process, anterior extent in ventral view):** terminates at or posterior to the level of the anterior margin of the interpterygoid vacuity (0); terminates anterior to this level (1). [NEW]
94. **Quadrate trochlea:** medial bulge only slightly larger than lateral one (0); much larger (1). [adapted from Schoch, 2013 – 135]
95. **Opisthotic**: ossified (0); unossified (1). [modified from BJS – 43]
96. **Sphenethmoid**: ossified (0); unossified (1). [modified from CS – 54; Anderson et al., 2008 – 114]
97. **Dentition (marginal)**: heterogenous, varying sizes and distances (0); homogeneous, small teeth, equidistant (1). [GPM – 32; adapted from Schoch & Milner, 2000; Schoch, 2013]
98. **Adsymphyseal teeth**: (0) absent, (1) present. [GPM – 66; adapted from Schoch, 2013]
99. **Middle coronoid**: denticles only (0); teeth only (1); edentulous (2). - *unordered*
    a. The original character (BJS – 44) referred to the presence or absence of coronoid teeth, which created partial dependencies with original characters 45 and 46 for the presence or absence of an anterior coronoid tooth row and a posterior coronoid tooth row (any taxon with a tooth row on at least one coronoid would have coronoid teeth). Therefore, all three were modified to differentiate types of dentition on individual coronoids.
100. **Anterior coronoid**: denticles only (0); teeth only (1); edentulous (2). [modified from BJS – 45] – *unordered*
    a. Modified following the modification to character 80 of this matrix.
101. **Posterior coronoid**: denticles only (0); teeth only (1); edentulous (2). [modified from BJS – 46] – *unordered*
    a. Modified following the modification to character 80 of this matrix.
102. **Prearticular (anterior extent)**: midpoint of middle coronoid (0); not anterior to posterior coronoid (1). [BJS – 47; adapted from McHugh, 2012]
103. **Prearticular (hamate process)**: absent (0); present and short (1); present and tall (2). [modified from BJS – 48; adapted from McHugh, 2012, and Schoch, 2013]
104. **Preglenoid process**: labial side of surangular with straight dorsal margin anterior to glenoid (0); with dorsally convex margin (1). [adapted from Schoch, 2013 – 144]
105. **Meckelian window (length)**: small round or oval opening (0); elongate window shorter than the adductor fossa (1); as long or longer than adductor fossa (2). [GPM – 65; Schoch, 2013] - *ordered*
106. **Meckelian window (borders)**: (0) bounded by the prearticular, postsplenial, and angular; (1) bounded by the prearticular and postsplenial; (2) bounded by the prearticular and angular; (3) bounded by the prearticular, postsplenial, middle coronoid and angular; (4) entirely enclosed by the postsplenial. [Adapted from Warren and Marsicano 2000; McHugh, 2012]. - *unordered*
107. **Splenial contribution to symphysis**: absent (0); present (1). [BJS – 49]
108. **Splenial-coronoids:** splenial contacts multiple coronoids dorsally (0); splenial contacts only first coronoid dorsally (1). [Pardo et al., 2017 – 310]
109. **Angular (extent in lateral view)**. posterior tooth row (0); middle of tooth row (1). [Pardo et al., 2017 – 270]

110. **Mandibular anterior ventral margin**: straight (0); concave (1). [BJS – 51]
111. **Mandibular tapering in height anteriorly**: absent (0); present (1). [BJS – 52]
112. **Postglenoid area**: short boss (0); distinct process (1); or extended, longer than glenoid facet (2). [Damiani, 2001; Schoch, 2008] - *ordered*
113. **Glenoid (position)**: above level of dorsal surface of dentary (0); at same level (1); below (2). [modified from Damiani, 2001; Schoch, 2008] - *ordered*
114. **Chorda tympanic foramen**: located on the suture between the articular and the prearticular (0); located on the prearticular alone (1); foramen absent (2); located on the suture between the surangular and the prearticular (3). [Yates & Warren, 2000 – 100] - *unordered*
115. **Presacral count.** more than 28 vertebrae (0); 23-28 (1); < 23 (2). [modified from Schoch, 2013 – 158] - *ordered*
116. **Atlas**: occipital surfaces separated (0); occipital surfaces contacting (1). [GPM – 110]
117. **Axial neural arch**: absent (0); present (1). [BJS – 53; adapted from Hunt 1993]
118. **Intercentrum (shape)**: presacral intercentra form simple wedges (0); dorsally closed discs (1); dorsally closed and elongated cylinders (2). (Yates & Warren 2000). [GPM – 74; adapted from Schoch, 2013] – *ordered*
119. **Trunk intercentrum (chordal canal):** thoroughgoing and wider than intercentrum is high (0); thoroughgoing and narrower than intercentrum is high (1); reduced to surficial perforation or entirely closed (2). [modified from Schoch, 2013 – 164] – *ordered*
    a. This character was modified to reflect that the notochordal canal in metoposaurid presacral intercentra is either entirely closed without any surficial expression or is restricted to a shallow perforation; the only exception is *Apachesaurus*, which has a thoroughgoing canal.
120. **Intercentrum (ventral surface)**: ventral surface shorter than wide in ventral view, giving transversely rectangular outline (0); as long as wide, quadrangular (1). [Schoch, 2013 – 165]
121. **Intercentrum (anterior surface)**: always concave (0); or convex at least in some presacral centra (1). [Schoch, 2013 – 166]
122. **Ossified pleurocentra in posterior trunk vertebrae**: present (0); absent (1). [BJS – 54; adapted from Hunt, 1993]
123. **Neural spine (height)**: low throughout vertebral column (0); dorsally extended in posterior portion of trunk or tail (1). [BJS – 56; adapted from Schoch 2008]
124. **Procoelous third vertebra**: absent (0); present (1). *Dutuitosaurus ouazzoui* is the only metoposaurid with a procoelous third vertebra. [BJS – 58; adapted from McHugh, 2012]
125. **Parapophysis**: segmental (0); intersegmental (1). [GPM – 78; adapted from Warren & Snell, 1991; Schoch, 2013]
126. **Ribs (uncinate processes)**: absent (0); uncinate plate (1); uncinate process (2). [modified from BJS – 60; adapted from McHugh, 2012]
    a. changed the grammar slightly
127. **Clavicles (contact)**: absent (0); reduced to anterior part of pectoral girdle (1); prolonged contact (2). [BJS – 61; adapted from McHugh, 2012] - *ordered*

128. **Clavicle (ornamentation)**: reticulate ornamentation confined to small region and with broader arc of radiating grooves (0); reticulate ornamentation forms large portion of posterolateral surface with narrower arc of radiating grooves (1). [GPM: 106; adapted from Hunt, 1993]
    a. This character is similar to the multistate character of BJS (62), but we opted for the binary character here because the distinction between 'intermediate' and 'large' areas of reticulate ornamentation seemed arbitrary as scored.
129. **Clavicle (sensory groove):** absent (0); present along posterolateral margin of ventral surface (1). [GPM – 105]
130. **Interclavicle (proportions):** as long as it is wide (0); 1.3 times as long as wide (1); more than twice as long as wide (2). [Schoch, 2013 – 182] - *ordered*
131. **Interclavicle (relative size of reticulate ornamentation)**: large, equal to or greater than half the total width of the ornamented surface (0); small, less than half the total width of the ornamented surface (1). [GPM – 107]
132. **Interclavicle (anterior termination of ornamented region)**: rounded (0); tapering to a triangular point (1). [GPM – 108]
133. **Humerus (supinator)**: discrete projection offset from ectepicondyle (0); process largely confluent with ectepicondyle (1); process absent (2). (Yates & Warren 2000). [modified from GPM – 88]
134. **Humerus (torsion)**: strong, 70-90° (0); weak, well below 60° (1). [GPM – 90; adapted from Witzmann & Schoch, 2006a; Schoch, 2013]
135. **Ilium (shaft, orientation):** posterodorsally inclined (0); vertically oriented (1). [Schoch, 2013 – 201]
136. **Ilium (shaft, length)**: shaft of variable length but laterally flattened (0); very long and slender (1). [GPM – 92; adapted from Schoch, 2013 – 198]
137. **Ilium (anterior margin of dorsal shaft)**: straight (0); concave (1); convex with flexure at the mid-height (2). (modified from BJS – 63 and GPM – 109; adapted from Schoch 2008)
138. **Pubis**: unossified (0); ossified (1). [Schoch, 2013 – 203]
139. **Femur (trochanter)**: internal trochanter present as discrete process offset from shaft (0); continuously confluent with shaft (1). [GPM – 95; adapted from Schoch, 2013]

Omitted characters

In designing our own matrix, we intentionally opted not to use several characters from Buffa, Jalil & Steyer (BJS) and Gee, Parker & Marsh (GPM). These are outlined below, with the rationale for their omission.

The following characters from BJS served only to differentiate metoposaurids from other temnospondyls (*Trimerorhachis*, *Eryops*, *Rhineceps* in their analysis) and may be parsimony-uninformative depending on the outgroup selection, which varies across all metoposaurid studies including this one:

- **Shape of orbits**: round (0); oval (1). [BJS – 2]
- **External nares orientation**: opened to lateral view (0); opened to anterior or dorsal view (1). [BJS – 3; adapted from McHugh, 2012]
- **Pterygoid ventral ornamentation**: absent (0); present (1). [BJS – 22; adapted from McHugh, 2012]

- **Quadrate visible in dorsal view**: present (0); absent (1). [BJS – 33; adapted from McHugh, 2012]

The following characters are considered to be problematic or parsimony-uninformative once scores are adjusted:

- **Skull roof (ornamentation)**: honeycomb pattern of pits (0); pits and elongated ridges in growth zones (1). [BJS – 1; adapted from McHugh, 2012]
    - *Rationale:* This character was derived from a six-state character of McHugh (2012) and reduced to two by Buffa, Jalil & Steyer. While the latter authors characterized the ornamentation of *Arganasaurus azerouali* as consisting only of deep pitting, an apomorphic condition among metoposaurids, there appear to be a few elongate grooves around the frontal-parietal suture and the anteriormost extent of the supratemporal in the holotype. Additionally, the regions where elongate grooves are often found in metoposaurids (e.g., squamosal, posteriormost region of the postorbital) are poorly preserved in this specimen. One of the referred specimens (fig. 2C therein) clearly exhibits elongate grooves on the squamosal. The original scoring listed only *A. azerouali* and *Rhineceps nyasaensis* as having state 0, but *R. nyasaensis* genuinely has evenly distribution of circular pits without any grooves (e.g., Watson, 1962; Schoch & Milner, 2000; Marsicano et al., 2017), not merely relatively reduced grooves as in *A. azerouali* (McHugh also differentiated these two taxa in her scoring). Therefore, we do not consider *A. azerouali* to meet the criterion of state 0 in this character's binary state, and it would be parsimony-uninformative as a result.
- **Septomaxilla**: present (0); absent (1). [BJS – 4; adapted from McHugh, 2012]
    - *Rationale:* While septomaxilla do have phylogenetic utility among temnospondyls (e.g., Schoch, 2012, 2013), they are particularly hard to identify in large stereospondyls because they are an intranarial ossification that is probably very thin, susceptible to taphonomic loss, and difficult to differentiate when preserved (e.g., Chakravorti & Sengupta, 2018). The scores of BJS indicate that this element is only present in *Anaschisma browni*, "*Metoposaurus*" *bakeri*, and *Panthasaurus maleriensis*, although it is unclear how the first two were characterized as a septomaxilla has never been reported in the literature for these taxa. However, Chakravorti & Sengupta (2018) also reported personal observations of the element in *Metoposaurus krasiejowensis* and *Dutuitosaurus ouazzoui* (the latter also personally examined by BJS). The only clear figure of a purported metoposaurid septomaxilla is in one specimen of *P. maleriensis* by Chowdhury (1965:fig. 3), who probably misidentified a bone of the skull roof, probably a fractured part of the nasal, since the putative septomaxilla is ornamented (common in early diverging stereospondyls but not in later diverging ones like trematosaurs). Given the uncertainty regarding identification of the element, the general inadequacy of existing figures to independently assess the presence or absence of the element, and the potential for the element to be dislodged and lost during preservation, we exclude it from this analysis.
- **Maxilla-nasal suture: absent (0); present (1).** [BJS – 5 Adapted from McHugh, 2012]
    - *Rationale:* This character is redundant with character 10 (lacrimal-nares) in typical taxon samples for metoposaurid studies. There are essentially only two

ways in which the lacrimal can be excluded from the naris: by a maxilla-nasal contact or by the dorsal expression of a septomaxilla. The latter is mostly confined to early diverging stereospondyls, and while it occurs in some rhinesuchids, is not found in the one sampled in their matrix, *Rhinceps nyasaensis* (Marsicano et al., 2017), so in the taxon sample of BJS, if the maxilla does not contact the nasal, then the lacrimal will always contact the naris. This is verified by the identical scoring for these two characters.

- **Exoccipital process**: absent (0); present but not visible in dorsal view (1); present and visible in dorsal view (2). [BJS – 36; adapted from McHugh, 2012]
    - *Rationale*: the original character was defined as the 'paroccipital process' by McHugh, so it is inferred that the renaming by BJS is interpreted to mean specifically the portion of the process that is formed by the exoccipital since a dorsal exposure of this region would require it to be slanted, thereby creating the 'sloped occiput' that diagnoses *Arganasaurus*. Note however that McHugh's figure showing the character state (fig. A10 therein) is only in occipital view and points to the tabular portion of the paroccipital process (this portion is more often referred to as the 'parotic process' in metoposaurids; e.g., Sulej, 2007; Brusatte et al., 2015; Kufner & Gee, 2021). This ambiguity might account for the range of scores across Metoposauridae in her analysis: 0 (*Anaschisma browni, Apachesaurus gregorii*, *Ar. lyazidi*, *Buettnererpeton bakeri*, *Dutuitosaurus ouazzoui*); 2 (*Ar. azerouali*), but it is worth noting that all metoposaurids have a paroccipital contribution by the tabular (contra most of these scores), even if it is shorter than the exemplar she used to illustrate the character (*Eocyclotosaurus wellesi*).

      We were not able to discern the difference between *Arganasaurus* and most other metoposaurids regardless of which part of the process is being considered. Especially if treated as only the exoccipital's contribution (the basal portion), any specimen in which there is a lateral projection from the exoccipital in dorsal view meets the criterion for state 2 (scored as a synapomorphy of *Arganasaurus* by BJS). Such a condition is observed in *Anaschisma browni* (e.g., Sawin, 1945:fig. 3; Lucas et al., 2016:fig. 29A, 29C, 29E), *Buettnererpeton bakeri* (as verified here but also evident in Case, 1932:pl. 2.1), *Metoposaurus algarvensis* (Brusatte et al., 2015:fig. 2), *Metoposaurus krasiejowensis* (e.g., Sulej, 2007:figs. 5–8), and perhaps in *Panthasaurus maleriensis* (Chakravorti & Sengupta, 2018:fig. 3, but see Sengupta, 2002:figs. 1, 4). Most specimens of *Ar. lyazidi* appear to lack exoccipitals at all, and it is not apparent from Dutuit's (1976) figures that they share a condition with *Ar. azerouali* (this would not preclude personal observation by BJS from verifying this). The only taxon in which this process is present but definitively obscured in dorsal view is *Apachesaurus gregorii*. It is possible that BJS differentiate the purported condition of *Arganasaurus* by whether the posttemporal foramen/fenestra is also visible in dorsal view (it is visible in *Ar. azerouali*), but the character would then need to be reformulated. Because of the uncertainty in scoring this character, as well as the possibility for taphonomic distortion to push the exoccipitals out posteriorly (e.g., Gee & Jasinski, 2021), we elect not to use this character in our analysis.

- **Paraquadrate accessory foramen**: absent (0); present (1). [BJS – 38]
    - *Rationale*: this feature was not identified in a metoposaurid until Sulej (2007). In *Metoposaurus krasiejowensis*, the foramen is very narrowly separated from the paraquadrate foramen by a minute lamina that could easily be lost during preservation or preparation. Although identified in *Apachesaurus gregorii* by Spielmann & Lucas (2012), in this taxon, it is a shallow fossa at the ventrolateral edge of the paraquadrate foramen, not an actual foramen itself, questioning the homology of these features. We consider it highly likely that the dividing lamina could have been lost in many historic specimens and that it should not be scored for taxa described only from material discovered prior to 2007 (all metoposaurids other than *Metoposaurus algarvensis* at present) – for this reason, we err on the side of caution and omit this character.
- **Foramen magnum shape**: subtriangular (0); keyhole-shaped (1). [BJS – 40]
    - *Rationale*: this feature has been previously addressed by Gee & Parker (2018:appendix 1). A triangular foramen is purported to be diagnostic for *Apachesaurus gregorii* (Spielmann & Lucas, 2012), but there are several lines of evidence to indicate that this is a taphonomic artifact. These include: (1) clear disturbance of the postparietals in the holotype of *A. gregorii*; (2) marked asymmetry of the foramen; (3) medial convexity on the left side that mirrors the margin seen in other metoposaurids with a keyhole-shaped foramen; and (4) presence of non-divided, triangular foramina in clearly distorted specimens of other taxa (see Gee & Parker, 2018:appendix 1 for references; also Gee, Parker, & Marsh, 2019). Spielman & Lucas (2012:fig. 16) also cite a partial skull of *A. gregorii* as having a triangular foramen magnum, but this specimen clear has a partially subdivided foramen, even if not to the degree observed in other metoposaurids.
- **Posterior Meckelian fenestra shape**: round (0); elongate (1); subtriangular (2). [BJS – 50].
    - *Rationale:* This feature is undoubtedly a valid distinction among temnospondyls, but the fenestra is frequently damaged or distorted, even in otherwise undistorted hemimandibles, such that it becomes very difficult to discern the genuine condition. BJS scored non-metoposaurids for state 0 and all metoposaurids other than *Arganasaurus azerouali* for either state 1 or '?' However, their single figure of a hemimandible shows a clearly distorted, subdivided fenestra (in an otherwise undistorted hemimandible), which is not exactly 'subtriangular' and almost certainly not biological. Other examples of taphonomic variation include *Metoposaurus krasiejowensis* (Sulej, 2007:fig. 21) and *Anaschisma browni* (Lucas et al., 2016:figs. 35–36); note that in the latter, at least one specimen has a 'reverse' subtriangular fenestra in which it is tallest anteriorly, not posteriorly. We prefer to err on the side of caution and therefore exclude this to avoid introducing extensive taphonomic variation in our analysis.
- **Ossified pleurocentra in posterior trunk vertebrae**: present (0); absent (1). [BJS – 54; adapted from Hunt, 1993]
    - *Rationale:* Dutuit (1972) reported ossified pleurocentra in a specimen of *Dutuitosaurus ouazzoui*, the only metoposaurid in which this has ever been reported; consequently, the presence of pleurocentra has been repeatedly used in

diagnoses of this taxon (e.g., Hunt, 1993; Schoch & Milner, 2000). As an early appearing taxon, it might be expected that *D. ouazzoui* captures the transition from trematosaurs with pleurocentra to metoposaurids without. However, as has been pointed out by Sulej (2007:118), Dutuit only reported two pairs of pleurocentra in a single specimen (though Dutuit's plate XIX appears to depict at least two specimens with pleurocentra, one with a neural arch and one without), even though there are dozens of individuals represented from the type locality. Sulej interpreted this as evidence of a pathological condition and considering that *D. ouazzoui* is known from many articulated skeletons, more definitive evidence for pleurocentra would be expected. Pleurocentra are, however, not apparent in Dutuit's (1976) figures of articulated skeletons (pls. 31–34). Dutuit's (1972) observation that pleurocentra were absent from the first six positions, found throughout the remainder of the presacral region, and absent from the tail is highly abnormal. However, it appears to be substantiated by his figuring of the anteriormost positions (pl. 19C-D in Dutuit, 1976) and perhaps by a trio of articulated presacral positions (pl. 19I). While the failure to ossify pleurocentra certainly could have proceeded in a gradual fashion rather than all at once, there is no precedent for pleurocentra to ossify only in the middle part of the axial column. The peculiar regionalization and scarce documentation of the pleurocentra is sufficient in our opinion to question whether this was a normal ossification, and we consider it best to either leave the condition as unknown or as polymorphic in this taxon until this issue is more clearly resolved. Since pleurocentra are clearly absent from the anteriormost and posteriormost regions, it would be misleading to homologize this with taxa in which pleurocentra occur throughout the trunk (scoring it as 'ossified' merely because at least one position had ossified pleurocentra) in the same way as scoring it as 'unossified' because at least one position lacks ossified pleurocentra is also misleading.

  - We still included this character in our analysis, but the issue requires future redress and would benefit from a redescription of *Dutuitosaurus ouazzoui*, admittedly a very daunting task in light of the amount of known material.

- **Dorsal notochordal incision on caudal intercentra:** (0) open dorsally, forming wedge- or U-shaped anterior profile; (1) closed, forming circular anterior profile. [GPM – 112]
  - **= Caudal intercentra deeply notched**: present (0); absent (1). *Dutuitosaurus ouazzoui* is the only metoposaurid with deeply notched caudal intercentra. [BJS – 57; adapted from Hunt 1993]

  a. *Rationale:* Articulated caudal series are only known from *Metoposaurus krasiejowensis* and *Dutuitosaurus ouazzoui*. The former exhibits unnotched intercentra in the anterior caudal region and notched intercentra in the posterior caudal region (the latter is contrary to the scoring by Buffa, Jalil & Steyer, who stated this feature is only found in *D. ouazzoui*). Isolated caudal intercentra have been reported in *Anaschisma browni* (Sawin, 1945; Lucas et al., 2016), *Panthasaurus maleriensis* (Chowdhury, 1965; Sengupta, 2002), and *Apachesaurus gregorii* (Spielmann & Lucas, 2012; Rinehart & Lucas, 2018). None of these taxa exhibit notched intercentra, but none were specified to a particular region of the tail, and many have parapophyses (indicating a position

closer to the sacrum). For this reason, we consider it unreliable to score any taxa for which only isolated intercentra are known, as ontogeny and axial position may confound purported taxonomy.

Comparison of characters between analyses

Table S1. Correlation of phylogenetic characters across different metoposaurid analyses. Correlation is established by the overall aspect of the character and may be only partially equivalent in some instances where character state definitions and number of states differ. Character names are truncated for space constraints. Abbreviations: BJS-19, Buffa, Jalil & Steyer (2019); CS-18, Chakravorti & Sengupta (2018); GPM-19, Gee, Parker & Marsh (2019).

CS-18	BJS-19	GPM-19	this study	Character
			1	Skull length
		4	2	Preorbital length
3		11	3	Orbit (location on roof)
	30		4	Orbit (longitudinal position)
			5	Ornamentation (prepineal region)
			6	Lateral line sulci
			7	Premaxilla (tooth count)
			8	Maxilla (tooth count)
		5	9	Premaxilla (alary process)
			10	Premaxilla (mandibular apertures)
11	6	100	11	Maxilla-orbit
			12	Nasal (width)
			13	Lacrimal
	7		14	Lacrimal-nasal
	8		15	Lacrimal (length)
9	9	99	16	Lacrimal-orbit
10	10	98	17	Lacrimal-naris
			18	LEP
		16	19	Prefrontal (anterior end)
	11	19	20	Prefrontal (anterior contacts)
			21	Prefrontal, frontal (anterior extent)
			22	Prefrontal-postfrontal
	12	18	23	Prefrontal-jugal
		101	24	Frontal
			25	Frontal-nasal (suture)
			26	Frontal, nasal (length)
	13		27	Postfrontal-orbit
			28	Postorbital (lateral process)

		20	29	Postorbital, postfrontal
	14	23	30	Jugal (anterior margin)
			31	Parietal (width)
			32	Parietal (length)
	15		33	Parietal-supratemporal
			34	Parietal-postorbital
			35	Parietal-tabular
			36	Pineal foramen (position)
			37	Supratemporal (proportions)
			38	Squamosal (shape)
	34	26	39	Squamosal (falciform crest)
		25	40	Squamosal-tabular
		28	41	Quadratojugal-maxilla
	32		42	Quadrate-squamosal
14			43	Otic notch (presence/absence)
		21	44	Otic notch (position)
			45	Postparietal (proportions)
4	35	27	46	Tabular (horn)
			47	Tabular (parotic process)
		30	48	Occipital flange
			49	Paraquadrate foramina (borders)
	37	102	50	Paraquadrate foramina
	39		51	Posttemporal foramina (size)
			52	Posttemporal foramina (shape)
	41		53	Foramen magnum
	31	29	54	Occiput
		29	55	Level of jaw articulation
		31	56	Quadrate/occipital condyles
5	16	14	57	Infraorbital sulci
6	17	15	58	Supraorbital sulcus
7			59	Postorbital sulcus (termination)
	18		60	Postorbital sulcus-posterior margin
8			61	Postorbital-infraorbital sulci
			62	Palate structure
			63	Choana (shape)
			64	Maxilla-choana
			65	Choana, interpterygoid vacuity
			66	Anterior palatal opening(s)
			67	Palatal tusks (cross-section)
	20		68	Maxilla-vomer

	19	35	69	Vomer (dentition)
		36	70	Vomer (transvomerine tooth row)
59	21		71	Vomer (parachoanal tooth row)
			72	Palatine (denticles)
			73	Ectopterygoid (denticles)
17		38	74	Ectopterygoid (fangs)
	23	22	75	Jugal (ventral process)
			76	Palatine, ectopterygoid (suture)
			77	Pterygoid (denticles)
			78	Pterygoid (anterior sutures)
			79	Pterygoid-exoccipital
			80	Pterygoid, ectopterygoid
	24		81	Pterygoid (posteromedial flange)
53			82	Pterygoid (palatine ramus)
	42		83	Pterygoid (oblique crest/otic ridge)
	25		84	Parasphenoid-pterygoid (suture)
			85	Basicranium (suture)
57	26	104	86	Parasphenoid (ornamentation)
58			87	Paraspehnoid (central depression)
	29	37	88	Parasphenoid (shagreen)
			89	Parasphenoid (plate, proportions)
61	27	51	90	Parasphenoid (cultriform process shape)
60	28	50	91	Parasphenoid (cultriform process relative width)
2			92	Parasphenoid (cultriform process width profile)
			93	Parasphenoid (cultriform process, anterior extent)
			94	Quadrate trochlea
55	43		95	Opisthotic
54		103	96	Sphenethmoid
		32	97	Marginal dentition
		66	98	Adsymphyseal teeth
	44		99	Middle coronoid (teeth)
	45	68	100	Anterior coronoid (teeth)
	46	67	101	Posterior coronoid teeth
	47		102	Prearticular (anterior extent)
	48	63	103	Prearticular (hamate process)
			104	Preglenoid process
	50	65	105	Meckelian window (length)
			106	Meckelian window (borders)

49		107	Splenial-symphysis
		108	Splenial-coronoids
		109	Angular (extent in lateral view)
51		110	Mandible (anteroventral margin)
52		111	Mandible (anterior height)
		112	Postglenoid area
		113	Glenoid (position)
		114	Chorda tympanic foramen
		115	Presacral count
	110	116	Atlas
53	111	117	Axis
69	74	118	Intercentrum (shape)
		119	Trunk intercentrum (chordal canal)
		120	Intercentrum (ventral surface)
		121	Intercentrum (anterior surface)
54		122	Pleurocentra
56	73	123	Neural spine
58		124	3rd vertebra
	78	125	Parapophysis
60	80	126	Ribs (uncinate processes)
61	86	127	Clavicle (contact)
62	106	128	Clavicle (ornamentation)
	105	129	Clavicle (sensory groove)
		130	Interclavicle (proportions)
	107	131	Interclavicle (reticulate ornamentation size)
	108	132	Interclavicle (reticulate ornamentation termination)
	88	133	Humerus (supinator)
	90	134	Humerus (torsion)
		135	Ilium (shaft, orientation)
	92	136	Ilium (shaft, length)
63	109	137	Ilium (anterior margin of shaft)
		138	Pubis
	95	139	Femur (trochanter)

Appendix 2. NEXUS file with this study’s character-taxon matrix

Refer to the online version of the manuscript for this file.

Appendix 3. Modifications made to the original matrix of Buffa, Jalil & Steyer (2019)

As noted in the main text, one of our motivations was to assess possible explanations for the topological disparity (mainly resolution versus a lack of resolution) among the three previous computer-assisted phylogenetic analyses (Chakravorti & Sengupta, 2018; Buffa, Jalil, & Steyer, 2019; Gee, Parker, & Marsh, 2019). Chakravorti & Sengupta's matrix consists of 61 characters, but 35 of those are discretized from continuous data that are specific to their sample with states derived from a cluster analysis (i.e., a different or expanded sample could produce different state thresholds or different numbers of states). Therefore, the main comparison to be made is between Buffa, Jalil & Steyer's matrix, which recovered nearly full resolution within Metoposauridae, and Gee, Parker & Marsh's matrix, which recovered none. Since one of us (BMG) authored the latter study, it made sense to examine the matrix of Buffa, Jalil & Steyer for comparison. In doing so, we identified several scores that we consider to be unequivocal errors, as well as a few problematic characters that Gee, Parker & Marsh did not use for various reasons. Separate from character ordering, we believe that a relatively small number of cells that we consider erroneous (either miscodings or overly simplified scores that do not account for polymorphism) can explain the vastly different topologies. The following appendix outlines the changes made to Buffa, Jalil & Steyer's matrix that were used in the reanalysis.

Since we already had our own modified and rescored matrix, the changes made here were made only for scores that we considered highly dubious or unequivocally erroneous (i.e. we attempted to make as few changes, especially regarding character deletion, as possible). There are therefore some discrepancies in scores for equivalent cells where we felt that the condition was ambiguous but leaned more conservatively than Buffa, Jalil & Steyer in often opting to score a feature as unknown (e.g., whether the fossae interpreted as 'accessory paraquadrate foramina' in *Apachesaurus gregorii* are homologous with the real foramina first identified as such in *Metoposaurus krasiejowensis* or whether a reduced clavicular contact can be inferred from the single articulated girdle of *Arganasaurus azerouali* when the three elements are incomplete anteriorly). There are also some scores that we are skeptical of (e.g., whether the ilium of *Metoposaurus diagnosticus* is known, as most of the non-pectoral postcrania has not been redescribed since Fraas, 1889, whose articulated skeleton clearly does not preserve the pelvis, and referred specimen listings by Schoch & Milner, 2000; Sulej, 2002; Milner & Schoch, 2004, suggest that no specimen preserves the ilium), but we have provisionally retained these scores for taxa only described in dated literature since personal observations made subsequent to those studies could account for the scores. The rescoring also does not incorporate any novel data published subsequent to Buffa, Jalil & Steyer (first online June 03, 2019), including that of *Buettnererpeton bakeri* (e.g., the scoring of this taxon as having a splenial reaching the symphysis, a condition invalidated in our study, was not corrected).

Character ordering

Buffa, Jalil & Steyer (BJS) left all characters unordered and equally weighted. As discussed in the main text, we prefer to order characters that can be reasonably inferred to occur along a morphocline. The following multi-state characters from BJS were therefore ordered (**numbering in bold** from the original study):

- (**9**) Lacrimal-orbital margin contact: absent (0); narrow contact (1); broad contact (2).
- (**14**) Jugal anterior margin: posterior to the anterior orbital margin (0); at same level as anterior orbital margin (1); anterior to the anterior orbital margin (2).
    - The three states were originally ordered as "anterior to orbital margin," "posterior to margin," and "at margin"; these could be reasonably reconfigured to form a morphocline that could then be ordered by switching states 1 and 2, which was applied in our own matrix and in the revised version of Buffa, Jalil & Steyer's matrix here.
- (**25**) Parasphenoid ornamentation: absent (0); confined to basal plate (1); extends on the cultriform process (2).
- (**30**) Orbits in interpterygoid fenestrae: posterior (0); second anterior quarter of interpterygoid fenestrae (1); anterior quarter of interpterygoid fenestrae (2).
- (**36**) Exoccipital process: absent (0); present but not visible in dorsal view (1); present and visible in dorsal view (2).
- (**37**) Paraquadrate fenestra: absent (0); small fenestra (1); elongate fenestra (2).
- (**61**) Clavicular contact: absent (0); reduced to anterior part of pectoral girdle (1); prolonged contact (2).
- (**62**) Clavicular ornamentation: large pitted zone in ossification centers (0); intermediate pits zone in ossification centers (1); reduced pits zone in ossification centers (2).

The following multi-state characters from BJS were <u>not ordered</u>:

- (**11**) Prefrontal anterior contact: nasal and lacrimal (0); nasal and maxilla (1); frontal and lacrimal (2).
- (**28**) Cultriform process narrowing: uniform width (0); thinner medial third (1); thinner posterior third (2).
- (**39**) Posttemporal fenestrae: large opening, larger than foramen magnum (0); small round foramen (1); small polygonal foramen (2).
- (**41**) Foramen magnum proportions: dorsal portion dorsoventrally deeper (0); ventral portion dorsoventrally deeper (1); both portions equal in dorsoventral depth (2)
- (**50**) Posterior Meckelian fenestra shape: round (0); elongate (1); subtriangular (2).
- (**59**) Intercentra: crescent-shaped (0); disc-shaped (1); spool-shaped (2).
    - Note that it does not matter whether this character is ordered because no taxon is scored for state 2 in the original matrix or in our revised version of it.
- (**60**) Ribs uncinated processes: absent (0); uncinate plate (1); uncinate process (2).

Scoring changes

Character-level changes

The following character changes relate to partial or full dependencies. To avoid ambiguity, several terms are defined here using an example of two binary characters.

Original character 5 referred to the presence or absence of a maxilla-nasal suture (0 = absence; 1 = presence). Original character 10 referred to the presence or absence of a lacrimal-naris contact (0 = presence; 1 = absence). When the maxilla and nasal contact, they do so posterior to the naris; this contact will always exclude the lacrimal from the naris. In other words, any taxon scored for state 5–1 will always be scored for state 10–0 (among temnospondyls that have a lacrimal). This could be written as "5–1 → 10–0" and establishes the presence of at least a

partial dependency – one state predicts another and is redundant with it. A **full dependency** exists if the same predictive/redundant relationship exists between the other two states, which we term here the '**inverse**' relationship; in this case, does 5–0 → 10–1? Here, the inverse is not valid, and there is no full dependency, because the maxilla-nasal contact is not the only configuration in temnospondyls that can exclude the lacrimal from the naris – many taxa (e.g., lydekkerinids and rhinesuchids) have an ornamented dorsal exposure of the septomaxilla that excludes the lacrimal. When a full dependency exists, one of the characters must be excluded.

The most common way of addressing partial dependencies is to score taxa as inapplicable for one of the two characters, otherwise a single condition is inadvertently overweighted. Which character should be scored as inapplicable is not random. In this example, one must consider what we term the '**reverse**' condition is valid; state 5–1 →10–0, but does state 10–0 → 5–1? Here, the reverse is valid, which means that either character could be validly treated as inapplicable for the relevant taxa. As will be shown below, the reverse is not always true, which then determines the treatment.

- **5 (maxilla-nasal suture); 10 (lacrimal-nares)**: this example has been covered above. It should be noted that the inverse (does the separation of the lacrimal from the nasal predict a maxilla-nasal suture) is not valid across Temnospondyli because the septomaxilla can also contribute to separation, but the inverse is valid in this taxon sample, creating a full dependency that is verified by the identical scoring for these characters (5–0 is always paired with 10–1, and 5–1 is always paired with 10–0).
  - Character 5 was omitted from the reanalysis.
- **6 (maxilla-orbit); 12 (prefrontal-jugal)**: if there is a prefrontal-jugal contact (12–1), the maxilla will not enter the orbit (6–0) because the maxilla can only enter laterally. Indeed, the three taxa scored for 12–1 were scored for 6–0 (*Arganasaurus azerouali*, *Dutuitosaurus*, *Almasaurus*). The reverse is not valid (6–0 → 12–1), as the maxilla may be excluded by a lacrimal-jugal contact in which the lacrimal also contacts the orbit and thereby separates the prefrontal and jugal. The inverse of the original (12–0 → 6–1) is also not valid, resulting in only a partial dependency; not all taxa without a prefrontal-jugal contact have a maxilla entering the orbit (the separation may be created by the lacrimal entering the orbit). However, the reverse of this relationship is valid (6–1 → 12–0).
  - Based on the unidirectional nature of the partial dependency, taxa scored for 12–1 should be scored as inapplicable for character 6 <u>and</u> taxa scored for 6–1 should be scored as inapplicable for character 12.
- **7 (lacrimal-nasal); 10 (lacrimal-naris)**: if the lacrimal reaches the naris, it will contact the nasal (10–0 → 7–1); there is no temnospondyl in which the prefrontal extends to enter the naris to separate the nasal from the lacrimal at the posterior narial margin. Indeed, the three taxa scored for a lacrimal-naris contact (10–0) have a lacrimal-nasal contact (7–1). The reverse (7–1 → 10–0) is not valid; a taxon can have a lacrimal-nasal contact but without the lacrimal reaching the naris. The inverse (10–1 → 7–0) is also not valid; a lacrimal that does not reach the naris might still contact the nasal, but the reverse of this relationship (7–0 → 10–1) is valid, as any taxon without a lacrimal-nasal contact will not have a lacrimal reaching the naris.
  - The three taxa originally scored for 10–0 were rescored as inapplicable for character 7. The three taxa originally scored for 7–0 were rescored as inapplicable for character 10.

- **8 (lacrimal, shape); 10 (lacrimal-naris)**: because the 'shape' of the lacrimal is really the relative length, any taxon with a compact lacrimal (8–0) will not have a lacrimal-naris contact (10–1) by definition of the former, in which state 0 is a lacrimal less than half the distance between the naris and the orbit; indeed, five of six taxa scored for 8–0 were scored for 10–1. The exception, *Buettnererpeton bakeri*, should be treated as having a compact lacrimal based on the literature (Case, 1931, 1932), a condition that is verified by this study. There are a few temnospondyls in which a short lacrimal does enter the naris (e.g., the dvinosaur *Acroplous vorax*; Englehorn et al., 2008), but they are not sampled here, and the use of the naris-orbit distance as the reference point means that this would beconsidered an 'elongate' lacrimal. The reverse (10–1 → 8–0) is not valid; the absence of a lacrimal-naris contact does not mean that the lacrimal is short (e.g., *Panthasaurus maleriensis*). The inverse (8–1 → 10–0) is also not true; an 'elongate' lacrimal does not ensure a lacrimal-naris contact, but the reverse of this relationship (10–0 → 8–1) is valid, although only for this taxon sample (see above comment on *A. vorax*).
    - The six taxa originally scored for 8–0 were rescored as inapplicable for character 10. The three taxa originally scored for 10–0 were rescored as inapplicable for character 8.
- **9 (lacrimal-orbit); 12 (prefrontal-jugal)**: if there is a prefrontal-jugal contact (12–1), it must occur along the anterolateral side of the orbit, which will always exclude the lacrimal from the orbit (9–0); indeed, the five taxa scored for 12–1 were scored for 9–0 (*Koskinonodon bakeri*, *Apachesaurus*, *Arganasaurus lyazidi*, *Rhineceps*, and *Eryops*). The reverse (9–0 → 12–1) is only true in this taxon sample; the lacrimal can be separated from the orbit by a lateral exposure of the palatine, which also separates the prefrontal and jugal, in other temnospondyls (mainly dissorophoids). Character 9 has three states, so there is no direct inverse; state 12–0 can lead to either 9–1 or 9–2, so there is only a partial dependency.
    - The five taxa originally scored for 12–1 were rescored as inapplicable for character 9. Even though the reverse dependency is valid, it only holds for a matrix where the LEP is not sampled; the approach taken here is resilient to any taxon or character additions (e.g., a taxon with an LEP that separates the prefrontal from the jugal and possibly the lacrimal from the orbit).
- **44 (coronoid teeth); 45 (anterior coronoid tooth row); 46 (posterior coronoid tooth row):** the ambiguity in these characters stem from the operational definition of 'teeth'; some workers will use this to refer to dentition of a sub-equal size to the marginal teeth; this occurs in the posterior coronoid of some capitosaurs, for example. Other workers may treat 'teeth' as any form of dentition, which appears to be the case here, as *Rhineceps*, *Trimerorhachis*, and *Eryops* were scored for 44–0 (coronoid teeth present) but only have denticles, in contrast to *Callistomordax* and *Almasaurus*. This should create a partial dependency with characters 45 and 46 because any taxon with a tooth row on either coronoid (45–0 and 46–0) would inherently have coronoid teeth (44–0). However, *Eryops* and *Trimerorhachis* were peculiarly scored as having tooth rows on the anterior and posterior coronoids; both only have denticle fields, and *Trimerorhachis* does not have any dentition on the anterior coronoid (Sawin, 1941:430–431; Milner & Schoch, 2013:107). *Rhineceps* was strangely scored for 45–1 and 46–0 even though it has a dense covering of denticles on all three coronoids (Watson, 1962:237, fig. 8), as was *Almasaurus*, even though it appears to have a legitimate tooth row across all three

coronoids (Dutuit, 1976:216, fig. 97; scored as such by Yates & Warren, 2000). There is no way to reconcile these scores simply by changing the terminology of 'teeth.'

- In keeping with our approach of minimizing scoring changes, including omission of characters, the approach that would require the fewest scoring changes is to treat character 44 as referring to the presence or absence of dentition on the middle coronoid; this did not require any scoring changes and captures the autapomorphic condition of *Callistomordax* in which a row of teeth is present only on the middle coronoid, and the other two are edentulous (Schoch, 2008). Character 45 is then reconfigured to refer more broadly to the presence or absence of dentition on the anterior coronoid; this required three scoring changes: *Almasaurus* and *Callistomordax* from state 1 to state 0 and *Trimerorhachis* from state 0 to state 1. Character 46 is reconfigured to refer to the presence or absence of dentition on the posterior coronoid and did not require any scoring changes.

Taxon-level changes

The following scores were changed for individual taxa. A total of 49 scores were changed; these are annotated in the associated revised matrix (Appendix 4).

Almasaurus habbazi

- (**62**, clavicular ornamentation): as figured by Dutuit (1976:fig. 102), there is barely any pitted ornamentation on the clavicle and no ornamentation on the posterior region equivalent to where pitting occurs in metoposaurids. [**0 → 2**]

Anaschisma browni (= "*Koskinonodon perfectus*")

- (**13**, postfrontal-orbit contribution): the postfrontal generally has a large contribution (about half of the medial orbital border), but there are numerous specimens with one or both postfrontals being anteriorly restricted (Lucas et al., 2016:figs. 28A, 30A, 34A, 34E). [**1 → 0&1**]
- (**14**, jugal anterior margin): all three conditions, posterior to anterior orbital margin (Lucas et al., 2016:fig. 28A), in line with the margin (Lucas et al., 2016:fig. 30G), and well anterior to the margin (Lucas et al., 2016:fig. 30A) are observed in this taxon, with variation within single individuals. [**0 → 0&1&2**]
- (**15**, parietal-supratemporal suture): while this suture is typically angled in this taxon, there are examples in which the suture is straight (e.g., Lucas et al., 2016:fig. 28E). [**1 → 0&1**]
- (**26**, parasphenoid ornamentation): while the ornamentation can extend onto the cultriform process (e.g., Sawin, 1945:fig. 3), it does not do so in all specimens and may instead be restricted to the basal plate (e.g., Case, 1922:16). [**2 → 1&2**]
- (**37**, paraquadrate foramen): Case (1922:fig. 1C) illustrated small foramina in the holotype of "*Buettneria perfecta*," but much larger foramina are noted in other taxa now considered synonymous with this taxon (Branson, 1905:fig. 3; Sawin, 1945:fig. 4). Having personally examined the type of "*B. perfecta*," it is clear that Case misrepresented these foramina as unnaturally small in that specimen, but in keeping with our approach of only modifying scores based on the available literature prior to publication of BJS's study, the character is rescored as polymorphic in this taxon, rather than only for state 2. [**1 → 1&2**]

- (**50**, posterior Meckelian fenestra): the hemimandibles illustrated by Case (1922:fig. 4B) and Lucas et al. (2016:figs. 35B, 36B) depict a subtriangular opening in which one end is distinctly shorter than the other. [**1 → 2**]
- (**58**, third vertebra): numerous third vertebra ("cervicals" of Lucas et al., 2016:fig. 41) are known (and can be more confidently identified to this position than the "cervicals" of *Apachesaurus gregorii*). These exhibit a procoelous morphology. [**1 → 0**]

Apachesaurus gregorii

- (**13**, postfrontal contribution to orbit): this condition appears to be polymorphic based on comparative figures (e.g., Spielmann & Lucas, 2012:fig. 13); the right side of the holotype is no more reduced than the right side of the widely propagated reconstruction of *Arganasaurus lyazidi* of Hunt (1993:fig. 4E). See also the specimen figured by Rinehart & Lucas (2018:fig. 1). [**1 → 0&1**]
- (**14**, jugal anterior margin): as figured by Spielmann & Lucas (2012:fig. 10), the jugal extends well past the anterior orbital margin. Because of the inversion of states 1 and 2 for this character, the score was not changed from state 2, but it was originally incorrectly scored.
- (**16**, infraorbital sulcus flexure): as illustrated by Spielmann & Lucas (2012:fig. 19), there is no flexure in this taxon. [**? → 0**]
- (**18**, postorbital sulcus-skull margin): Rinehart Lucas (2018:566) note a postorbital canal that "exits the skull roof." [**0 → 0&1**]
- (**21**, parachoanal tooth row): this feature has never been described or illustrated in this taxon, but as with all other metoposaurids, it is present, not absent, as confirmed by personal observation by BMG, and previous line drawings by Hunt (1993:fig. 12D) and Spielmann & Lucas (2012:fig. 10B) clearly represent oversimplifications without teeth illustrated. [**0 → 1**]
- (**35**, tabular horn): the taxon has been described as lacking tabular horns (e.g., Spielmann & Lucas, 2012), including by BJS. [**0 → -**]
- (**49**, splenial-symphysis): while Spielmann & Lucas (2012:25) note that the splenial underlies the dentary, that does not mean that it contributes to the symphysis. Their photographs are insufficient to identify sutures, and no corresponding line drawings were provided. [**1 → ?**]
- (**62**, clavicular ornamentation): as figured by Spielmann & Lucas (2012:fig. 24), there is barely any pitted ornamentation on the clavicle. [**0 → 2**]

Arganasaurus azerouali

- (**53**, axial neural arch): no vertebral material was described or listed among the referrable specimens by Dutuit (1976), Khaldoune et al. (2016), or BJS. [**1 → ?**]
- (**54**, ossified pleurocentra): as with character 53. [**1 → ?**]
- (**55**, presacral intercentra): as with character 53. Note also that character 59 (intercentra shape) was originally unscored. [**1 → ?**]

Arganasaurus lyazidi

- (**13**, postfrontal contribution to orbit): see comments for this character for *Apachesaurus gregorii*. [**0 → 0&1**]
- (**14**, jugal anterior margin): as with the widely propagated reconstruction by Hunt (1993:fig. 4E), this is polymorphic. [**2 → 1&2**]

Buettnererpeton bakeri (= "*Koskinonodon bakeri*")

- (**7**, lacrimal-nasal): this condition varies within a single individual (Case, 1932:fig. 3). [**1 → 0&1**]
- (**8**, lacrimal shape): based strictly on Case (1931, 1932), the lacrimal is no longer than that of other taxa scored as having a 'compact' lacrimal. **[1 → 0**]
- (**11**, prefrontal anterior contact): at least one referred specimen (Case, 1932:fig. 3) has a prefrontal that narrowly contacts the maxilla. [**0 → 0&1**]
- (**14**, jugal anterior margin): in all specimens other than the holotype, the jugal extends far anteriorly beyond the level of the anterior orbital margin (Case, 1932:figs. 3–5). The left jugal of the holotype could be considered as 'posterior to the margin' because the anterior margin slopes posteromedially (Case, 1932:fig. 2), but the lateralmost extent is more or less in line with the orbital margin. [**0 → 0&2**]
- (**15**, jugal-supratemporal suture): this condition is variable within the holotype. [**0 → 0&1**]
- (**49**, splenial-symphysis): per Case (1932:25), the splenial merely reaches "nearly to the symphysis." [**1 → 0**]
- (**50**, posterior Meckelian fenestra shape): the hemimandible illustrated by Case (1932:fig. 21) shows an opening that decrease with height anteriorly and with a straight, not convex, dorsal margin. [**1→2**]
- (**56**, neural spine height): Case (1932:27, figs. 24–25) noted only a single post-axial neural arch of this taxon, as verified by our own restudy; this is certainly insufficient to score this character.
- (**58**, third vertebra): while a large number of presacral vertebrae are known for this taxon, Case (1932:27–29), the only description of the postcrania, did not differentiate presacral positions other than the distinctive axis. [**1 → ?**]

Dutuitosaurus ouazzoui

- (**4**, septomaxilla): there is disagreement over whether a septomaxilla is present. Buffa, Jalil & Steyer, who personally examined material of this taxon, did not report a septomaxilla (or provide new figures of this taxon), while Chakravorti & Sengupta (2018:328) claimed that one was present (contra Dutuit, 1976) but provided no first-hand evidence. Due to the uncertainty and the lack of available data to assess this, we prefer to score this as unknown. [**1 → ?**]
- (**54**, ossified pleurocentra): refer to Appendix 1 regarding the debate over whether Dutuit's (1972, 1976) reports of pleurocentra reflect a true biological condition. [**0 → ?**]
- (**62**, clavicular ornamentation): as figured by Dutuit (1976:fig. 51) and compared by Sengupta (2002:fig. 13), there is no clear difference between this taxon and *Panthasaurus maleriensis* (scored as '1' originally), and *D. ouazzoui* clearly does not have a large region of pitting like that in *Anaschisma browni*, *Arganasaurus azerouali*, or *Buettnererpeton bakeri* (all scored as '0'). [**0 → 1**]

Metoposaurus algarvensis

- (**49**, splenial-symphysis): while Brusatte et al. (2015) conjectured that the splenial probably contributed to the symphysis, they did not identify any sutures to corroborate this, and it seems likely that they assumed as much based on *Metoposaurus krasiejowensis*. [**1 → ?**]
- (**53**, axial neural arch): no vertebral material was described by Brusatte et al. (2015). That reported from Algarve by Witzmann & Gassner (2008) is a pair of fused pathological

intercentra and two isolated intercentra. This material is not definitively from the type locality of *M. algarvensis* and was not referred to this taxon by Brusatte et al. [**1 → ?**]

- (**54**, ossified pleurocentra): as with character 53. The material described by Witzmann & Gassner is also too incomplete to assess this character. [**1 → ?**]
- (**55**, presacral intercentra): as with character 53. Note also that character 59 (intercentra shape) was originally unscored. [**1 → ?**]

Metoposaurus diagnosticus

- (**38**, paraquadrate accessory foramen): this feature was first described among metoposaurids in *Metoposaurus krasiejowensis* (Sulej, 2007). BJS cite Spielmann & Lucas (2012) for its occurrence in *M. diagnosticus*. However, they overlooked the fact that Spielmann & Lucas cite Sulej's reconstruction of *M. krasiejowensis* for their source (their fig. 11D) but identify it as *M. diagnosticus* following Lucas, Spielmann & Hunt (2007), who considered the Krasiejów metoposaurids to belong to *M. diagnosticus* without subspecies distinction. [**1 → ?**]

Metoposaurus krasiejowensis

- (**4**, septomaxilla): there is disagreement over whether a septomaxilla is present. Sulej (2007) stated none was present, while Chakravorti & Sengupta (2018:328) claimed that one was but provided no evidence. Due to the uncertainty and the lack of available data to assess this, we prefer to score this as unknown. [**1 → ?**]
- (**7**, lacrimal-nasal): the lacrimal and nasal are usually in contact in this taxon, but Sulej (2007:figs. 6, 13) depicts two specimens in which the condition varies within an individual. [**1 → 0&1**]
- (**9**, lacrimal-orbital margin): the lacrimal usually enters the orbit in this taxon, but Sulej (2007) figures one specimen in which this is not the case on either side of the skull and notes two specimens in which the condition varies (p. 37, fig. 12 therein). [**1 → 0&1**]
- (**11**, prefrontal anterior contact): the prefrontal usually contacts the nasal and the lacrimal anteriorly, but Sulej (2007:figs. 5, 12) depicts two specimens where there is a quadruple junction contact between the prefrontal, the nasal, the lacrimal, and the maxilla. In metoposaurids, any specimen in which the lacrimal does not meet the nasal will result in a prefrontal-maxilla contact (see character 7). In these cases, the lacrimal technically meets all three bones anteriorly (not fully captured by any single character state. [**0 → 0&1**]
- (**12**, prefrontal-jugal): the prefrontal and jugal are usually separated by the lacrimal, but if the lacrimal fails to meet the orbit (see character 9), then the prefrontal and jugal will meet. [**0 → 0&1**]
- (**25**, parasphenoid ornamentation): Sulej (2007:43) expressly states that the parasphenoid may either be smooth or ornamented. [**1 → 0&1**]
- (**57**, caudal intercentrum): BJS claim the caudal intercentra are only deeply notched in *Dutuitosaurus ouazzoui*, but this feature is clearly illustrated by Sulej (2007:fig. 36). [**1 → 0**]
- (**61**, clavicular contact): Sulej (2007:92) states there are no good specimens of articulated clavicles but noted variability in the clavicle margin that reflects variability in contact, both extensive and no contact at all. [**2 → 0&2**]
- (**62**, clavicle ornamentation): this feature has been shown to be polymorphic in the Krasiejów population by Antczak & Bodzioch (2018). Because of the ambiguity in

differentiating the three character states, it could conceivably be scored for all three states, but we only rescored it for two states here. [**2 → 1&2**]

Panthasaurus maleriensis

- (**7**, lacrimal-nasal): two specimens illustrated by Chowdhury (1965:figs. 3–4) and Sengupta (2002:figs. 3–4) exhibit different conditions, regardless of the former's purported identification of a dorsally exposed septomaxilla. [**1 → 0&1**]

Callistomordax kugleri

- (**56**, neural spine height): Schoch (2008:93) clearly states that "from the posterior third of the trunk backwards, the neural spines become successively higher." [**0 → 1**]
- (**62**, clavicular ornamentation): as figured by Schoch (2008:fig. 7C), there is barely any pitted ornamentation on the clavicle. [**0 → 2**]
- (**63**, ilium shaft): Schoch (2008:87, fig. 9C) clearly states and figures a concave anterior margin. [**0 → 1**]

Eryops megacephalus

- (**62**, clavicular ornamentation): as figured by Pawley & Warren (2006:fig. 3.4), there is barely any pitted ornamentation on the clavicle and no ornamentation on the posterior region equivalent to where pitting occurs in metoposaurids. [**0 → 2**]

Trimerorhachis insignis

- (**62**, clavicular ornamentation): as figured by Pawley (2007:fig. 6.2.1), there is barely any pitted ornamentation on the clavicle. [**0 → 2**]

Appendix 4. NEXUS file with modified character-taxon matrix

Refer to the online version of the manuscript for this file.

Appendix 5. ZIP file with MPTs for all parsimony analyses conducted in this study.

Refer to the online version of the manuscript for this file.

Appendix 6. List of measurements and specimens used to compare size patterns among metoposaurids

Table S2. Midline skull length measurements used for Figure 57. Note that this is not a comprehensive list of all metoposaurid specimens, as our primary goal was to sample the total size range of all taxa rather than the distribution of size bins within taxa. With a few exceptions of more poorly characterized taxa (e.g., *Arganasaurus lyazidi*), measurements were taken directly from the literature rather than being estimated from figures (these exceptions are marked with an asterisk next to the specimen number) and only for nearly complete skulls to avoid introducing potential error in estimating fragmentary specimens. The uncertain specimens taken from Colbert & Imbrie (1956) are only specimens from the Lamy quarry, measurements of which were not taken from other sources. A few specimens are slight overestimates based on a measurement from the premaxillae to the posterior face of the occipital condyles, rather than to the posterior margin of the postparietals; these are marked with a cross (†). All measurements are in centimeters.

Taxon	ML	Specimen	Source
Anaschisma browni	40.8	UMMP 7475	Lucas et al. (2016)

Anaschisma browni	56	UMMP 8854	Lucas et al. (2016)
Anaschisma browni	50.5	UMMP 21326	Lucas et al. (2016)
Anaschisma browni	37.6	3011-3	Lucas et al. (2016)
Anaschisma browni	45.4	3011	Lucas et al. (2016)
Anaschisma browni	36.5	3114	Lucas et al. (2016)
Anaschisma browni	37.6	WT 3055	Lucas et al. (2016)
Anaschisma browni	30.2	WT 3011	Lucas et al. (2016)
Anaschisma browni	39.2	WT 3166-1	Lucas et al. (2016)
Anaschisma browni	50	WT 3067-2	Lucas et al. (2016)
Anaschisma browni	43.2	PPHM 6	Lucas et al. (2016)
Anaschisma browni	50.5	PPHM 5	Lucas et al. (2016)
Anaschisma browni	45.1	WT 3011-1	Lucas et al. (2016)
Anaschisma browni	43	WT 3067	Lucas et al. (2016)
Anaschisma browni	41	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	45.9	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	48.3	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	38.6	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	40.8	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	35.2	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	50	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	48.5	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	46.7	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	44.5	MCZ ?	Colbert & Imbrie (1956)
Anaschisma browni	54.3	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	50.4	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	40.7	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	36.8	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	49.8	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	40	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	31.4	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	47.4	USNM ?	Colbert & Imbrie (1956)
Anaschisma browni	44.3	UMMNH 7475	Colbert & Imbrie (1956)
Anaschisma browni	35.3	TMM 31100-134	Sawin (1945)
Anaschisma browni	38.4	TMM 31220-2	Sawin (1945)
Anaschisma browni	40.9	TMM 32100-42	Sawin (1945)
Anaschisma browni	42.7	TMM 31100-30	Sawin (1945)
Anaschisma browni	43.1	TMM 31100-161	Sawin (1945)
Anaschisma browni	43.2	TMM 31100-122	Sawin (1945)
Anaschisma browni	50.4	TMM 31098-17	Sawin (1945)
Anaschisma browni	41	TMM 31172-11	Sawin (1945)

Anaschisma browni	15.3	TMM 31099-12b	Sawin (1945)
Anaschisma browni	42	SMP VP-44	Gee & Jasinksi (2021)
Apachesaurus gregorii	8.39	UCMP 171591	Rinehart & Lucas (2018)
Apachesaurus gregorii	16.9	UCMP 63845	Rinehart & Lucas (2018)
Apachesaurus gregorii	7.3	†TTUP 9216	Davidow-Henry (1987, 1989)
Apachesaurus gregorii	8.1	†UCMP 82/39/37	Davidow-Henry (1987, 1989)
Arganasaurus azerouali	37.5	MNHN.F.ARG 5	Buffa et al. (2019)
Arganasaurus lyazidi	16.5	*XIX/3/66	Hunt (1993)
Arganasaurus lyazidi	15.1	*XIX/8/66	Hunt (1993)
Buettnererpeton bakeri	29.1	UMMP 13055	this study
Buettnererpeton bakeri	30.5	UMMP 13820	this study
Buettnererpeton bakeri	24	UMMP 13822	this study
Buettnererpeton bakeri	29.6	UMMP 13823	this study
Buettnererpeton bakeri	28.7	MCZ 1054	Case (1932)
Buettnererpeton bakeri	19.3	YPM VPPU 021742	this study
Dutuitosaurus ouazzoui	67	†XIII/12/65 (1)	Dutuit (1976)
Dutuitosaurus ouazzoui	51	†XIII/12/65 (3)	Dutuit (1976)
Dutuitosaurus ouazzoui	50	†XIII/19/65 (1)	Dutuit (1976)
Dutuitosaurus ouazzoui	29	†XIII/19/65 (2)	Dutuit (1976)
Dutuitosaurus ouazzoui	31	†XIII/5/66	Dutuit (1976)
Dutuitosaurus ouazzoui	32.5	†XIII/7/66	Dutuit (1976)
Dutuitosaurus ouazzoui	69	†XIII/11/66	Dutuit (1976)
Dutuitosaurus ouazzoui	34.5	†XIII/13/66 (1)	Dutuit (1976)
Dutuitosaurus ouazzoui	32	†XIII/13/66 (2)	Dutuit (1976)
Dutuitosaurus ouazzoui	56	†XIII/14/66 (2)	Dutuit (1976)
Dutuitosaurus ouazzoui	42.5	†XIII/14/66 (4)	Dutuit (1976)
Dutuitosaurus ouazzoui	31.5	†XIII/14/66 (5)	Dutuit (1976)
Dutuitosaurus ouazzoui	48	†XIII/14/66 (6)	Dutuit (1976)
Dutuitosaurus ouazzoui	62	†x	Dutuit (1976)
Dutuitosaurus ouazzoui	62	†y	Dutuit (1976)
Metoposaurus algarvensis	27	FCT-UNL 600	Brusatte et al. (2015)
Metoposaurus algarvensis	45	FCT-UNL 601	Brusatte et al. (2015)
Metoposaurus diagnosticus	17.5	SMNS 80758	Sulej (2002); Milner & Schoch (2004)
Metoposaurus diagnosticus	30	generalized	Milner & Schoch (2004)
Metoposaurus diagnosticus	50	generalized	Milner & Schoch (2004)
Metoposaurus diagnosticus	29.6	*SMNS 4943	Hunt (1993)
Metoposaurus krasiejowensis	40	UOPB 01029	Gruntmejer et al. (2016)

Metoposaurus krasiejowensis	28	SMNS 80573	Milner & Schoch (2004)
Metoposaurus krasiejowensis	44	BSP 1931 X 3	Milner & Schoch (2004)
Metoposaurus krasiejowensis	32	BMNH 37938	Milner & Schoch (2004)
Metoposaurus krasiejowensis	27.2	ZPAL AbIII 684	Sulej (2007)
Metoposaurus krasiejowensis	27.4	ZPAL AbIII 892	Sulej (2007)
Metoposaurus krasiejowensis	27.6	ZPAL AbIII 1683	Sulej (2007)
Metoposaurus krasiejowensis	27.8	ZPAL AbIII 682	Sulej (2007)
Metoposaurus krasiejowensis	27.8	ZPAL AbIII 1660	Sulej (2007)
Metoposaurus krasiejowensis	28.4	ZPAL AbIII 1166	Sulej (2007)
Metoposaurus krasiejowensis	28.6	ZPAL AbIII 1679	Sulej (2007)
Metoposaurus krasiejowensis	28.7	ZPAL AbIII 1165	Sulej (2007)
Metoposaurus krasiejowensis	28.8	ZPAL AbIII 995	Sulej (2007)
Metoposaurus krasiejowensis	28.9	ZPAL AbIII 923	Sulej (2007)
Metoposaurus krasiejowensis	29	ZPAL AbIII 1682	Sulej (2007)
Metoposaurus krasiejowensis	29.1	ZPAL AbIII 894	Sulej (2007)
Metoposaurus krasiejowensis	29.5	ZPAL AbIII 870	Sulej (2007)
Metoposaurus krasiejowensis	29.5	ZPAL AbIII 883	Sulej (2007)
Metoposaurus krasiejowensis	29.5	ZPAL AbIII 893	Sulej (2007)
Metoposaurus krasiejowensis	29.5	ZPAL AbIII 4	Sulej (2007)
Metoposaurus krasiejowensis	29.6	ZPAL AbIII 914	Sulej (2007)
Metoposaurus krasiejowensis	29.8	ZPAL AbIII 854	Sulej (2007)
Metoposaurus krasiejowensis	30	ZPAL AbIII 5	Sulej (2007)
Metoposaurus krasiejowensis	30	ZPAL AbIII 872	Sulej (2007)
Metoposaurus krasiejowensis	30.3	ZPAL AbIII 871	Sulej (2007)
Metoposaurus krasiejowensis	30.5	ZPAL AbIII 1673	Sulej (2007)
Metoposaurus krasiejowensis	30.5	ZPAL AbIII 816	Sulej (2007)
Metoposaurus krasiejowensis	30.7	ZPAL AbIII 868	Sulej (2007)
Metoposaurus krasiejowensis	30.7	ZPAL AbIII 1675	Sulej (2007)

Metoposaurus krasiejowensis	30.8	ZPAL AbIII 318	Sulej (2007)
Metoposaurus krasiejowensis	31.1	ZPAL AbIII 1199	Sulej (2007)
Metoposaurus krasiejowensis	31.8	ZPAL AbIII 1191	Sulej (2007)
Metoposaurus krasiejowensis	32	ZPAL AbIII 688	Sulej (2007)
Metoposaurus krasiejowensis	32	ZPAL AbIII 1674	Sulej (2007)
Metoposaurus krasiejowensis	32.2	ZPAL AbIII 1681	Sulej (2007)
Metoposaurus krasiejowensis	32.2	ZPAL AbIII 681	Sulej (2007)
Metoposaurus krasiejowensis	32.3	ZPAL AbIII 358	Sulej (2007)
Metoposaurus krasiejowensis	33.2	ZPAL AbIII 992	Sulej (2007)
Metoposaurus krasiejowensis	33.9	ZPAL AbIII 882	Sulej (2007)
Metoposaurus krasiejowensis	35.2	ZPAL AbIII 890	Sulej (2007)
Metoposaurus krasiejowensis	35.5	ZPAL AbIII 873	Sulej (2007)
Metoposaurus krasiejowensis	36.2	ZPAL AbIII 1685	Sulej (2007)
Metoposaurus krasiejowensis	36.5	ZPAL AbIII 881	Sulej (2007)
Metoposaurus krasiejowensis	37.5	ZPAL AbIII 3	Sulej (2007)
Metoposaurus krasiejowensis	47	ZPAL AbIII 1192	Sulej (2007)
Metoposaurus krasiejowensis	47.5	ZPAL AbIII 10	Sulej (2007)
Panthasaurus maleriensis	41	ISI A 56	Chakravorti & Sengupta (2018)
Panthasaurus maleriensis	41.8	*ISI A 59	Sengupta (2002)
Panthasaurus maleriensis	31.7	ISI A 4	Chowdhury (1965)
Panthasaurus maleriensis	40.8	ISA A 8	Chowdhury (1965)

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