SUPPLEMENTAL DATA

Journal of Vertebrate Paleontology

*Kholumolumo* *ellenbergerorum*, gen. et sp. nov., a new basal sauropodomorph from the Lower Elliot Formation (Late Triassic) of Maphutseng, Lesotho

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TABLE S1. List of the five field campaigns in the Maphutseng bone bed, with the approximate number of collection numbers for individual elements allocated in the field and the team involved in each campaign. In green: MNHN researchers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1955August & September | 1955November300numbers attributed | 1956February400numbers attributed | 1959Month?200numbers attributed | 1963Month?100numbers attributed | 1970September300numbers attributed |
| P. EllenbergerF. Ellenberger | P. EllenbergerF. EllenbergerA.W. CromptonR.F. Ewer | P. EllenbergerF. EllenbergerA.W. CromptonR.F. Ewer | P. EllenbergerF. EllenbergerH. EllenbergerL. GinsburgJ. Fabre | P. EllenbergerL. GinsburgJ. FabreC. Mendrez | P. EllenbergerL. GinsburgJ. FabreB. Battail |

TABLE S2. Complete list of the material collected on the main excavation site of Maphutseng, referred to *Kholumolumo ellenbergerorum* gen. et sp. nov. and housed in the Muséum National d’Histoire Naturelle (MNHN), Paris. This list includes 211 bones collected between 1959 and 1970. The material is listed depending on anatomical areas, and the collection numbers are ranked in ascending order for each anatomical region. **Abbreviations**: **C**, complete; **I**, incomplete; **SC**, subcomplete.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Collection number** | **Bone** | **Lateralization** | **Completeness** |
| Skull | MNHN.F.LES54 | Postorbital | Right | I |
| MNHN.F.LES153 | Postorbital | Left | I |
| Cervicals vertebrae | MNHN.F.LES169 | Posterior cervical | - | C |
| MNHN.F.LES338 | Anterior cervical | - | I |
| MNHN.F.LES342 | Anterior cervical | - | I |
| Dorsals | MNHN.F.LES32 | Posterior dorsal | - | I | - | C |
| MNHN.F.LES171 | Posterior dorsal | - | I | - | I |
| MNHN.F.LES172 | Anterior dorsal | - | I | - | I |
| MNHN.F.LES329 | Dorsal | - | I |  |  |
| MNHN.F.LES332 | Dorsal | - | I |  |  |
| MNHN.F.LES337 | Dorsal | - | I |  |  |
| MNHN.F.LES344 | Dorsal | - | I |  |  |
| MNHN.F.LES397 | Anterior dorsal | - | I |  |  |
| Sacrals  | MNHN.F.LES155 | Sacral | - | I |
| Caudals | MNHN.F.LES19 | Middle caudal | - | I |
| MNHN.F.LES20 | Middle caudal | - | I |
| MNHN.F.LES21 | Middle caudal | - | I |
| MNHN.F.LES22 | Middle caudal | - | I |
| MNHN.F.LES23 | Middle caudal | - | I |
| MNHN.F.LES24 | Anterior caudal | - | I |
| Caudals | MNHN.F.LES33 | Middle caudal | - | I |
| MNHN.F.LES34 | Middle caudal | - | I |
| MNHN.F.LES35 | Posterior caudal | - | I |
| MNHN.F.LES36 | Posterior caudal | - | I |
| MNHN.F.LES37 | Posterior caudal | - | I |
| MNHN.F.LES38 | Posterior caudal | - | I |
| MNHN.F.LES39 | Posterior caudal | - | I |
| MNHN.F.LES40 | Posterior caudal | - | I |
| MNHN.F.LES41 | Posterior caudal | - | I |
| MNHN.F.LES42 | Middle caudal | - | I |
| MNHN.F.LES43 | Middle caudal | - | I |
| MNHN.F.LES44 | Middle caudal | - | I |
| MNHN.F.LES45 | Middle caudal | - | I |
| MNHN.F.LES46 | Posterior caudal | - | I |
| MNHN.F.LES47 | Posterior caudal | - | I |
| MNHN.F.LES56 | Middle caudal | - | I |
| MNHN.F.LES57 | Middle caudal | - | I |
| MNHN.F.LES58 | Middle caudal | - | I |
| MNHN.F.LES59 | Middle caudal | - | I |
| MNHN.F.LES161 | Caudal | - | I |
| MNHN.F.LES163 | Anterior caudal | - | I |
| MNHN.F.LES168 | Anterior caudal | - | I |
| MNHN.F.LES176 | Anterior caudal | - | I |
| MNHN.F.LES177 | Middle caudal | - | I |
| MNHN.F.LES328-3 | Anterior caudal | - | I |
| MNHN.F.LES328-4 | Anterior caudal | - | I |
| MNHN.F.LES328-5 | Anterior caudal | - | I |
| MNHN.F.LES341 | Anterior caudal | - | I |
| MNHN.F.LES376 | Anterior caudal | - | I |
| MNHN.F.LES380 | Caudal | - | I |
|  | MNHN.F.LES391 | Anterior caudal | - | I |
|  | MNHN.F.LES170 | Vertebrae indet. |
|  | MNHN.F.LES346 |
| Ribs | MNHN.F.LES48 | Dorsal rib | ? | I |
| MNHN.F.LES49 | Dorsal rib | ? | I |
| MNHN.F.LES55 | Cervical rib | ? | I |
| MNHN.F.LES60 | Dorsal rib | ? | I |
| MNHN.F.LES61 | Dorsal rib | ? | I |
| MNHN.F.LES62 | Dorsal rib | ? | I |
| MNHN.F.LES138 | Dorsal rib | ? | I |
| MNHN.F.LES345 | Dorsal rib | ? | I |
|  | MNHN.F.LES388 | Rib | ? | I |
| Chevrons | MNHN.F.LES50 | Middle chevron | - | I |
| MNHN.F.LES51 | Middle chevron | - | I |
| MNHN.F.LES52 | Chevron | - | I |
| MNHN.F.LES53 | Chevron | - | I |
| Pectoral girdle | MNHN.F.LES133 | Scapula | Right | I |
| MNHN.F.LES134 | Scapula | Left | I |
| MNHN.F.LES135 | Scapula | Right | I |
| MNHN.F.LES158 | Scapula | ? | I |
| MNHN.F.LES386 | Scapula | Left | SC |
| Forelimb | MNHN.F.LES157 | Humerus | Right | I |
| MNHN.F.LES379 | Humerus | Left | C |
| MNHN.F.LES385 | Humerus | Right | SC |
| MNHN.F.LES390 | Humerus | Right | C |
| MNHN.F.LES393 | Humerus | Left | I |
| MNHN.F.LES145 | Ulna | Right | SC |
| MNHN.F.LES156 | Ulna | Right | C |
| MNHN.F.LES159 | Ulna | Right | C |
| MNHN.F.LES347 | Ulna | ? | I |
| MNHN.F.LES140 | Radius | Left | I |
| MNHN.F.LES142 | Radius | Right | I |
| MNHN.F.LES143 | Radius | Left | I |
|  | MNHN.F.LES144 | Radius | Left | SC |
|  | MNHN.F.LES147 | Radius | Left | C |
|  | MNHN.F.LES154 | Radius | Left | I |
| Manus | MNHN.F.LES335 | Carpal? | ? | I |
| MNHN.F.LES25 | Metacarpal I | Left | I |
| MNHN.F.LES26 | Metacarpal I | Right | C |
| MNHN.F.LES100 | Metacarpal I | Left | C |
| MNHN.F.LES92 | Metacarpal II | Right | C |
| MNHN.F.LES331 | Metacarpal II | Right | I |
| MNHN.F.LES93 | Metacarpal III | Right | C |
| MNHN.F.LES95 | Metacarpal III? | ? | I |
| MNHN.F.LES75 | Metacarpal IV | Right | I |
| MNHN.F.LES76 | Metacarpal IV | Right | SC |
| MNHN.F.LES29 | Phalanx I.1 | Left | C |
| MNHN.F.LES97 | Phalanx I.1 | Left | SC |
| MNHN.F.LES103 | Phalanx I.1 | Right | C |
| MNHN.F.LES108 | Phalanx I.1 | Right | SC |
| MNHN.F.LES110 | Phalanx I.1 | Right | I |
| MNHN.F.LES116 | Phalanx I.1 | Left | SC |
| MNHN.F.LES101 | Phalanx IV.2 | ? | I |
| MNHN.F.LES105 | Phalanx IV.2 | ? | SC |
| Pelvic girdle | MNHN.F.LES162 | Ilium | Right | I |
| MNHN.F.LES164 | Ilium | Right | I |
| MNHN.F.LES372 | Ilium | Left | I |
| MNHN.F.LES375a | Ilium | Right | C |
| MNHN.F.LES375b | Ilium | Left | I |
| MNHN.F.LES396 | Ilium | Right | C |
| MNHN.F.LES373 | Pubis | Right |  |
| MNHN.F.LES378 | Pubis | Left | SC |
| MNHN.F.LES152 | Ischium | Left | I |
| Hindlimb | MNHN.F.LES165 | Femur | Right | I |
| MNHN.F.LES166 | Femur | ? | I |
| MNHN.F.LES173 | Femur | ? | I |
| MNHN.F.LES174 | Femur | ? | I |
| MNHN.F.LES175 | Femur | ? | I |
| MNHN.F.LES371 | Femur | Left | C |
| MNHN.F.LES384 | Femur | ? | I |
| MNHN.F.LES394 | Femur | Right | C |
| MNHN.F.LES395 | Femur | Right | I |
| MNHN.F.LES148 | Tibia | Left | SC |
| MNHN.F.LES160 | Tibia |  | I |
| MNHN.F.LES167 | Tibia | Right | SC |
| MNHN.F.LES381m | Tibia | Right | C |
| MNHN.F.LES387 | Tibia | Right | C |
| MNHN.F.LES389 | Tibia | Left | SC |
| MNHN.F.LES146 | Fibula | Right | SC |
| MNHN.F.LES149 | Fibula | Right | I |
| MNHN.F.LES150 | Fibula | Left | I |
| MNHN.F.LES151 | Fibula | Left | I |
| MNHN.F.LES374 | Fibula | Right | SC |
| Pes | MNHN.F.LES89 | Metatarsal I | Left | SC |
| MNHN.F.LES90 | Metatarsal I | Right | I |
| MNHN.F.LES91 | Metatarsal I | Left | C |
| MNHN.F.LES381e | Metatarsal I | Left | I |
| MNHN.F.LES381h | Metatarsal I | Left | I |
| MNHN.F.LES81 | Metatarsal II | Left | SC |
| MNHN.F.LES381i&j | Metatarsal II | Left | I |
| MNHN.F.LES82 | Metatarsal III | Left | SC |
| MNHN.F.LES83 | Metatarsal III | Right | I |
| Pes | MNHN.F.LES136 | Metatarsal III | Left | SC |
| MNHN.F.LES72 | Metatarsal IV | Right | SC |
| MNHN.F.LES73 | Metatarsal IV | Left | SC |
| MNHN.F.LES381a | Metatarsal IV | Right | I |
| MNHN.F.LES381c | Metatarsal IV | Left | C |
| MNHN.F.LES74 | Metatarsal V | Right | I |
| MNHN.F.LES77 | Metatarsal V | Left | SC |
| MNHN.F.LES27 | Phalanx I.1 | Left | I |
| MNHN.F.LES87 | Phalanx I.1 | Left | I |
| MNHN.F.LES111 | Phalanx I.1 | Right | SC |
| MNHN.F.LES114 | Phalanx I.1 | Left | I |
| MNHN.F.LES118 | Phalanx I.2 | Right | SC |
| MNHN.F.LES28 | Phalanx II.1 | Right | SC |
| MNHN.F.LES31 | Phalanx II.1 | Left | SC |
| MNHN.F.LES86 | Phalanx II.1 | Left | SC |
| MNHN.F.LES107 | Phalanx II.1 | Right | I |
| MNHN.F.LES192 | Phalanx II.1 | Left | SC |
| MNHN.F.LES333 | Phalanx II.1 | Left | SC |
| MNHN.F.LES381d | Phalanx II.1 | Left | SC |
| MNHN.F.LES30 | Phalanx III.1 | Right | I |
| MNHN.F.LES88 | Phalanx III.1 | Left | I |
| MNHN.F.LES109 | Phalanx III.1 | Right | I |
| MNHN.F.LES115 | Phalanx III.1 | Left | I |
| MNHN.F.LES381k | Phalanx III.2 | Left | SC |
| MNHN.F.LES381g | Phalanx III.3 | Left | SC |
| MNHN.F.LES381b | Phalanx III.4 | Left | I |
| MNHN.F.LES66 | Phalanx IV.1 | Left | I |
| MNHN.F.LES117 | Phalanx IV.1 | Left | SC |
| MNHN.F.LES381l | Phalanx IV.2 | Left | I |
| MNHN.F.LES381f | Phalanx IV.3 | Left | I |
|  | MNHN.F.LES67 | Phalangesindet. |
|  | MNHN.F.LES68 |
|  | MNHN.F.LES69 |
|  | MNHN.F.LES70 |
|  | MNHN.F.LES71 |
|  | MNHN.F.LES94 |
|  | MNHN.F.LES96 |
|  | MNHN.F.LES98 |
|  | MNHN.F.LES99 |
|  | MNHN.F.LES102 |
|  | MNHN.F.LES104 |
|  | MNHN.F.LES106 |
|  | MNHN.F.LES112 |
|  | MNHN.F.LES113 |
|  | MNHN.F.LES330 |
|  | MNHN.F.LES63 | Clawsindet. |
|  | MNHN.F.LES64 |
|  | MNHN.F.LES65 |
|  | MNHN.F.LES78 |
|  | MNHN.F.LES79 |
|  | MNHN.F.LES80 |
|  | MNHN.F.LES119 |
|  | MNHN.F.LES120 |
|  | MNHN.F.LES121 |
|  | MNHN.F.LES122 |
|  | MNHN.F.LES123 |
|  | MNHN.F.LES124 |
|  | MNHN.F.LES125 |
|  | MNHN.F.LES126 | Clawsindet. |
|  | MNHN.F.LES127 |
|  | MNHN.F.LES128 |
|  | MNHN.F.LES129 |
|  | MNHN.F.LES130 |
|  | MNHN.F.LES131 |
|  | MNHN.F.LES132 |
|  | MNHN.F.LES141 | Indet. |
|  | MNHN.F.LES339 |
|  | MNHN.F.LES382 |
|  | MNHN.F.LES383 |

TABLE S3. Sources of comparative data used in the anatomical descriptions. The underlined specimens were studied first-hand by the first author of this work.

|  |  |
| --- | --- |
| Aardonyx celestae | BP/1/6254; Yates et al., 2010 |
| Adeopapposaurus mognai | PVSJ 610; PVSJ 568; PVSJ 569; Martínez, 2009 |
| Anchisaurus polyzelus | AM 41/109; YPM 208; YPM 1883; Galton, 1976; Fedak and Galton, 2007; Yates, 2010 |
| Antetonitrus ingenipes | BP/1/4952; McPhee et al., 2014 |
| Blikanasaurus cromptoni | SAM-PK-K403; Galton and Van Heerden, 1985, 1998 |
| Chromogisaurus novasi | PVSJ 845; Ezcurra, 2010; Martínez et al., 2013 |
| Coloradisaurus brevis | PVL 3967; PVL 5904; Apaldetti et al., 2013, 2014 |
| Eoraptor lunensis | PVSJ 512; Sereno et al., 2013 |
| Eucnemesaurus entaxonis | McPhee et al., 2015 |
| Jingshanosaurus xinwaensis | Zhang and Yang, 1994 |
| Leonerasaurus taquetrensis | MPEF-PV 1663; Pol et al., 2011 |
| Lessemsaurus sauropoides | PVL 4822; Pol and Powell, 2007 |
| Lufengosaurus huenei | IVPP V15; Young, 1941; Barrett et al., 2005 |
| Massospondylus carinatus | BP/1/4934; BP/1/5241; BP/1/5247; BP/1/4924; BP/1/4693; Sues et al., 2004; MNHN.F.LES15 |
| Melanorosaurus readi | NM QR3314; NM QR1551; SAM-PK-3449; SAM-PK-3450; Yates, 2007 |
| Meroktenos thabanensis | MNHN.F.LES16; MNHN.F.LES351 |
| Mussaurus patagonicus | MLP 61-III-20-22; MLP 61-III-20-23; MLP 68-II-27-1; Pol and Powell, 2007; Otero and Pol, 2013 |
| Panphagia protos | PVSJ 874; Martínez and Alcober, 2009; Martínez et al., 2013 |
| Plateosaurus longiceps | MB.R.1937; MB.R.4402; MB.R.4404; MB.R.4416 |
| Riojasaurus incertus | PVL 3808 ; Bonaparte and Pumares, 1995 |
| Ruehleia bedheimensis | MB.R.4718; MB.R.4430; Galton, 2001 |
| Sarahsaurus aurifontanalis | MCZ 8893; TMM 43646-2; Rowe et al., 2010 |
| Saturnalia tupiniquim | MCP 3845-PV; MCP 3846-PV; Langer et al., 1999; Langer 2003; Langer et al., 2007 |
| Sefapanosaurus zastronensis | BP/1/386; BP/1/7409–7455; Otero et al., 2015 |
| Xixiposaurus suni | Sekiya, 2010 |
| Yunnanosaurus huangi | IVPP V20; IVPP V505; Young, 1942; Barrett et al., 2007 |

TABLE S4. Selected measurements (in mm) of the vertebrae of *Kholumolumo ellenbergerorum*. **Abbreviations**: **L**, maximum anteroposterior ventral length; **antW**, anterior width; **medW**, medial width; **postW**, posterior width; **antH**, anterior height; **postH**, posterior height; **naH**, neural arch height; **nsH**, maximum neural spine height; **nsL**, maximum neural spine length; **nsW**, maximum neural spine width measured at its distal end; **przD**, distance between the lateral borders of the prezygapophyses; **H**, total height; **\***, deformation.

|  |  |  |  |
| --- | --- | --- | --- |
|  | CENTRUM | NEURAL ARCH | VERTEBRA |
|  | L | antW | medW | postW | antH | postH | naH | nsH | nsL | nsW | przD | H |
| CmidMNHN.F.LES338 | ? | 65 | 30 | ? | 78 | ? | ? | ? | ? | ? | ? | ? |
| CmidMNHN.F.LES342 | 127 | 41\* | 20\* | ? | 54\* | ? | ? | ? | ? | ? | ? | ? |
| C10?MNHN.F.LES169 | 132 | 90 | 34 | 85 | 105 | 92 | 150 | 46 | 39 | 37 | 88 | 255 |
| D1?MNHN.F.LES397 | ? | ? | ? | ? | ? | ? | >110 | ? | ? | ? | 91 | ? |
| D2-3?MNHN.F.LES172 | 115 | 90\* | 33\* | 82\* | 117\* | 105\* | ? | ? | ? | ? | ? | ? |
| D8-12?MNHN.F.LES32 | 120 | 63\* | 38\* | 71\* | 97\* | 108\* | >120 | ? | ? | ? | 68 | >233 |
| Sp2?MNHN.F.LES155 | 101 | 105 | 73 | 175 | 137 | 155 | 265 | 175 | 75 | 45 | ? | 420 |
| Ca1-5MNHN.F.LES168 | 90 | ? | 102 | 155 | 141 | 165 | 260 | 180 | 65 | 41 | ? | 425 |
| Ca5-15MNHN.F.LES376 | 105 | 108 | 68 | 107 | 125 | 124 | 210 | 155 | 55 | 23 | 75 | 335 |
| Ca15-25MNHN.F.LES177 | 90 | 60 | 46 | 59 | 53 | 52 | ? | ? | ? | ? | ? | ? |
| Ca25+MNHN.F.LES35 | 65 | 35 | 25 | 34 | 34 | 29 | ? | ? | ? | ? | ? | ? |

TABLE S5. Selected measurements (in mm) of the scapulae of *Kholumolumo ellenbergerorum*. **Abbreviations**: **L**, maximum dorsoventral length; **dW**, maximum distal width; **bW**, blade minimal anteroposterior width; **bT**, blade transversal thickness measured at midpoint on the posterior border; **pW**, maximum proximal width; **amxH**, acromion maximum height measured at the level of the point of divergence with the anterior border of the blade; **amnH**, acromion minimum height measured on its distal extremity; **aW**, acromion anteroposterior width measured at the level of the anterior border of the blade; **aT**, acromion transversal thickness; **nsW**, maximum neural spine width measured at its distal end; **gcT**, glenoid cavity maximum thickness.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | BLADE |  | ACROMION |  |
|  | L | dW | bW | bT | pW | amxH | amnH | aW | aT | gcT |
| Scapula (right)MNHN.F.LES133 | ? | ? | ? | 35 | ? | ? | ? | ? | ? | ? |
| Scapula (left)MNHN.F.LES134 | ? | ? | 132 | 34 | ? | ? | ? | ? | ? | ? |
| Scapula (right)MNHN.F.LES135 | ? | ? | 164 | 35 | ? | ? | ? | ? | ? | ? |
| Scapula (right)MNHN.F.LES158 | ? | ? | 76 | 34 | ? | ? | ? | ? | ? | ? |
| Scapula (left)MNHN.F.LES386 | 720 | ? | 172 | 30 | 385 | 265 | 140 | 85 | 40 | 106 |

TABLE S6. Selected measurements (in mm) of the bones from the anterior member of *Kholumolumo ellenbergerorum*. **Abbreviations**: **L**, maximum proximodistal length; **dpcL**, deltopectoral crest dorsoventral length (measured from the proximal border of the humerus); **W**, maximum transverse width; **T**, maximum anteroposterior thickness; **C**, circumference of the diaphysis (measured beneath the deltopectoral crest on humeri); **>**, length measured given that one or both extremities of the bone are broken.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | PROXIMAL | DIAPHYSIS | DISTAL |
|  | L | dpcL | W | T | W | T | C | W | T |
| Humerus (left)MNHN.F.LES379 | 685 | 330 | 300 | 70 | 82 | 80 | 262 | 220 | 68 |
| Humerus (right)MNHN.F.LES385 | 630 | 280 | ? | ? | 77 | 70 | 235 | 225 | ? |
| Humerus (right)MNHN.F.LES390 | 610 | 265 | 233 | 64 | 85 | 72 | 257 | 214 | 60 |
| Ulna (right)MNHN.F.LES145 | >305 | - | ? | ? | 50 | 44 | - | 54 | ? |
| Ulna (right)MNHN.F.LES156 | 370 | - | 120 | 150 | 53 | 50 | - | 50 | 100 |
| Ulna (right)MNHN.F.LES159 | 390 | - | 126 | 142 | 52 | 48 | - | 56 | 108 |
| Radius (left)MNHN.F.LES140 | >264 | - | 112 | 65 | 47 | 45 | - | ? | ? |
| Radius (right)MNHN.F.LES142 | >235 | - | ? | ? | 42 | 39 | - | ? | 58 |
| Radius (left)MNHN.F.LES144 | 320 | - | 97 | 54 | 42 | 42 | - | ? | 65 |
| Radius (left)MNHN.F.LES147 | 320 | - | 99 | 58 | 46 | 38 | - | 85 | 64 |
| Metacarpal I (right)MNHN.F.LES26 | 97 | - | 95 | 69 | 66 | 33 | - | 85 | 53 |
| Metacarpal II (left)MNHN.F.LES92 | 125 | - | 68 | 60 | 32 | 27 | - | 60 | 38 |
| Metacarpal III (right)MNHN.F.LES93 | 142 | - | 67 | 64 | 26 | 29 | - | 57 | 40 |
| Metacarpal IV (right)MNHN.F.LES76 | >103 | - | ? | ? | 28 | 21 | - | 43 | 27 |
| Phalanx I.I (left)MNHN.F.LES29 | 94 | - | 65 | - | - | - | - | - | - |

TABLE S7. Selected measurements (in mm) of the ilia, pubes and ischium of Kholumolumo ellenbergerorum. **Abbreviations**: **L**, maximum anteroposterior length; **La**, anteroposterior length above the acetabulum (at the level of the notch); **H**, maximum dorsoventral height; **Hibl**, maximum dorsoventral height of the iliac blade (measured on the lateral surface above the supracetabular crest); **Dac**, maximum diameter of the acetabulum (measured on the medial side); **Lprp**, length of the preacetabular process measured from its extremity to the level of the notch; **Lpop**, length of the postacetabular process measured from its extremity to the level of the notch of the ischial peduncle; **Lpup**, length of the pubic peduncle following its main axis; **Lepup**, anteroposterior length of the extremity of the pubic peduncle measured in ventral view; **Wepup**, transverse width of the extremity of the pubic peduncle measured in ventral view; **Lisp**, length of the ischial peduncle following its main axis; **Leisp**, anteroposterior length of the extremity of the ischial peduncle measured in ventral view; **Weisp**, transverse width of the extremity of the ischial peduncle measured in ventral view; **>**, length measured given that one or both extremities of the bone are broken; **\***, deformation.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |
|  | L | La | H | Hibl | Dac | Lprp | Lpop | Lpup | Lepup | Wepup | Lisp | Leisp | Weisp |
| Ilium (right)MNHN.F.LES375a | 610 | 390 | 385 | 205 | 180 | 95 | 200 | 185 | 155 | 117 | 110 | 117 | 122 |
| Ilium (right)MNHN.F.LES396 | 550 | 360 | 350 | 180 | 177 | 85 | 160 | 160 | 113 | 90 | 75 | 102 | 105 |
|  | L | Lpp | Wpp | Hepp | Lilp | Lac | Lisp | Lpa | Wpa | Wde | Hde |  |  |
| Pubis (right)MNHN.F.LES373 | 660 | 180 | ? | >160 | 136 | 45 | ? | ≈430 | 155 | ? | ? |  |  |
| Pubis (left)MNHN.F.LES378 | 665 | 215 | 243 | 74\* | 160 | 75 | >155 | 450 | 148 | 152 | 75 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ischium (left)MNHN.F.LES152 | 315 | 300 | 160 | 51 | 70 | 31 | 155 | 68 |  |  |  |  |  |

TABLE S8. Selected measurements (mm) of the femora, tibiae and fibulae of Kholumolumo ellenbergerorum. **Abbreviations**: **L**, maximum proximodistal length; **W**, maximum transverse width; **T**, maximum anteroposterior thickness; **C**, circumference of the diaphysis (measured beneath the fourth trochanter on femora, at midpoint on tibiae and fibulae); **dp**, distance between the proximalmost point of the fourth trochanter and the proximal extremity of the femur; **IR**, robustness index (L/C); **E**, eccentricity of the diaphysis (W/T); **>**, length measured given that one or both extremities of the bone are broken; **\***, deformation.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | PROXIMAL | DIAPHYSIS | DISTAL | 4th TROCH. | RATIOS |
|  | L | W | T | W | T | C | W | T | dp | L | IR | E |
| Femur (left)MNHN.F.LES371 | 860 | 235 | 140 | 102 | 109 | 333 | 198 | 195 | 300 | 165 | 2,58 | 0,94 |
| Femur (right)MNHN.F.LES394 | 755 | 220 | 107 | 108 | 93 | 320 | 172 | 140 | 280 | 145 | 2,36 | 1,16 |
| Tibia (left)MNHN.F.LES148 | 345 | ? | ? | 50 | 51 | 165 | 99 | 67 | - | - |  |  |
| Tibia (right)MNHN.F.LES167 | >410 | 128 | 173 | 78 | 88 | 267 | ? | ? | - | - |  |  |
| Tibia (right)MNHN.F.LES381m | 510 | 130 | 205 | 63 | 100 | 270 | 148 | 116 | - | - |  |  |
| Tibia (right)MNHN.F.LES387 | 580\* | 218\* | 110\* | 90\* | 85\* | 275\* | 156\* | 90\* | - | - |  |  |
| Tibia (left)MNHN.F.LES389 | 515 | 145 | 200 | 70 | 95 | 255 | 138 | 105 | - | - |  |  |
| Fibula (right)MNHN.F.LES149 | >460 | ? | ? | 40 | 48 | 146 | 60 | 104 | - | - |  |  |
| Fibula (right)MNHN.F.LES150 | >400 | ? | ? | 46 | 54 | 163 | ? | ? | - | - |  |  |
| Fibula (right)MNHN.F.LES374 | 575 | 40 | >141 | 45 | 54 | 162 | 52 | 107 | - | - |  |  |
| Metatarsal I (left)MNHN.F.LES89 | 134 | 92 | 43 | 61 | 34 | - | 81 | 50 | - | - | - | - |
| Metatarsal II (left)MNHN.F.LES81 | 180 | ? | ? | 48 | 35 | - | 70 | 47 | - | - | - | - |
| Metatarsal III (left)MNHN.F.LES82 | 219 | 78 | 50 | 45 | 34 | - | 73 | 50 | - | - | - | - |
| Metatarsal IV (left)MNHN.F.LES381c | 228 | 100 | 40 | 43 | 27 | - | 55 | 50 | - | - | - | - |
| Metatarsal V (left)MNHN.F.LES77 | 111 | 92 | 41 | 39 | 29 | - | 36 | 31 | - | - | - | - |

APPENDIX S1. Amended data matrix from Apaldetti et al. (2018) consisting in 372 characters and 63 terminal taxa, including *Kholumolumo*, and list of anatomical characters.

#NEXUS

BEGIN DATA;

 DIMENSIONS NTAX=63 NCHAR=372;

 FORMAT DATATYPE = STANDARD GAP = - MISSING = ? SYMBOLS = " 0 1 2 3 4 5";

 MATRIX

 Euparkeria 00000000?0000?0000000?000?100100000000000000000?00000000010010000000000000000?0000000?00?000?000000000?1000000000000000000?00000000000???0000??000000000?00?0?00??00000000000000000000000?0?0?????????000?0020000000000??????00000000001?0?0?0000???00?0010?0000?0110000000000010000000000?02?000??01000001?000?100000?0000000??0?00010??0000??0001?100000000?000?????????0?00000?(0 1)0

 Crurotarsi

0000000000000?0(0 1)000000000?0000000000(0 1)0000000000000000000010000000000000000000?00000000000000000000000000000000000000000000000000000000???0000??000002000?00?0?00??00002000000000000000000000000000(0 1)00?0(0 1)0?002000000000000000000000000000000000000(0 1)000000010?0000?0(0 1)00000000000000000000000?00?0000000000001?0000000000?0000000??0?000000000000000000100000000000(0 1)0000??00???0?0?01??

 Marasuchus 00???????0?0????????????0?00???????0???????????0???????????????????????????00???00000???????????????????????00?00000000?1?100000000010???00?0??00?000000?00???00??000?00000000?000000000??01010000000?000?0121000?0000??????????????????????????????000000000000?0100010000000000000001000000011000000000000000000001000100100000?00000000000000000?00?0??00???10????????0?0000?0???

 Agnosphitys ?0???????0?0????????????11?0?0001000????????????????????????????????????????????????????????????????????????00?000000000????????????????????????????????????????????????????????000??????????????????????????1100?00????????????????????????????????00000020000100????????????????????????????????????????????????10??????011000100??0??????????????????????????????????????????????

 Anchisaurus 10???00??0102?1??11?????111011?010?001010?10001100111101110?10??????01?001101?1??002110??????10?10?00??10000000101?1(1 2)?0111?0011???1001001111011?10000?010?001100?000??0000000??0100?0??0?01?00?10?????11(0 1)0??21100101100??0??1101011100100201000002000(0 1)10113100000?0111100010011?001010000101101000000(0 1)11101000000110111?1?01?010???10111?0?01??0011?0010000010011??0????10??0?0?01??

 Barapasaurus ???????????????????????????????????????????????????????????????????????????????????????????????????????????????1?111211???????????1?1????00??002??100101??00201101111120121100?0(1 2)1001?10?11??1????????101?00?1???????11?????????????????????????????11110131011000111110011???11110010???????????????????1?1?1?????????1?1???????1?????????0???????????1?1??????5????????0000?000???

 Blikanasaurus ???????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????0000?0110111?1?0100101101011100101111112102110000100?211?0?1?11?0?0??????

 Camelotia ???????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????1???????????0??0??001??002100000000??00?0??????????1???0??011???????????????????????????????????????????????????????????????????1??????????1??00111?111011110111?1??110?000000????????????????????????????????????(1 2)???000????5???????????????????

 Cetiosaurus 1????????????????????????????????????????????????????????11?????????????????????????????????????????????????????????????2??0011110111110100100020?2001?10?1020??1011102010100???(1 2)?????1001??00100???0111101031100100011???????1?????????????????????1111013?0210?0110?1?011??1101?00???211112??0???110?111210100010010111???????????????????????????????????????5?????????1?000?????

 Chindesaurus ???????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????100?????????????01?0??0?1??0?1??????000??00???????????1??0????1?00??????????????????????????????????????????????????????????0???101?1????0??????????????00?0101110000000100??00?10111100???011110100??1??????????????????????????1???????????00??????

 Efraasia 100?1001?010??1?111?112?1110?100???00100100000??0?10??01?0??1??????10?000?1?????0110100??????10010010??11?021001010100001???1?11001101001011011010000001??001?00000000000000000110000101000?0110000?0?010011212000111001101012010?11000001110100010000100131000101000010000001100101101000011110000001100010000001101?001?011010?0?01?1110001??0011?0010000010002??0???000?1000100??

 Eoraptor 0010?000?01010?001100000101001001?000110100000?10110010101001000001001???0??1????????????????000000?0?0?0?0?00?100000000??????100001010000?10????000??00?0????00?000??00000001??10???100??????????????01?0??011???0?0????????20?000?1?000?0?0100000110100?2?001110??0???0?0???10?0010?10????0?100??0011??000?0?10?0110??1????0???????????0?0???00?0000000000??000????????????00100??

 Eucnemosaurus ??????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????0???01??001100100000??00?0??????????10000?01100?????????11???????????????????????????????????????????????????????110???0?????????????001101?1010?0010110??00000110110?????????????????????????????????????????(3 4)????????????0??????

 Gongxianosaurus 1?????0??????????12???????????????????????????????????????????????????????????????????????????????????????00???1??2121????????????0????????????1??0??001??0??????0?0??00000????????????0??0?0?1?0?000?011???2110????1?1?????????????????????????????0?100????0?????????????????????????(1 2)111?2??????0???1101??????1?0??1???0?1?1????1?11??010???10?2?1111000020005???????????????????

 Plateosaurus\_ingens ????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????01??01????????10???????????????????????????????????????????????????????????????????????????????????????????????????????????00?010????????????????????????????????????(0 1)???0?0????4????????00??00?????

 Guaibasaurus ??????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????0???01??011001000000??00000???????0?01100???????1????1?0??????????????????????????????????????????0?????1?00210100010000000010?10110?00001001000000?1?1010000?001111001?0?01????00101??0000??10?0000000000000110??0?????0?0?0101??

 Herrerasaurus 00000000?0101000000000000?00010000000000100000010001010100000100001101000000101?0000000?1000?00000000?1000000000000000001010001000000100000?000010000011??0010(0 1)10000002000000100000101100000110010100?1110??01100000000000001200000110000011011010010000002000000000000010???01?010100100001011100000110001000010000100010010010100000011000100001000000000000?02000000000?000010011

 Isanosaurus ????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????0??0???????????2??10??0???????????????2?011000???????????????????????101?0?????????????????????????????????????????????????????????????????????????????211112??0???001?1?0??????????????????????????????????????????????????????3?110??1??????????11

 Jingshanosaurus 1001?002??10211111100?0?111011101100?102001??1?10111011100001000????01100000101?211001000??1?10110010??11102100101211001????111??010??????1???10100??0011100?1???0000000000000??10??01000000001000000?0010??11201011100??00??0011?3100100?010001020000100131000002011001002??110010110?01001101000000111101010000110110?12011010?00??????0101111012000100000010?4???????????1????1??

 Lufengosaurus 100???02???0211?1?11?11111111110100101011010000101110101100010?1????0110??0110??01010100?011010010????0111?21011010100011?00011100200110111?0110100020011100110000000000000010011010010000000(0 1)10000000001011112(0 1)1011100110111101113100101201000102000010013110000201101100210110010110000101101000000211101010000110110010011110?0001?1110101110012000110000(1 2)(0 1)00410111011???00?000??

 Mamenchisaurus 11000113?11120110120000000101112??001112010101011111110121100000111221010000111?201?00?????2?11(0 1)0000100100011111111121113?0001110121010000110002?1110101010020110001102012100000110111111111011001011111100031100100110110011011000100011?0?10?1?31?11110131011?00111110011000110100100211112??0???110?01121010?1??0??????101011111??????1101??21?2?121111102??05?1?????????0?00????

 Melanorosaurus 1001?1031000211111101?1110101111???1010101101011001101011?00000010220110110010??2002010011011101?00111?1000210?10021100110?010110011011010010111?0000001??00210000000010000000?020100110010?001100????0000??21100000110??????00?0?2100101(1 2)0?0001020000100131000001011010001???1?010110?11101111001100011101000000110110010211010100001110010111001?101110000110?301100?1101?0011?1??

 Neosauropoda

1100011311112011012000001010111(0 2)11101112010101011(0 1)11110121100(0 1)10112221110010111120(0 1)200000102011100001201000(0 2)111111(0 2)12(0 1)112(0 1)00001110011110100110020121010101(0 1)0201110011020121100002100111001111(0 1)10000100111000311001(0 1)00111100010100000000110001??1?30011110131021000111110011001110(0 1)10(0 1)00211012??0???110?11121010?11000011111010111111011??111100210201211111021105?11???110?20?000211

 Neotheropoda

00(0 1)0(0 1)002(0 1)010201001100001(0 1)000000000000110000000010(0 1)100(0 1)01000001(0 1)0001(0 1 2)0100000010110000001110001000000001?00000000000000000101100110000010000(0 1)1000010200001010110010000001000000000(1 2)10001100000000010100001000101100000100010001200000010?0001001101(1 2)010101013000211101010000111110000110100001?011000000000000(0 1)011011111002001011000011111000?0?000001000000000001200000?1?00?000100(0 1)(0 1)

 Omeisaurus 110001131111201101200000101011?201001112010101011111010121100000112221110010111???0?00???1???11100001?0?00021101111121113??001110120011010111002?12101010110201100011020121100?021??1?10011100100?011111100031100100011??????0100001000110001001?31011110131011000111110011000111100100211012??0???110?01021010011?0??111?011010?11??1????1111021020121111102?105?????????0?0?0?0???

 Ornithischia 0010000000000?0000000?000?1011000100100?1000000100100001000000(0 1)000100100000000100000000010010(0 1)01(0 1)000000100111001110100001000000000010100(0 1)0000??010000000?00?0?00?000000000000000(1 2)10000000000010000100001001111100000100000000000000000000000000000000110112100010001??000?000110000000100001?010111002000000000(0 1)011110002?01?(0 1)100000111100000000000(0 1)0000000000010?000???????000?00(0 1)(0 1)

 Patagosaurus 11????????????????????????????????????????????????????????????????????????????????????????????1?00001??????0??0111012111??????1100101100000110020?2001010?00201?01111120121?00?0210011100?1?0?100???0?111?00?1100100?11?????????????????????????????1111013101000011111001100111110010?211112??0???1011111?101000??0????????????????????????????????????????????5???????????0?????11

 Plateosaurus\_engelhardti

1001100110102011(0 1)11111211110010110000100101010110011001100011001001101101101101111011000101111001011010111121001010100001100111100110100(0 1)0110110100020011100110000000000000010110100010000000010000000010011112000111001101111010111001002010000010000100131100102001010001111100101111000011110000001100010000101111100100110101000101110001100011100100000100040000001110100000001

 Plateosaurus\_gracilis ?00??001?0102?110111?1??1110?101??00?10?1010?0??0?10001100??10??????????????????1?????????????0??0110?????12100101010?001?????1100??01???01101101?00?001?100110000000000000010?1010001010000001000?00????????1200?11100?1011?10101010000???10?????0?001001311001020010100011111001011??00001111000000110?010000?0??0110????????????????????0?????????0?0????????(2 3)????????001000?00??

 Plateosauravus ???????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????10???0100101?01101?00(1 2)0011?00110000000001000000??10??011???0??110????????0???(2 3)1110011100????????????1????????????????00100131100101?01????????11??10110?00001111000000110001000000110110??????0???????????????11?0????0??????????4????????????000????

 Riojasaurus 1001?00??0102011?110??00111011011000?100001000?10010?00110001000001101?0?100101?01011??????1?001000?1??101?200010101000010??1111001101001011011010001001110011000000000000001011101001000000011000??0?01001121210111100111111?011111011001010001020?0010013110010201101000110110010110010110111010100201101000000110110010011010100??011?00011100121011000001??13????????0?101000100

 Ruehleia ???????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????10???0????01???101?002001??00110010000011000000?1100001?00?0?0110??????01001111200011100?0100??01011101000???0??00???001001311000020??11000110110?10110?101011010000002100010?00?011011001?000010100?????????????????????????????3?????????0?00010???

 Saturnalia 10????????????????????????1??1????00?100?0??????????????????10?????1??00???0?0??0?0000??????????01000??????0000100010000????????0000010010??01101?00000100001100100000000000000000000101??????????????11101111100010100?????????????????????????????0??0?01100210200000000100110010010000001001100000110001000000010100010010010100000001000000001010000?000?0010000000000000000??01

 Panphagia ?0????????1??????????0?1???????????????????0??0????????1???0???????10?1?1?1??????????????????1?01000010000?10?0101000000????????01100100011?01100?000?01???01?10000?0000000000?0???001?0100?001000?01?0010??????????????????????????????????????????0??0?111102101?00??0001??11??10110?????????????????????000010010100???00001010?????????????0?1???0????????????0??00?????????????

 Pampadromaeus 00???0021100??1?011??0???000?1000000?110?0?0?0??0?10?1??0???10????111?1??????????????????0???00000000??0010?100101000000???????????????????1??????0?0?01??001?110?01000?000000?0??0000?11?0??01????00?1010??1?????1?0?1?????????????????????????????00100111010202?????????????????????0000111110011011100?00?000??????010??????????????????????????????????????0??0???0????????????

 Shunosaurus 11000113?110201101200000001011?20100111201010101001101012000011011121010001011?120020???110200100000120100011111112121112??01011?1001?1?10010012?1100001011021?00001?0201210000?11?00?100111011001?111?1?000211001100?11000?1011001?000110000??1?3101111013101100011111?01100?111100100211112??0???100?01121010?01?0????110?101???11011??1111102002?12111?1021105???????????0?0002??

 Silesaurus 00?0??00?0000?00100000??0?00?0?01010?????????0010??0????00?????????00?0?0?0000??000000?????1?00?0?010???0?0000010001000010?00000000000???0010000000000010100001100000000000000??00000100000?0?0???????111?1110000100000?????????????????????????????000000000000000000000000?010100?0?10000110110000011000100011000000000?0000000??11?1??00??000000?00???000?001100000?0?1?00000??0(0 1)

 Staurikosaurus 00???????????????????????????????????????????????????????????????????????????????????????????0000000001000?00?0000000000????????00010????00?01001?000011?000?00000000020000001??010101100000110010????1?1???????????????????????????????????????????000000200110000110?010?00010?00000100001??000?0001?000000001000000001????01?????????????????????????????????1???????????01??????

 Tazoudasaurus 11??????????????????????????????????????????????????010??1?????????(0 2)011???1???1??????????????00?00000???0??10?1111012101???000??001010??????0002??100001??00200100011020121000????????111?1?111????11?????01?1100100??????????010?210000100?0001?310?1???03101??0?111001002??11??1??1??21100111001111011?0?0010000101010?1111011111?011??????????????1??10?1????51??0????1?0??100110

 Thecodontosaurus ?0????????????????????????1??1??1000??????0?0?0?0???000????????????10?0?0?1010??011000???????00?11010??????2100101010000?1??????000101010?1?01101?000001??00110000000000000000?1000?0101100?01000??00?010011211000101001100012010001100001010000010100000121000001???0?000??011??01010?000011110000001100010000000101100??011010100????110001110?1?000??00?0????1????????????1??00??

 Pantydraco

?0???0????????????(0 1)00?0???1??1????000100100000010?100001?00????????00?000?1?10??00100011?000?00?01010??0000?1001010100001001??1100?10101001101101?00???1????1???????????????????????0??11?00010000100?????11?1?00???????????????????????????????????00100121100001?????????0011??10110?00??????????0?1?000?0000000?01?001?????????????????001110011?000000001001?0??00000????0??????

 Unaysaurus 100110011010??1?111??1??1010?1011000????????????0??00????001???000??0?10??0?10??110100??????010?10110?????02100101010000???0?1?????0?1?0??????????0??0?11?00?10000?0??00000?????????????0????01000?00?010011?1200001100??????1????110????211???0??0??????????????????????????????????????????????????????????????110110???011010?00???????0?110???0??0???0??????1?????????10??0000??

 Vulcanodon ????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????(1 2)????????????????????1??????0111?0?00?0?0??01???2110?10?011???????????????????????????????????310(1 2)?00?01111000100111110010?111011110010111?1??20?10001?0???11?1010110111011??11?01010120111110?121?05?1??00?11?00000????

 Yunnanosaurus 100?1002??00??10011001??1011111????00101110?00??0?11011111001000001?01?0?00010???????????????10000010???0???00010?21000?1???111100110110100?0110100000011000110000000001000000?010110100000?00?0??0??001?0??11200?11100??01??0011?2101100201000(0 1)020?001001310000000110100010?110010111?0010110100000011010101000010011001?011010100011110010111001???11?0000110?2?0???11??0??1??01??

 Glacialisaurus ????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????????0???????????????00????????????????0???1010(0 1)????11010111?01???????????????101110111?0????????

 Aardonyx 1101?00210002?11?11?????1110?1011000??????1010??0?11010??10?1????????1?0????????????0??????1??0?0?1?0?????1(1 2)?00101011001?1??????0010?110100101101?0000011?00110000000020000010?1100?0110000?01110??00?????11?????????00??00??????13101???1?10??10?????????????????1110100010011??10110?101?111100000111000???????1101110?0???01??????????010111?01?0?2??00?0???0(3 4)???00011???0?111???

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**Character List**

SKULL

1. Skull to femur ratio: greater than (0), or less than (1), 0.6.

2. Lateral plates appressed to the labial side of the premaxillary, maxillary, and dentary teeth: absent (0) or present (1).

3. Relative height of the rostrum at the posterior margin of the naris: more than (0), or less than (1), 0.6 times the height of the skull at the middle of the orbit.

4. Foramen on the lateral surface of the premaxillary body: absent (0) or present (1).

5. Distal end of the dorsal premaxillary process: tapered (0) or transversely expanded (1).

6. Profile of premaxilla: convex (0) or with an inflection at the base of the dorsal process (1).

7. Size and position of the posterolateral process of premaxilla: large and lateral to the anterior process of the maxilla (0) or small and medial to the anterior process of the maxilla (1).

8. Relationship between posterolateral process of the premaxilla and the anteroventral process of the nasal: broad sutured contact (0), point contact (1), or separated by maxilla (2). Ordered.

9. Posteromedial process of the premaxilla: absent (0) or present (1).

10. Shape of the anteromedial process of the maxilla: narrow, elongated, and projecting anterior to lateral premaxilla−maxilla suture (0) or short, broad, and level with lateral premaxilla−maxilla suture (1).

11. Development of external narial fossa: absent to weak (0) or well developed with sharp posterior and anteroventral rims (1).

12. Development of narial fossa on the anterior ramus of the maxilla: weak and orientated laterally to dorsolaterally (0) or well developed and forming a horizontal shelf (1).

13. Size and position of subnarial foramen: absent (0), small (no larger than adjacent maxillary neurovascular foramina) and positioned outside of narial fossa (1), or large and on the rim of, or inside, the narial fossa (2).

14. Shape of subnarial foramen: rounded (0) or slotshaped (1).

15. Maxillary contribution to the margin of the narial fossa: absent (0) or present (1).

16. Diameter of external naris: less than (0), or greater than (1), 0.5 times the orbital diameter.

17. Shape of the external naris (in adults): rounded (0) or subtriangular with an acute posteroventral corner (1).

18. Level of the anterior margin of the external naris: anterior to (0) or posterior to (1) the midlength of the premaxillary body.

19. Level of the posterior margin of external naris: anterior to, or level with, the premaxilla−maxilla suture (0), posterior to the first maxillary alveolus (1), or posterior to the midlength of the maxillary tooth row and the anterior margin of the antorbital fenestra (2). Ordered.

20. Dorsal profile of the snout: straight to gently convex (0) or with a depression behind the naris (1).

21. Elongate median nasal depression: absent (0) or present (1).

22. Width of anteroventral process of nasal at its base: less than (0) or greater than (1) width of anterodorsal process at its base.

23. Nasal relationship with dorsal margin of antorbital fossa: not contributing to the margin of the antorbital fossa (0), lateral margin overhangs the antorbital fossa and forms its dorsal margin (1), overhang extensive, obscuring the dorsal lachrymal−maxilla contact in lateral view (2).

24. Pointed caudolateral process of the nasal overlapping the lachrymal: absent (0) or present (1).

25. Anterior profile of the maxilla: slopes continuously towards the rostral tip (0) or with a strong inflection at the base of the ascending ramus, creating a rostral ramus with parallel dorsal and ventral margins (1).

26. Length of rostral ramus of the maxilla: less than (0), or greater than (1), its dorsoventral depth.

27. Shape of the main body of the maxilla: tapering posteriorly (0) or dorsal and ventral margins parallel for most of their length (1).

28. Shape of the ascending ramus of the maxilla in lateral view: tapering dorsally (0) or with an anteroposterior expansion at the dorsal end (1).

29. Rostrocaudal length of the antorbital fossa: greater (0), or less (1), than that of the orbit.

30. Posteroventral extent of medial wall of antorbital fossa: reaching (0), or terminating anterior to (1), the anterior tip of the jugal.

31. Development of the antorbital fossa on the ascending ramus of the maxilla: deeply impressed and delimited by a sharp, scarp-like rim (0) or weakly impressed and delimited by a rounded rim or a change in slope (1).

32. Shape of the antorbital fossa: crescentic with a strongly concave posterior margin that is roughly parallel to the rostral margin of the antorbital fossa (0), subtriangular with a straight to gently concave posterior margin (1), or antorbital fossa absent (2).

33. Size of the neurovascular foramen at the caudal end of the lateral maxillary row: not larger than the others (0) or distinctly larger than the others in the row (1).

34. Direction that the neurovascular foramen at the caudal end of the lateral maxillary row opens: caudally (0) or rostrally, ventrally, or laterally (1).

35. Arrangement of lateral maxillary neurovascular foramina: linear (0) or irregular (1).

36. Longitudinal ridge on the posterior lateral surface of the maxilla: absent (0) or present (1).

37. Dorsal exposure of the lachrymal: present (0) or absent (1).

38. Shape of the lachrymal: dorsoventrally short and block-shaped (0) or dorsoventrally elongate and shaped like an inverted L (1).

39. Orientation of the lachrymal orbital margin: strongly sloping anterodorsally (0) or erect and close to vertical (1).

40. Length of the anterior ramus of the lachrymal: greater than (0), or less than (1), half the length of the ventral ramus, or absent altogether (2). Ordered.

41. Web of bone spanning junction between anterior and ventral rami of lachrymal: absent and antorbital fossa laterally exposed (0) or present, obscuring posterodorsal corner of antorbital fossa (1).

42. Extension of the antorbital fossa onto the ventral end of the lachrymal: present (0) or absent (1).

43. Length of the caudal process of the prefrontal: short (0), or elongated (1), so that total prefrontal length is equal to the rostrocaudal diameter of the orbit.

44. Ventral process of prefrontal extending down the posteromedial side of the lachrymal: present (0) or absent (1).

45. Maximum transverse width of the prefrontal: less than (0), or more than (1), 0.25 times the skull width at that level.

46. Shape of the orbit: subcircular (0) or ventrally constricted, making the orbit subtriangular (1).

47. Slender anterior process of the frontal intruding between the prefrontal and the nasal: absent (0) or present (1).

48. Jugal−lachrymal relationship: lachrymal overlapping lateral surface of jugal or abutting it dorsally (0), or jugal overlapping lachrymal laterally (1).

49. Shape of the suborbital region of the jugal: an anteroposteriorly elongate bar (0) or an anteroposteriorly shortened plate (1).

50. Jugal contribution to the antorbital fenestra: absent (0) or present (1).

51. Dorsal process of the anterior jugal: present (0) or absent (1).

52. Ratio of the minimum depth of the jugal below the orbit to the distance between the rostral end of the jugal and the rostroventral corner of the infratemporal fenestra: less than (0), or greater than (1), 0.2.

53. Transverse width of the ventral ramus of the postorbital: less than (0), or greater than (1), its rostrocaudal width at midshaft.

54. Shape of the dorsal margin of postorbital in lateral view: straight to gently curved (0) or with a distinct embayment between the anterior and posterior dorsal processes (1).

55. Height of the postorbital rim of the orbit: flush with the posterior lateral process of the postorbital (0) or raised so that it projects laterally to the posterior dorsal process (1).

56. Postfrontal bone: present (0) or absent (1).

57. Position of the rostral margin of the infratemporal fenestra: behind the orbit (0), extends under the rear half of the orbit (1), or extends as far forward as the midlength of the orbit (2). Ordered.

58. Frontal contribution to the supratemporal fenestra: present (0) or absent (1).

59. Orientation of the long axis of the supratemporal fenestra: longitudinal (0) or transverse (1).

60. Medial margin of supratemporal fossa: simple smooth curve (0) or with a projection at the frontal/ postorbital−parietal suture producing a scalloped margin (1).

61. Length of the quadratojugal ramus of the squamosal relative to the width at its base: less than (0), or greater than (1), four times its width.

62. Proportion of infratemporal fenestra bordered by squamosal: more than (0), or less than (1), 0.5 times the depth of the infratemporal fenestra.

63. Squamosal−quadratojugal contact: present (0) or absent (1).

64. Angle of divergence between jugal and squamosal rami of quadratojugal: close to 90° (0) or close to parallel (1).

65. Length of jugal ramus of quadratojugal: no longer than (0), or longer than (1), the squamosal ramus.

66. Shape of the rostral end of the jugal ramus of the quadratojugal: tapered (0) or dorsoventrally expanded (1).

67. Relationship of quadratojugal to jugal: jugal overlaps the lateral surface of the quadratojugal (0), quadratojugal overlaps the lateral surface of the jugal (1), or quadratojugal sutures along the ventrolateral margin of the jugal (2). Unordered.

68. Position of the quadrate foramen: on the quadrate−quadratojugal suture (0), deeply incised into, and partly encircled by, the quadrate (1), or on the quadrate−squamosal suture, just below the quadrate head (2). Unordered.

69. Shape of posterolateral margin of quadrate: sloping anterolaterally from posteromedial ridge (0), everted posteriorly creating a posteriorly facing fossa (1), posterior fossa deeply excavated, invading quadrate body (2). Ordered.

70. Exposure of the lateral surface of the quadrate head: absent, covered by lateral sheet of the squamosal (0) or present (1).

71. Percentage of the length of the quadrate that is occupied by the pterygoid wing: at least 70% (0) or greater than 70% (1).

72. Depth of the occipital wing of the parietal: less than (0), or more than (1), 1.5 times the depth of the foramen magnum.

73. Position of foramina for midcerebral vein on occiput: between supraoccipital and parietal (0) or on the supraoccipital (1).

74. Postparietal fenestra between supraoccipital and parietals: absent (0) or present (1).

75. Shape of the supraoccipital: diamond-shaped, at least as high as wide (0), or semilunate and wider than high (1).

76. Orientation of the supraoccipital plate: erect to gently sloping (0) or strongly sloping forward so that the dorsal tip lies level with the basipterygoid processes (1).

77. Orientation of the paroccipital processes in occipital view: slightly dorsolaterally directed to horizontal (0) or ventrolaterally directed (1).

78. Orientation of the paroccipital processes in dorsal view: posterolateral forming a V-shaped occiput (0) or lateral forming a flat occiput (1).

79. Size of the post-temporal fenestra: large fenestra (0) or a small hole that is much less than half the depth of the paroccipital process (1).

80. Exit of the midcerebral vein: through trigeminal foramen (0) or through a separate foramen anterodorsal to trigeminal foramen (1).

81. Shape of the floor of the braincase in lateral view: relatively straight with the basal tuberae, basipterygoid processes, and parasphenoid rostrum roughly aligned (0), bent with the basipterygoid processes and the parasphenoid rostrum below the level of the basioccipital condyle and the basal tuberae (1), or bent with the basal tuberae lowered below the level of the basioccipital and the parasphenoid rostrum raised above it (2). Unordered.

82. Shape of basal tuberae: knob-like, with basisphenoidal component rostral to basioccipital component (0), or forming a transverse ridge with the basisphenoidal component lateral to the basioccipital component (1).

83. Length of the basipterygoid processes (from the top of the parasphenoid to the tip of the process): less than (0), or greater than (1), the height of the braincase (from the top of the parasphenoid to the top of the supraoccipital).

84. Ridge formed along the junction of the parabasisphenoid and the basioccipital, between the basal tuberae: present with a smooth rostral face (0), present with a median fossa on the rostral face (1), or absent with the basal tuberae being separated by a deep, caudally opening U-shaped fossa (2). Unordered.

85. Deep septum spanning the interbasipterygoid space: absent (0) or present (1).

86. Dorsoventral depth of the parasphenoid rostrum: much less than (0), or about equal to (1), the transverse width.

87. Shape of jugal process of ectopterygoid: gently curved (0) or strongly recurved and hook-like (1).

88. Pneumatic fossa on the ventral surface of the ectopterygoid: present (0) or absent (1).

89. Relationship of the ectopterygoid to the pterygoid: ectopterygoid overlapping the ventral (0), or dorsal (1), surface of the pterygoid.

90. Position of the maxillary articular surface of the palatine: along the lateral margin of the bone (0) or at the end of a narrow anterolateral process owing to the absence of the posterolateral process (1).

91. Centrally located tubercle on the ventral surface of palatine: absent (0) or present (1).

92. Medial process of the pterygoid forming a hook around the basipterygoid process: absent (0), flat and blunt-ended (1), or bent upward and pointed (2). Ordered.

93. Length of the vomers: less than (0), or more than (1), 0.25 times the total skull length.

94. Position of jaw joint: no lower than the level of the dorsal margin of the dentary (0) or depressed well below this level (1).

95. Shape of upper jaws in ventral view: narrow with an acute rostral apex (0) or broad and U-shaped (1).

96. Length of the external mandibular fenestra: more than (0), or less than (1), 0.1 times the length of the mandible.

97. Caudal end of dentary tooth row medially inset with a thick lateral ridge on the dentary forming a buccal emargination: absent (0) or present (1).

98. Height: length ratio of the dentary: less than (0), or greater than (1), 0.2.

99. Orientation of the symphyseal end of the dentary: in line with the long axis of the dentary (0) or strongly curved ventrally (1).

100. Position of first dentary tooth: adjacent to symphysis (0) or inset one tooth’s width from the symphysis (1).

101. Dorsoventral expansion at the symphyseal end of the dentary: absent (0) or present (1).

102. Splenial foramen: absent (0), present and enclosed (1), or present and open anteriorly (2). Ordered.

103. Splenial−angular joint: flattened sutured contact (0), synovial joint surface between tongue-like processes of angular, fitting in groove of the splenial (1).

104. A stout, triangular, medial process of the articular, behind the glenoid: present (0) or absent (1).

105. Length of the retroarticular process: less than (0), or greater than (1), than the depth of the mandible below the glenoid.

106. Strong medial embayment behind glenoid of the articular in dorsal view: absent (0), or present (1).

107. Number of premaxillary teeth: four (0) or more than four (1).

108. Number of dentary teeth (in adults): fewer than 18 (0) or 18 or more (1).

109. Arrangement of teeth within the jaws: linearly placed, crowns not overlapping (0) or imbricated with distal side of tooth overlapping mesial side of the succeeding tooth (1).

110. Orientation of the maxillary tooth crowns: erect (0) or procumbent (1).

111. Orientation of the dentary tooth crowns: erect (0) or procumbent (1).

112. Teeth with basally constricted crowns: absent (0) or present (1).

113. Tooth–tooth occlusal wear facets: absent (0) or present (1).

114. Mesial and distal serrations of the teeth: fine and set at right angles to the margin of the tooth (0) or coarse and angled upwards at an angle of 45° to the margin of the tooth (1).

115. Distribution of serrations on the maxillary and dentary teeth: present on both the mesial and distal carinae (0), absent on the posterior carinae (1), or absent on both carinae (2). Unordered.

116. Long axis of the tooth crowns distally recurved: present (0) or absent (1).

117. Texture of the enamel surface: entirely smooth (0), finely wrinkled in some patches (1), or extensively and coarsely wrinkled (2).

118. Lingual concavities of the teeth: absent (0) or present (1).

119. Longitudinal labial grooves on the teeth: absent (0) or present (1).

120. Distribution of the serrations along the mesial and distal carinae of the tooth: extend along most of the length of the crown (0) or are restricted to the upper half of the crown (1).

VERTEBRAE

121. Number of cervical vertebrae: eight or fewer (0), nine to ten (1), 12–13 (2), or more than 13 (3). Ordered.

122. Shallow, dorsally facing fossa on the atlantal neurapophysis bordered by a dorsally everted lateral margin: absent (0) or present (1).

123. Width of axial intercentrum: less than (0), or greater than (1), width of axial centrum.

124. Position of axial prezygapophyses: on the anterolateral surface of the neural arch (0) or mounted on anteriorly projecting pedicels (1).

125. Posterior margins of the axial postzygapophyses: overhang the axial centrum (0) or are flush with the caudal face of the axial centrum (1).

126. Length of the axial centrum: less than (0), or at least (1), three times the height of the centrum.

127. Length of the anterior cervical centra (cervicals 3–5): no more than (0), or greater than (1), the length of the axial centrum.

128. Length of middle to posterior cervical centra (cervicals 6–8): no more than (0), or greater than (1), the length of the axial centrum.

129. Dorsal excavation of the cervical parapophyses: absent (0) or present (1).

130. Lateral compression of the anterior cervical vertebrae: centra are no higher than they are wide (0) or are approximately 1.25 times higher than wide (1).

131. Relative elongation of the anterior cervical centra (cervicals 3–5): lengths of the centra are less than 2.5 times the height of their anterior faces (0), lengths are 2.5–4 times the height of their anterior faces (1) or the length of at least cervicals 4 or 5 exceeds four times the anterior centrum height (2). Ordered.

132. Ventral keels on cranial cervical centra: present (0) or absent (1).

133. Height of the midcervical neural arches: no more than (0), or greater than (1), height of the posterior centrum face.

134. Cervical epipophyses on the dorsal surface of the postzygapophyses: absent (0), or present on at least some cervical vertebrae (1).

135. Caudal ends of cranial, postaxial epipophyses: with a free pointed tip (0) or joined to the postzygapophysis along their entire length (1).

136. Shape of the epipophyses: tall ridges (0) or flattened, horizontal plates (1).

137. Epipophyses overhanging the rear margin of the postzygapophyses: absent (0), or present in at least some postaxial cervical vertebrae (1).

138. Anterior spur-like projections on midcervical neural spines: absent (0) or present (1).

139. Shape of midcervical neural spines: less than (0), or at least twice as long as high (1).

140. Shape of cervical rib shafts: short and posteroventrally directed (0) or longer than the length of their centra and extending parallel to cervical column (1).

141. Position of the base of the cervical rib shaft: level with, or higher than, the ventral margin of the cervical centrum (0) or located below the ventral margin because of a ventrally extended parapophysis (1).

142. Postzygodiapophyseal lamina in cervical neural arches 4–8: present (0) or absent (1).

143. Laminae of the cervical neural arches 4–8: welldeveloped tall laminae (0) or weakly developed low ridges (1).

144. Shape of anterior centrum face in cervical centra: concave (0), flat (1), or convex (2). Ordered.

145. Ventral surface of the centra in the cervicodorsal transition: transversely rounded (0) or with longitudinal keels (1).

146. Number of vertebrae between cervicodorsal transition and primordial sacral vertebrae: 15–16 (0) or no more than 14 (1).

147. Lateral surfaces of the dorsal centra: with at most vague, shallow depressions (0), with deep fossae that approach the midline (1), or with invasive, sharp-rimmed pleurocoels (2). Ordered.

148. Oblique ridge dividing pleural fossa of cervical vertebrae: absent (0) or present (1).

149. Laterally expanded tables at the midlength of the dorsal surface of the neural spines: absent in all vertebrae (0), present on the pectoral vertebrae (1) or present on the pectoral and cervical vertebrae (2). Ordered.

150. Dorsal centra: entirely amphicoelous to amphiplatyan (0), first two dorsals are opisthocoelous (1), or cranial half of dorsal column is opisthocoelous (2). Ordered.

151. Shape of the posterior dorsal centra: relatively elongated for their size (0) strongly axially compressed for their size (1).

152. Laminae bounding triangular infradiapophyseal fossae (chonae) on dorsal neural arches: absent (0) or present (1).

153. Location of parapophysis in first two dorsals: at the anterior end of the centrum (0), or located at the midlength of the centrum, within the middle chonos (1).

154. Parapophyses of the dorsal column completely shift from the centrum to the neural arch: anterior (0), or posterior (1), to the thirteenth presacral vertebra.

155. Orientation of the transverse processes of the dorsal vertebrae: most horizontally directed (0) or all upwardly directed (1).

156. Contribution of the paradiapophyseal lamina to the margin of the anterior chonos in mid-dorsal vertebrae: present (0) or prevented by high placement of parapophysis (1).

157. Hyposphenes in the dorsal vertebrae: absent (0), present but less than the height of the neural canal (1), or present and equal to the height of the neural canal (2). Ordered.

158. Prezygodiapophyseal lamina and associated anterior triangular fossa (chonos): present on all dorsals (0) or absent in mid-dorsals (1).

159. Anterior centroparapophyseal lamina in dorsal vertebrae: absent (0) or present (1).

160. Prezygoparapophyseal lamina in dorsal vertebrae: absent (0) or present (1).

161. Accessory lamina dividing posterior chonos from postzygapophysis: absent (0) or present (1).

162. Lateral pneumatic fenestra in middle chonos of middle and posterior dorsal vertebrae opening into neural cavity: absent (0) or present (1).

163. Separation of lateral surfaces of anterior dorsal neural arches under transverse processes: widely spaced (0) or only separated by a thin midline septum (1).

164. Height of dorsal neural arches, from neurocentral suture to level of zygapophyseal facets: much less than (0), or subequal to or greater than (1), height of centrum.

165. Form of anterior surface of neural arch: simple centroprezygopophyseal ridge (0) or broad anteriorly facing surface bounded laterally by centroprezygopophyseal lamina (1).

166. Shape of posterior dorsal neural canal: subcircular (0) or slit-shaped (1).

167. Height of middle dorsal neural spines: less than the length of the base (0), higher than the length of the base but less than 1.5 times the length of the base (1) or greater than 1.5 times the length of the base (2). Ordered.

168. Shape of anterior dorsal neural spines: lateral margins parallel in anterior view (0) or transversely expanding towards dorsal end (1).

169. Cross-sectional shape of dorsal neural spines: transversely compressed (0), broad and triangular (1), or square-shaped in posterior vertebrae (2).

170. Spinodiapophyseal lamina on dorsal vertebrae: absent (0), present and separated from spinopostzygapophyseal lamina (1) or present and joining spinopostzygapophyseal lamina to create a composite posterolateral spinal lamina (2).

171. Well-developed, sheet-like suprapostzygapophyseal laminae: absent (0), present on at least the caudal dorsal vertebrae (1).

172. Shape of the spinopostzygapophyseal lamina in middle and posterior dorsal vertebrae: singular (0) or bifurcated at its distal end (1).

173. Shape of posterior margin of middle dorsal neural spines in lateral view: approximately straight (0) or concave with a projecting posterodorsal corner (1).

174. Transversely expanded plate-like summits of posterior dorsal neural spines: absent (0) or present (1).

175. Last presacral rib: free (0) or fused to vertebra (1).

176. Sacral rib much narrower than the transverse process of the first primordial sacral vertebra (and dorsosacral if present) in dorsal view: absent (0) or present (1).

177. Number of dorsosacral vertebrae: none (0), one (1), or two (2). Ordered.

178. Caudosacral vertebra: absent (0) or present (1).

179. Shape of the iliac articular facets of the first primordial sacral rib: singular (0) or divided into dorsal and ventral facets separated by a nonarticulating gap (1).

180. Depth of the iliac articular surface of the primordial sacrals: less than (0), or greater than (1), 0.75 times the depth of the ilium.

181. Sacral ribs contributing to the rim of the acetabulum: absent (0) or present (1).

182. Posterior and anterior expansion of the transverse processes of the first and second primordial sacral vertebrae, respectively, partly roofing the intercostal space: absent (0) or present (1).

183. Length of first caudal centrum: greater than (0), or less than (1), its height.

184. Length of base of the proximal caudal neural spines: less than (0), or greater than (1), half the length of the neural arch.

185. Position of postzygapophyses in proximal caudal vertebrae: protruding with an interpostzygapophyseal notch visible in dorsal view (0) or placed on either side of the caudal end of the base of the neural spine without any interpostzygapophyseal notch (1).

186. A hyposphenal ridge on caudal vertebrae: absent (0) or present (1).

187. Depth of the bases of the proximal caudal transverse processes: shallow, restricted to the neural arches (0), deep, extending from the centrum to the neural arch (1).

188. Position of last caudal vertebra with a protruding transverse process: distal (0), or proximal (1), to caudal 16.

189. Orientation of posterior margin of proximal caudal neural spines: sloping posterodorsally (0) or vertical (1).

190. Longitudinal ventral sulcus on proximal and middle caudal vertebrae: present (0) or absent (1).

191. Length of midcaudal centra: greater than (0), or less than (1), twice the height of their anterior faces.

192. Cross-sectional shape of the distal caudal centra: oval with rounded lateral and ventral sides (0) or square-shaped with flattened lateral and ventral sides (1).

193. Length of distal caudal prezygapophyses: short, not overlapping the preceding centrum by more than a quarter (0) or long and overlapping the preceding centrum by more than a quarter (1).

194. Shape of the terminal caudal vertebrae: unfused, size decreasing toward tip (0) or expanded and fused to form a club-shaped tail (1).

195. Length of the longest chevron: is less than (0), or greater than (1), twice the length of the preceding centrum.

196. Anteroventral process on distal chevrons: absent (0) or present (1).

197. Midcaudal chevrons with a ventral slit: absent (0) or present (1).

APPENDICULAR SKELETON

198. Longitudinal ridge on the dorsal surface of the sternal plate: absent (0) or present (1).

199. Craniocaudal length of the acromion process of the scapula: less than (0), or greater than (1), 1.5 times the minimum width of the scapula blade.

200. Minimum width of the scapula: less than (0), or greater than (1), 20% of its length.

201. Caudal margin of the acromion process of the scapula: rises from the blade at angle that is less than (0), or greater than (1), 65° from the long axis of the scapula at its steepest point.

202. Width of dorsal expansion of the scapula: less than (0), or equal to (1), the width of the ventral end of the scapula.

203. Flat, caudoventrally facing surface on the coracoid between glenoid and coracoid tubercle: absent (0) or present (1).

204. Coracoid tubercle: present (0) or absent (1).

205. Length of the humerus: less than 55% (0), 55– 65% (1), 65–70% (2), or more than 70% (3), of the length of the femur. Ordered.

206. Shape of the deltopectoral crest: subtriangular (0) or subrectangular (1).

207. Length of the deltopectoral crest of the humerus: less than 30% (0), 30–50% (1), or greater than 50% (2), of the length of the humerus. Ordered.

208. Shape of the anterolateral margin of the deltopectoral crest of the humerus: straight (0) or strongly sinuous (1).

209. Rugose pit centrally located on the lateral surface of the deltopectoral crest: absent (0) or present (1).

210. Well-defined fossa on the distal flexor surface of the humerus: present (0) or absent (1).

211. Transverse width of the distal humerus: is less than (0), or greater than (1), 33% of the length of the humerus.

212. Shape of the entepicondyle of the distal humerus: rounded process (0) or with a flat, distomedially facing surface bounded by a sharp proximal margin (1).

213. Length of the radius: greater than (0), or less than (1), 80% of the length of the humerus.

214. Deep radial fossa, bounded by an anterolateral process, on proximal ulna: absent (0) or present (1).

215. Olecranon process on proximal ulna: present (0) or absent (1).

216. Maximum linear dimensions of the ulnare and radiale: exceed that of at least one of the first three distal carpals (0) or are less than any of the distal carpals (1).

217. Transverse width of the first distal carpal: less than (0), or greater than (1), 120% of the transverse width of the second distal carpal.

218. Sulcus across the medial end of the first distal carpal: absent (0) or present (1).

219. Lateral end of first distal carpal: abuts (0), or overlaps (1), second distal carpal.

220. Second distal carpal: does (0), or does not (1), completely cover the proximal end of the second metacarpal.

221. Ossification of the fifth distal carpal: present (0) or absent (1).

222. Length of the manus: less than 38% (0), 38– 45% (1), or greater than 45% (2), of the humerus + radius. Ordered.

223. Shape of metacarpus: flattened to gently curved and spreading (0) or a colonnade of subparallel metacarpals tightly curved into a U-shape (1).

224. Proximal width of first metacarpal: less than (0), or greater than (1), the proximal width of the second metacarpal.

225. Minimum transverse shaft width of first metacarpal: less than (0), or greater than (1), twice the minimum transverse shaft width of second metacarpal.

226. Proximal end of first metacarpal: flush with other metacarpals (0) or inset into the carpus (1).

227. Shape of the first metacarpal: proximal width less than 65% (0), 65–80% (1), 80–100% (2), or greater than 100% (3), of its length. Ordered.

228. Strong asymmetry in the lateral and medial distal condyles of the first metacarpal: absent (0) or present (1).

229. Deep distal extensor pits on the second and third metacarpals: absent (0) or present (1).

230. Shape of the distal ends of second and third metacarpals: subrectangular in distal view (0) or trapezoidal with flexor rims of distal collateral ligament pits flaring beyond extensor rims (1).

231. Shape of the fifth metacarpal: longer than wide at the proximal end with a flat proximal surface (0) or close to as wide as it is long with a strongly convex proximal articulation surface (1).

232. Length of the fifth metacarpal: less than (0), or greater than (1), 75% of the length of the third metacarpal.

233. Length of manual digit one: less than (0), or greater than (1), the length of manual digit two.

234. Ventrolateral twisting of the transverse axis of the distal end of the first phalanx of manual digit one relative to its proximal end: absent (0), present but much less than 60° (1), or 60° (2). Ordered.

235. Length of the first phalanx of manual digit one: less than (0), or greater than (1), the length of the first metacarpal.

236. Shape of the proximal articular surface of the first phalanx of manual digit one: rounded (0) or with an embayment on the medial side (1).

237. Shape of the first phalanx of manual digit one: elongate and subcylindrical (0) or strongly proximodistally compressed and wedge-shaped (1).

238. Length of the penultimate phalanx of manual digit two: less than (0), or greater than (1), the length of the second metacarpal.

239. Length of the penultimate phalanx of manual digit three: less than (0), or greater than (1), the length of the third metacarpal.

240. Shape of nonterminal phalanges of manual digits two and three: longer than wide (0) or as long as wide (1).

241. Shape of the unguals of manual digits two and three: straight (0), or strongly curved with tips projecting well below flexor margin of proximal articular surface (1).

242. Length of the ungual of manual digit two: greater than the length of the ungual of manual digit one (0), 75–100% of the ungual of manual digit one (1), less than 75% of the ungual of manual digit one (2), or the ungual of manual digit two is absent (3). Ordered.

243. Phalangeal formula of manual digits two and three: three and four, respectively (0), or with at least one phalanx missing from each digit (1).

244. Phalangeal formula of manual digits four and five: greater than (0), or less than (1), 2–0 respectively.

245. Strongly convex dorsal margin of the ilium: absent (0) or present (1).

246. Cranial extent of preacetabular process of ilium: does not (0), or does (1), project further forward than cranial end of the pubic peduncle.

247. Shape of the preacetabular process: blunt and rectangular (0) or with a pointed, projecting cranioventral corner and a rounded dorsum (1).

248. Depth of the preacetabular process of the ilium: much less than (0), or subequal to (1), the depth of the ilium above the acetabulum.

249. Length of preacetabular process of the ilium: less than (0), or greater than (1), twice its depth.

250. Buttress between preacetabular process and the supra-acetabular crest of the ilium: present (0) or absent (1).

251. Medial wall of acetabulum: fully closing acetabulum with a triangular ventral process between the pubic and ischial peduncles (0), partially open acetabulum with a straight ventral margin between the peduncles (1), partially open acetabulum with a concave ventral margin between the peduncles (2), or fully open acetabulum with medial ventral margin closely approximating lateral rim of acetabulum (3). Ordered.

252. Length of the pubic peduncle of the ilium: less than (0), or greater than (1), twice the craniocaudal width of its distal end.

253. Caudally projecting ‘heel’ at the distal end of the ischial peduncle: absent (0) or present (1).

254. Length of the ischial peduncle of the ilium: similar to pubic peduncle (0), much shorter than pubic peduncle (1), or virtually absent so that the chord connecting the distal end of the pubic peduncle with the ischial articular surface contacts the postacetabular process (2). Ordered.

255. Length of the postacetabular process of the ilium: between 40 and 100% of the distance between the pubic and ischial peduncles (0), less than 40% of this distance (1), or more than 100% of this distance (2). Unordered.

256. Well-developed brevis fossa with sharp margins on the ventral surface of the postacetabular process of the ilium: absent (0) or present (1).

257. Anterior end of ventrolateral ridge bounding brevis fossa: not connected to (0), or joining (1), supraacetabular crest (1).

258. Shape of the caudal margin of the postacetabular process of the ilium: rounded to bluntly pointed (0), square-ended (1), or with a pointed ventral corner and a rounded caudodorsal margin (2). Unordered.

259. Width of the conjoined pubes: less than (0), or greater than (1), 75% of their length.

260. Pubic tubercle on the lateral surface of the proximal pubis: present (0) or absent (1).

261. Proximal anterior profile of pubis: anterior margin of pubic apron smoothly confluent with anterior margin of iliac pedicel (0) or iliac pedicel set anterior to the pubic apron, creating a prominent inflection in the proximal anterior profile of the pubis (1).

262. Minimum transverse width of the pubic apron: much more than (0), or less than (1), 40% of the width across the iliac peduncles of the ilium.

263. Position of the obturator foramen of the pubis: at least partially occluded by the iliac pedicel (0), or completely visible (1), in anterior view.

264. Lateral margins of the pubic apron in anterior view: straight (0) or concave (1).

265. Orientation of distal third of the blades of the pubic apron: confluent with the proximal part of the pubic apron (0) or twisted posterolaterally relative to proximal section so that the anterior surface turns to face laterally (1).

266. Orientation of the entire blades of the pubic apron: transverse (0) or twisted posteromedially (1).

267. Craniocaudal expansion of the distal pubis: absent (0), less than (1), or greater than (2), 15% of the length of the pubis. Ordered.

268. Notch separating posteroventral end of the ischial obturator plate from the ischial shaft: present (0) or absent (1).

269. Elongate interischial fenestra: absent (0) or present (1).

270. Longitudinal dorsolateral sulcus on proximal ischium: absent (0) or present (1).

271. Shape of distal ischium: broad and plate-like, not distinct from obturator region (0) or with a discrete, rod-like distal shaft (1).

272. Length of ischium: less than (0), or greater than (1), that of the pubis.

273. Ischial component of acetabular rim: larger than (0), or equal to (1), the pubic component.

274. Shape of the transverse section of the ischial shaft: ovoid to subrectangular (0) or triangular (1).

275. Orientation of the long axes of the transverse section of the distal ischia: meet at an angle (0) or are coplanar (1).

276. Depth of the transverse section of the ischial shaft: much less than (0), or at least as great as (1), the transverse width of the section.

277. Distal ischial expansion: absent (0) or present (1).

278. Transverse width of the conjoined distal ischial expansions: greater than (0), or less than (1), their sagittal depth.

279. Length of the hindlimb: greater than (0), or less than (1), the length of the trunk.

280. Longitudinal axis of the femur in lateral view: strongly bent with an offset between the proximal and distal axes greater than 15° (0), weakly bent with an offset of less than 10° (1), or straight (2). Ordered.

281. Shape of the cross-section of the midshaft of the femur: subcircular (0) or strongly elliptical with the long axis orientated mediolaterally (1).

282. Angle between the long axis of the femoral head and the transverse axis of the distal femur: about 30° (0) or close to 0° (1).

283. Shape of femoral head: roughly rectangular in profile with a sharp medial distal corner (0) or roughly hemispherical with no sharp medial distal corner (1).

284. Posterior proximal tubercle on femur: well developed (0) or indistinct to absent (1).

285. Shape of the lesser trochanter: small rounded tubercle (0), proximodistally orientated, elongate ridge (1), or absent (2). Unordered.

286. Position of proximal tip of lesser trochanter: level with (0), or distal to (1), the femoral head.

287. Projection of the lesser trochanter: just a scar upon the femoral surface (0) or a raised process (1).

288. Transverse ridge extending laterally from the lesser trochanter: absent (0) or present (1).

289. Height of the lesser trochanter in cross section: less than (0), or at least as high as (1), basal width.

290. Position of the lesser trochanter: near the centre of the anterior face (0), or close to the lateral margin (1), of the femoral shaft in anterior view.

291. Visibility of the lesser trochanter in posterior view: not visible (0) or visible (1).

292. Height of the fourth trochanter: tall crest (0) or a low rugose ridge (1).

293. Position of the fourth trochanter along the length of the femur: in the proximal half (0) or straddling the midpoint (1).

294. Symmetry of the profile of the fourth trochanter of the femur: subsymmetrical without a sharp distal corner (0) or asymmetrical with a steeper distal slope than the proximal slope and a distinct distal corner (1).

295. Shape of the profile of the fourth trochanter of the femur: rounded (0) or subrectangular (1).

296. Position of fourth trochanter along the mediolateral axis of the femur: centrally located (0) or on the medial margin (1).

297. Extensor depression on anterior surface of the distal end of the femur: absent (0) or present (1).

298. Size of the medial condyle of the distal femur: subequal to (0), or larger than (1), the fibular + lateral condyles.

299. Tibia: femur length ratio: greater than 1.0 (0), between 0.6 and 1.0 (1) or less than 0.6 (2). Ordered.

300. Orientation of cnemial crest: projects anteriorly to anterolaterally (0) or projecting laterally (1).

301. Paramarginal ridge on lateral surface of cnemial crest: absent (0) or present (1).

302. Position of the tallest point of the cnemial crest: close to the proximal end of the crest (0) or about half-way along the length of the crest, creating an anterodorsally sloping proximal margin of the crest (1).

303. Proximal end of tibia with a flange of bone that contacts the fibula: absent (0) or present (1).

304. Position of the posterior end of the fibular condyle on the proximal articular surface tibia: anterior to (0) or level with (1), the posterior margin of the proximal articular surface.

305. Shape of the proximal articular surface of the tibia: ovoid, anteroposteriorly longer than transversely wide (0) or subcircular and as wide transversely as anteroposteriorly long (1).

306. Transverse width of the distal tibia: subequal to (0), or greater than (1), its craniocaudal length.

307. Anteroposterior width of the lateral side of the distal articular surface of the tibia: as wide (0), or narrower than (1), the anteroposterior width of the medial side.

308. Relationship of the posterolateral process of the distal end of the tibia with the fibula: not flaring laterally and not making significant contact with the fibula (0) or flaring laterally and backing the fibula (1).

309. Shape of the distal articular end of the tibia in distal view: ovoid (0) or subrectangular (1).

310. Shape of the anteromedial corner of the distal articular surface of the tibia: forming a right angle (0) or forming an acute angle (1).

311. Position of the lateral margin of descending caudoventral process of the distal end of the tibia: protrudes laterally at least as far as (0), or set well back from (1), the craniolateral corner of the distal tibia.

312. A triangular rugose area on the medial side of the fibula: absent (0) or present (1).

313. Transverse width of the midshaft of the fibula: greater than 0.75 (0), between 0.5 and 0.75 (1), or less than 0.5 (2), times the transverse width of the midshaft of the tibia. Ordered.

314. Position of fibula trochanter: on anterior surface of fibula (0), laterally facing (1), or anteriorly facing but with strong lateral bulge (2).

315. Depth of the medial end of the astragalar body in cranial view: roughly equal to the lateral end (0) or much shallower, creating a wedgeshaped astragalar body (1).

316. Shape of the posteromedial margin of the astragalus in dorsal view: forming a moderately sharp corner of a subrectangular astragalus (0) or evenly rounded without formation of a caudomedial corner (1).

317. Dorsally facing horizontal shelf forming part of the fibular facet of the astragalus: present (0) or absent with a largely vertical fibular facet (1).

318. Pyramidal dorsal process on the posteromedial corner of the astragalus: absent (0) or present (1).

319. Shape of the ascending process of the astragalus: anteroposteriorly deeper than transversely wide (0) or transversely wider than anteroposteriorly deep (1).

320. Posterior extent of ascending process of the astragalus: well anterior to (0), or close to the posterior margin of (1), the astragalus.

321. Sharp medial margin around the depression posterior to the ascending process of the astragalus: absent (0) or present (1).

322. Buttress dividing posterior fossa of astragalus and supporting ascending process: absent (0) or present (1).

323. Vascular foramina set in a fossa at the base of the ascending process of the astragalus: present (0) or absent (1).

324. Transverse width of the calcaneum: greater than (0), or less than (1), 30% of the transverse width of the astragalus.

325. Lateral surface of calcaneum: simple (0) or with a fossa (1).

326. Medial peg of calcaneum fitting into astragalus: present, even if rudimentary (0) or absent (1).

327. Calcaneal tuber: large and well developed (0) or highly reduced to absent (1).

328. Shape of posteromedial heel of distal tarsal four (lateral distal tarsal): proximodistally deepest part of the bone (0) or no deeper than the rest of the bone (1).

329. Shape of posteromedial process of distal tarsal four in proximal view: rounded (0) or pointed (1).

330. Ossified distal tarsals: present (0) or absent (1).

331. Proximal width of the first metatarsal: less than (0), or at least as great as (1), the proximal width of the second metatarsal.

332. Orientation of proximal articular surface of metatarsal one: horizontal (0) or sloping proximolaterally relative to the long axis of the bone (1).

333. Orientation of the transverse axis of the distal end of metatarsal one: horizontal (0) or angled proximomedially (1).

334. Shape of the medial margin of the proximal surface of the second metatarsal: straight (0) or concave (1).

335. Shape of the lateral margin of the proximal surface of the second metatarsal: straight (0) or concave (1).

336. Length of the third metatarsal: greater than (0), or less than (1), 40% of the length of the tibia.

337. Minimum transverse shaft diameters of third and fourth metatarsals: greater than (0), or less than (1), 60% of the minimum transverse shaft diameter of the second metatarsal.

338. Transverse width of the proximal end of the fourth metatarsal: less than (0), or at least (1), twice the anteroposterior depth of the proximal end.

339. Transverse width of the proximal end of the fifth metatarsal: less than 25% (0), between 30 and 49% (1), or greater than 50% (2), of the length of the fifth metatarsal. Ordered.

340. Transverse width of distal articular surface of metatarsal four in distal view: greater (0), or less than (1), anteroposterior depth.

341. Pedal digit five: reduced, nonweight bearing (0) or large (fifth metatarsal at least 70% of fourth metatarsal), robust and weight bearing (1).

342. Length of nonterminal pedal phalanges: all longer than wide (0), proximal-most phalanges longer than wide whereas more distal phalanges are as wide as long (1), or all nonterminal phalanges are as wide, if not wider, than long (2). Ordered.

343. Length of the first phalanx of pedal digit one: greater than (0), or less than (1), the length of the ungual of pedal digit one.

344. Length of the ungual of pedal digit one: less than at least some nonterminal phalanges (0) or longer than all nonterminal phalanges (1).

345. Shape of the ungual of pedal digit one: shallow, pointed, with convex sides and a broad ventral surface (0) or deep, abruptly tapering, with flattened sides and a narrow ventral surface (1).

346. Shape of proximal articular surface of pedal unguals: proximally facing, visible on medial and lateral sides (0) or proximomedially facing and visible only in medial view, causing medial deflection of pedal unguals in articulation (1).

347. Penultimate phalanges of pedal digits two and three: well developed (0) or reduced disc-shaped elements if they are ossified at all (1).

348. Shape of the unguals of pedal digits two and three: dorsoventrally deep with a proximal articulating surface that is at least as deep as it is wide (0) or dorsoventrally flattened with a proximal articulating surface that is wider than deep (1).

349. Length of the ungual of pedal digit two: greater than (0), between 90 and 100% of (1), or less than 90% of (2), the length of the ungual of pedal digit one. Ordered.

350. Size of the ungual of pedal digit three: greater than (0), or less than (1), 85% of the ungual of pedal digit two in all linear dimensions.

351. Number of phalanges in pedal digit four: four (0) or fewer than four (1).

352. Phalanges of pedal digit five: present (0) or absent (1).

353. Femoral length: less than 200 mm (0), between 200 and 399 mm (1), between 400 and 599 mm (2), between 600 and 799 mm (3), between 800 and 1000 mm (4), or greater than 1000 mm. Ordered.

354. Lateral extent of ventrolateral flange on plantar surface of metatarsal II in proximal aspect: similar in development to ventromedial flange (0) or well developed, extending further laterally than ventromedial flange extends medially (1).

355. Distal articular surface of astragalus: relatively flat or weakly convex (0) or extremely convex and ‘roller-shaped’ (1).

356. Distal surface of tibiofibular crest: as deep anteroposteriorly as wide mediolaterally or deeper (0) or wider mediolaterally than deep anteroposteriorly (1).

357. Well-developed facet on proximolateral corner of plantar ventrolateral flange of metatarsal II for articulation with medial distal tarsal: absent (0) or present (1).

358. Proximal outline of metatarsal III: subtriangular with acute or rounded posterior border (0) or subtrapezoidal, with posterior border broadly exposed in plantar view (1).

359. Angle formed by the anterior and anteromedial borders of metatarsal IV: obtuse (0), right angle or acute (1).

360. Well-developed tibiofibular crest on distal femur: absent (0) or present (1).

361. Shaft of metatarsal I: closely appressed to metatarsal II throughout its length (0) or only closely appressed proximally, with a space between metatarsals I and II distally (1).

362. Posterior margin of astragalus: straight (0) or convex (1).

363. Ventromedial ridge of scapula: absent (0) or present (1).

364. Mediolateral surface of distal astragalus straight (0), concave (1), or convex (0). Unordered.

365. Anterior fossa on the proximal region of the pubic apron: absent (0) or present (1).

366. Proximal end of the tibia with a transverse/ anteroposterior length ratio: narrow (ratio less than 0.7) (0) or broad (more than 0.7) (1).

367. Caudodistal tubercle of the radius: absent (0) or present (1).

368. Biceps tubercle of the radius: absent (0) or present (1).

369. Ventromedial margin of first metacarpal: poorly concave (0) or deeply concave (1).

370. Length of first phalanx of manual digit 1: much greater than (0), subequal or equal to (1), or much less than (2), its mediolateral width at proximal end.

371. Presence of growth marks (LAGs and/or annuli) in the cortical bone: growth marks in the whole cortex (0) and growth marks absent or only formed in the outer cortex (1).

372. Relative abundance of woven fibered (WFB) or parallel fibered bone (PFB) in the primary compact bone: PFB> WFB:0, WFB> PFB.

FIGURE S1. Strict consensus tree of the phylogenetic analysis conducted with 63 taxa and 372 characters and based on the matrix and scorings (except for *Kholumolumo*) of Apaldetti et al. (2018). Consensus tree of 44 MPTs of 1,491 steps each (CI = 0.29, RI = 0.64).



FIGURE S2. Strict consensus tree of the phylogenetic analysis conducted with 60 taxa and 372 characters and based on the matrix and scorings (except for *Kholumolumo*) of Apaldetti et al. 2018. *Barapasaurus*, *Isanosaurus*, and *Gongxianosaurus* were pruned a priori. Consensus tree of 72 MPTs of 1,472 steps each (CI = 0.29, RI = 0.61).



TABLE S9. Size and body mass estimations for Kholumolumo ellenbergerorum compared to those of other Gondwanan basal sauropodomorphs from the Norian or Rhaetian. The parameters were defined by Campione & Evans (2012) and the linear regression curve is from Apaldetti et al. (2018). Material used for Kholumolumo measurements: MNHN.F.LES371 (femur); MNHN.F.LES390 (humerus); MNHN.F.LES386 (scapula); MNHN.F.LES375a (ilium). Specimens considered for the comparison: Coloradisaurus PVL 5904; Lessemsaurus 1 PVL 4822 (subadult); Lessemsaurus 2 CRILAR PV-303 (scapula), CRILAR PV-302 (ilium); Melanorosaurus NM QR 1551; Plateosauravus SAM PK 3602 (femur), SAM PK 3609 (ilium); Riojasaurus PVL 3808; Ruehleia MB.R.4718; Unaysaurus UFSM11069. All were measured first-hand, except Unaysaurus.

|  |  |  |
| --- | --- | --- |
| Genera | Size | Body mass |
|  | Sizeestimation(Sander and Klein, 2005) | Bipedal equation(Benson et al., 2018) | Quadrupedal equation(Benson et al., 2018) | Scapula equation(Apaldetti et al., 2018) | IliumEquation (Apaldetti et al., 2018) |
| *Kholumolumo* | 8.6 m | 1754 kg | 3259 kg | 3864 kg | 3963 kg |
| *Coloradisaurus* | 5.0 m | 438 kg | 757 kg | 307 kg | ? |
| *Lessemsaurus* 1 | 8.4 m | 1963 kg | 2208 kg | 1746 kg | 2792 kg |
| *Lessemsaurus* 2 | ? | ? | ? | 5268 kg | 7165 kg |
| *Melanorosaurus* | 6.2 m | 946 kg | 1603 kg | 1396 kg | 1656 kg |
| *Plateosauravus* | 8.0 m | 824 kg | ? | ? | 2792 kg |
| *Riojasaurus* | 6.1 m | 1005 kg | 1923 kg | ? | 1552 kg |
| *Ruehleia* | 7.6 m | 986 kg | ? | ? | 2371 kg |
| *Unaysaurus* | ? | ? | ? | 88 kg | ? |

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