Supplementary Information Soto-Acuña et al. (2021)

"Bizarre tail weaponry in a transitional ankylosaur from subantarctic Chile"

†email: sesotacu@ug.uchile.cl, alexvargas@uchile.cl

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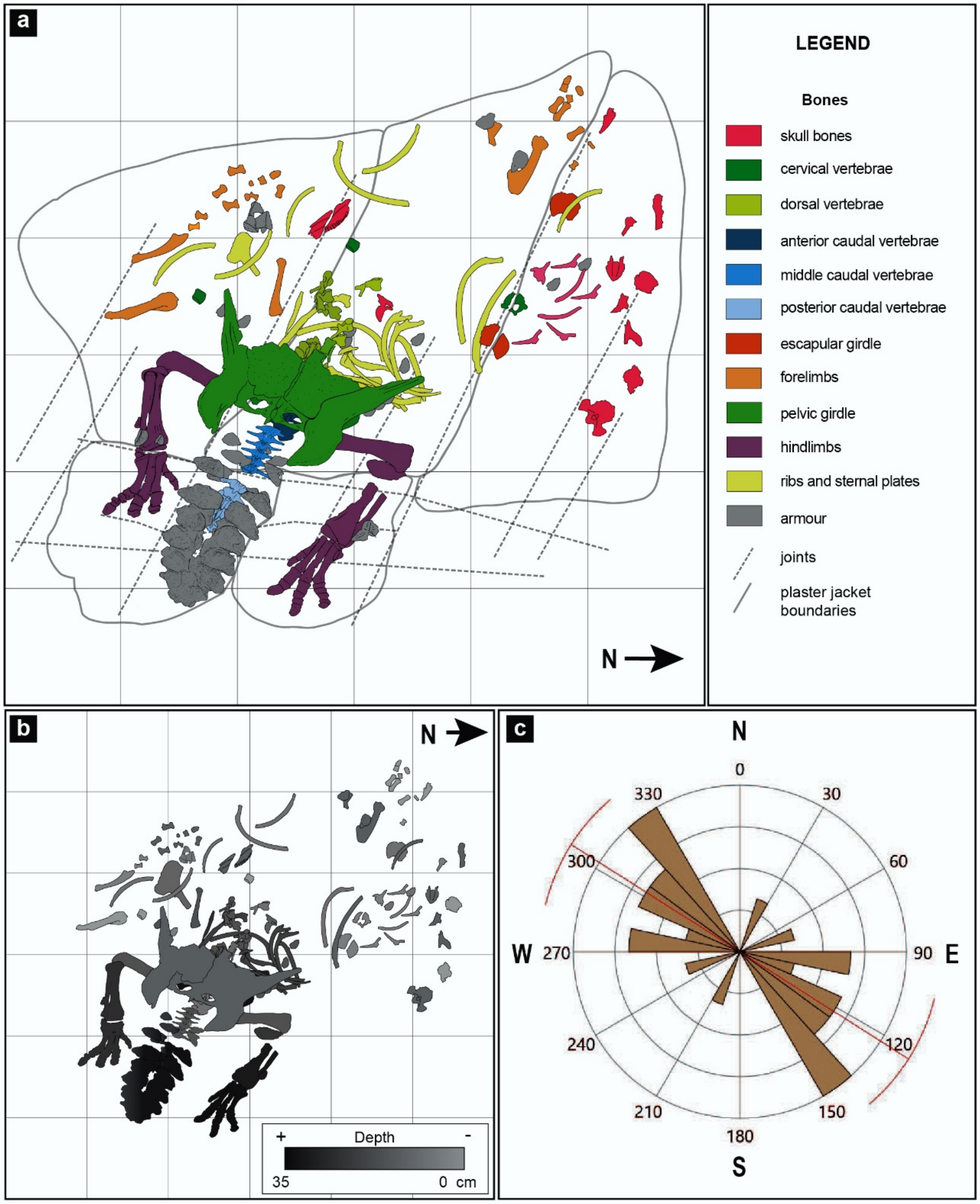
1. Taphonomical aspects of the holotype

The holotype of *Stegouros* was found semi-articulated, partially exposed in a slope within a coarse to medium grain sandstone level, featuring some centimetric mudstone intercalations. The whole skeleton lay within a vertical range of approximately 40 cm (Supplementary Fig. 1a, b). These layers are interpreted locally as the bar of a river in a meandering fluvial system (Supplementary Fig. 1a, b). The posterior half of the skeleton, including most of the pelvis, hindlimbs, and tail was articulated. In contrast, the anterior half of the skeleton was mostly disarticulated but closely associated in an area of approximately 2 m^2. The posterior half of the skeleton was also the portion lying deepest respect to the sandy (bottom) to muddy (top) layers of sediment (Supplementary Data Fig. 1b). The skeleton was not overturned, with its dorsal aspect facing upward. The proximal portion of the tail was bent into a "zig-zag" below the pelvis, with the distal tail closer to the pelvic girdle than would be expected in its natural extended position. Within the articulated half of the skeleton, portions of some elements are absent, such as part of the right diaphysis of the tibia and fibula. This is likely due to diagenetic alteration marked by the presence of joints (diaclases) which were mapped in relation to bone positions and orientation (Supplementary Fig. 1a). One joint plane also coincides with the breakage and unnatural position of the proximal tail, and the missing posterior half of the 18th caudal vertebra, distal to which all vertebrae within the caudal weapon are missing (supplementary movie 1). This brings up the possibility that the joint may have led to conditions within the tail weapon that were unfavourable for preservation of these vertebrae.

A directional analysis (rose diagram) was performed using PAST 4.0 (Hammer et al., 2001). Due to extreme field conditions and challenging weather, the direction of some dorsal ribs, some cervical ribs, left sternal plate, right radius, ulna, and articulated manus were not measured in the field. Their positions shown in the quarry map are according to observations made during the preparation process. A list of elements was made, considering those recovered at the quarry and throughout the preparation of the five jackets processed in the laboratory (Supplementary Table I). The presence/absence of elements was then compared to attributed susceptibility to transportation of the Voorhies groups (Voorhies, 1969), taking into consideration the revisions undertaken by several authors (Behrensmeyer, 1975; Wood, 1988; Holz and Barberena, 1994; Kaufman et al, 2011). The recovered disarticulated elements were consistent with the skeletal composition and proportions expected for a single individual, since no duplicated elements were found, and every element had a consistent size and proportion (Supplementary Table I). Moreover, the articulated portion has a similar surface texture to the associated anterior portion of the specimen. The directional analysis showed a preferred trend to the NW-SE (Supplementary Fig.1c; $p<0.05$)- Accordingly, the palaeocurrent direction measured in the trough cross-bedding structure of the sandstone bed at the bottom of the deposition site was of NW direction (290º). The top layer of the depositional site had no visible sedimentary structures that denote any movement by currents, being thinner in granulometry (Extended Data Fig.1b) and therefore interpreted as a calmer deposition environment at the final part of this portion of the sequence. On the other hand, no alteration of the bone was observed regarding abrasion or wear pattern (which could be obscured by diagenetic processes) and the analysis of presence/absence of elements based on expected skeletal completeness is unrelated to water transportation for most of the transportability classifications. For example, most of the phalanges are present, as well as most vertebrae, ribs, sacrum, ilia (groups I and II, sensu Voorhies, 1969; Holz and Barberena, 1994). Meanwhile, the elements that are missing include scapulae and vertebrae, including the more distal caudal vertebrae within the caudal weapon (group I or II, Voorhies, 1969; Holz and Barberena, 1994; Group I of Kaufman et al., 2011), some of the cranial bones (group III for all authors, including Beherensmeyer, 1975) and most of the left dentary (Group II or III Voorhies, 1969; Holz and Barberena, 1994; Group I of Kaufman et al., 2011). It is possible that missing skull elements were removed by recent weathering of the site, considering that skull elements were found in disarticulation, and lied within the first 5 to 10 cm of depth in the sediment. Nevertheless, no recovered skull bone was extensively exposed at the moment of the excavation. Since there is an observed directional trend, but not an expected pattern of bone removal, it is possible that hydrodynamic transportation is one of the factors of bone dispersion, but not entirely responsible for the resulting pattern. In turn, combined action of breakage and disarticulation through biotic activity and later redirection though a weak hydraulic transport could explain the scattering of these bones through breakage and forced disarticulation of the skull and neck (although there are no evident scavenging marks) and some degree of trampling or scavenging related to delayed burial of the anterior portion of the skeleton. Given that this skeleton differs from the most common upside-down position for floating ankylosaur carcasses (as analysed by Mallon et al., 2018), if there was any transportation of the entire carcass, it would have been for a rather short distance, without time for bloating. A plausible explanation to the whole ensemble would be rapid burial of the posterior portion, or as a dead carcass floating down the river, deposited at the river bar and rapidly buried (Weigelt, 1989). Meanwhile, the anterior portion could be slightly dispersed by a low energy water current as scavenging disarticulated and dispersed the remaining exposed bones, for a longer time span during which the anterior portion remained exposed. The possibility of a floating carcass has the significant directional trend to its favour (both articulated and associated portions of the skeleton) but would not suppose a very long transportation stage from its original death place, given articulation (Holz and Barerena, 1994) and no evidence for bloating (according to Mallon et al., 2018). If the unnatural breakage of the tail and its missing distal caudal vertebrae are diagenetic and related to the associated joints, a quicksand death trap scenario remains plausible. This can be argued from the lower depth of the skeleton based on its exquisite preservation of almost perfectly articulated bones, the skull and vertebral column twisted to the side (Weigtl, 1989), and extended legs which are unusual for a floating carcass. In any scenario, there is no evidence of an accumulation site, with a single specimen present, which could be autochthonous to parautochthonous, having been deposited near its original death time and place, at least in the same river system and in a somewhat humid environment, given that there are no signs of extensive desiccation or tendon contraction in the entire skeleton.



Supplementary Fig. 1 Taphonomic information on the excavation of the holotype of *Stegouros elengassen*. a, Quarry map showing the distribution of bones, reconstructed from field data and preparation of the jackets. b, Quarry map showing the depth of the skeletal elements in the sedimentary layers. c, Rose diagram of the long bones and axial skeleton of the posterior portion of the holotype of *Stegouros elengassen.* The red line shows the average trend in degrees with respect to the North (0).

Supplementary Table I: List of preserved bones of *Stegouros elengassen* gen. et sp. nov

Skull bones	**Forelimb bones**	**Left hindlimb bones**	**Right hindlimb bones**
Rostral premaxilla	Left humerus	Left femur	Right femur
Left maxilla	Left radius	Left tibia	Right tibia
Right maxilla	Left ulna	Left metatarsal I	Right metatarsal I
Right supraorbital?	Left metacarpal I	Left phalanx I-1	Right phalanx I-1
Right prefrontal?	Left metacarpal II	Left phalanx I-2	Right phalanx I-2
Occipital complex	Left metacarpal III	Left metatarsal II	Right metatarsal II
Left prootic	Left metacarpal IV	Left phalanx II-1	Right phalanx II-1
Basisphenoid	Left metacarpal V	Left phalanx II-2	Right phalanx II-2
Predentary	Right metacarpal I	Left phalanx II-3	Right phalanx II-3
8 isolated teeth	Right phalanx I-1	Left metatarsal III	Right metatarsal III
Middle fragment of left dentary	Right phalanx I-2	Left phalanx III-1	Right phalanx III-1
Right dentary	Right metacarpal II	Left phalanx III-2	Right phalanx III-2
	Right phalanx II-1	Left phalanx III-3	Right phalanx III-3
Axial postcranial bones	Right phalanx II-2	Left phalanx III-4	Right phalanx III-4
Axis		Left metatarsal IV	Right metatarsal IV
4 Postaxial cervical vertebrae	**Pelvic girdle bones**	Left phalanx IV-1	Right phalanx IV-1
10 Dorsal Vertebrae	Left ilium	Left phalanx IV-2	Right phalanx IV-2
2 Dorsosacral verebrae	Left ischium	Left phalanx IV-3	Right phalanx IV-3
4 sacral vertebrae	Right ilium	Left phalanx IV-4	Right phalanx IV-4
12 proximal caudal vertebrae	Right ischium	Left phalanx IV-5	Right phalanx IV-5
5 distal caudal vertebrae			Right metatarsal V
Left sternal plate			
Right sternal plate			**Osteoderms**
			Sacral shield
Scapular girdle bones			7 limb osteoderms
Left coracoid			12 isolated osteoderms
Right coracoid			7 free caudal osteoderms
			Caudal weapon

2. Geological and Paleoenvironmental context

2.1. Geographical and Stratigraphic Provenance

The holotype of *Stegouros elengassen* gen. et sp. nov. CPAP-3165 was discovered in the Río de las Chinas Valley (50° 42' 42.72'' S /72° 32' 29, 08'' W) in beds from the lower part of the Dorotea Formation located in the Estancia Cerro Guido, northwest to the Torres del Paine National Park, Ultima Esperanza Province, Magallanes Region, Chile (Fig. 2a - b).

The Late Cretaceous strata of Ultima Esperanza Province were deposited over the Magallanes/Austral foreland basin. This basin was formed during the Andean compressional orogenesis (Wilson, 1991; Fildani et al., 2003), associated with the initial break-up of Gondwana and the opening of the Atlantic Ocean (Biddle et al., 1986; Mella, 2001). The Upper Cretaceous-Paleogene succession in the Rio de las Chinas Valley includes the following formations in ascending order (Extended Data Fig. 2b): Tres Pasos Formation assigned to Campanian – lower Maastrichtian (Romans et al., 2009; Hubbard et al., 2010; Auchter et al., 2016; Daniels et al., 2018), Dorotea Formation, upper Campanian-Danian (Schwartz et al., 2016; Gutierrez et al., 2017; Daniels et al., 2018; George et al., 2020) and Man Aike Formation assigned to middle Eocene (Malumián, 1990; Camacho et al., 2000; Marenssi et al., 2003; Daniels et al., 2018; Gutiérrez et al., 2017; Schwartz et al., 2016; Sickmann et al., 2018; Manríquez et al., 2019; George et al., 2020).

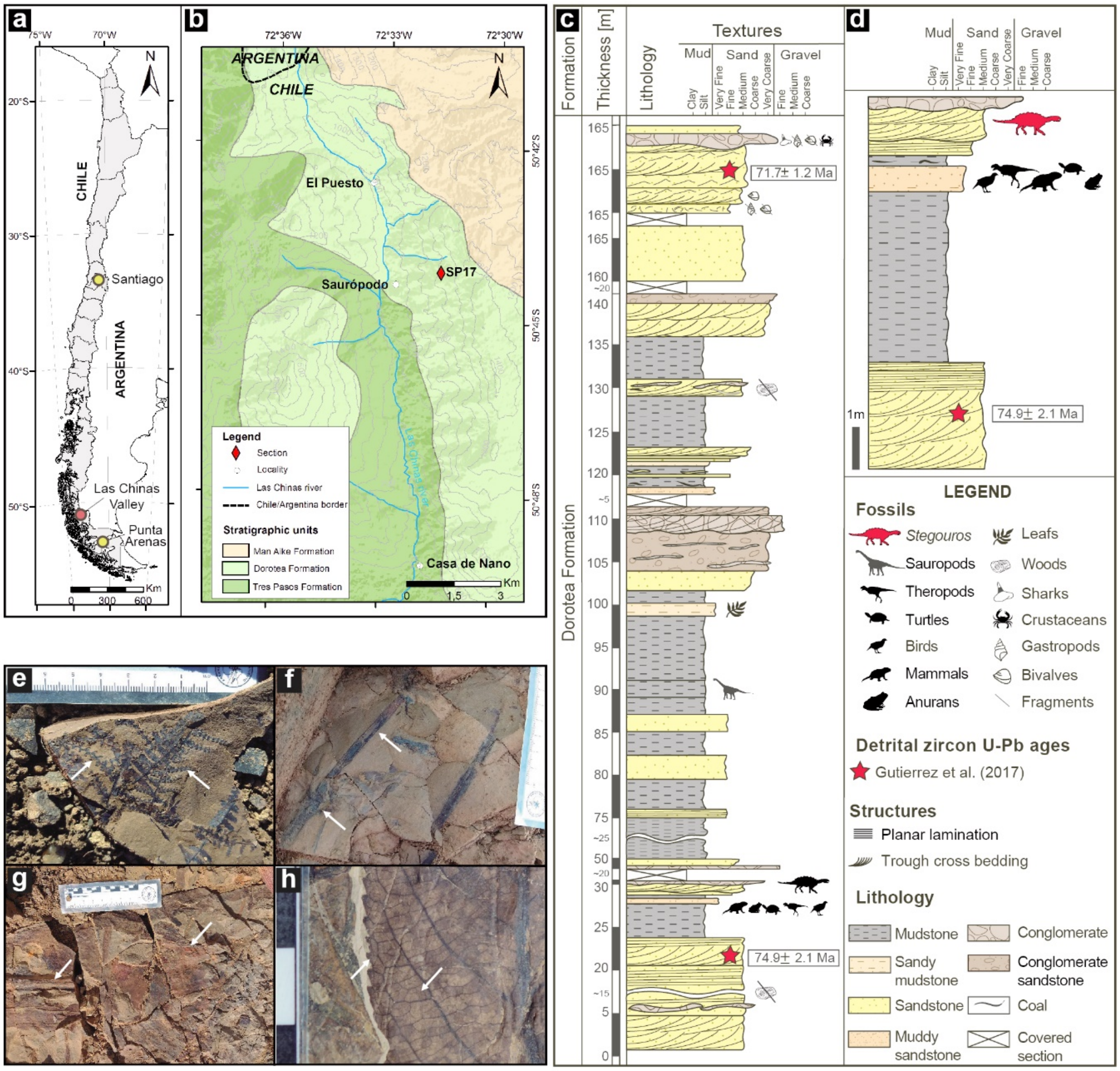
The Dorotea Formation (Katz, 1963) is characterized as a coastal environment, shoreface and delta influenced by tides (Covault et al., 2009, Hubbard et al., 2010, Vogh et al., 2014; Schwartz and Graham, 2015; Manríquez et al., 2019). It is constituted by 1250 - 900 m of thick, predominantly sandstones of different granulometries, frequent conglomerate lenses, and thin beds of calcareous sandy concretions and mudstones (Fig. 2c). In addition, this unit includes abundant fossils of marine invertebrates (bivalves, gastropods, among others) and vertebrates, among which are the remains of sharks, anurans, mammals, plesiosaurs, mosasaurs, turtles and dinosaurs including birds (Otero et al., 2013; Jujihara et al., 2014; Soto-Acuña et al., 2014; Otero et al., 2015; Soto-Acuña et al., 2015; Suazo-Lara et al., 2018; Goin et al., 2020; Alarcón-Muñoz et al., 2020; Martinelli et al., 2021), as well as mudstones with micro and macroflora (pollen, plant remains and wood; Katz, 1963; Cortés, 1964; Schwartz and Graham, 2015; González, 2015; Manríquez et al., 2019; Trevisan et al., 2020).

The skeleton of *Stegouros elengassen* was collected from the Sauropodo locality (SP-17 stratigraphic column, Fig. 2c) found in the middle part of the valley, about a distance of 250 m from where the holotypes of the mammals *Magallanodon baikaskenke* and *Orretherium tzen* were discovered (Goin et al., 2020, Martinelli et al., 2021). The fossil-bearing level corresponds to medium- to coarse-grained sandstones with trough cross-bedding of 1 m thickness (Fig. 2d). The depositional environment of the sandstone bed with *Stegouros* is interpreted as a channel-bar deposit, associated to meandering fluvial system. U-Pb maximum depositional age above and below the *Stegouros* horizons provides values between 71.7 ± 1.2 Ma and 74.9 ± 2.1 Ma (Gutiérrez et al., 2017) supporting an upper Campanian - lower Maastrichtian age for the fossil-bearing levels (Fig. 2c).

2.2. The Sauropodo Locality Flora

The palaeoflora of the Sauropodo locality was found in mudstones deposited in floodplain facies of a meandering fluvial system, a few meters above the sandstone sequence that bears *Stegouros* remains (Manríquez et al., 2019). The fossil flora consists mainly of palynomorphs, and macrofossil remains of compressed stems, tree branches, sterile and fertile pinnae of ferns, and leaves, predominantly ferns and angiosperms (Fig. 2e-h). The pteridophytic fossils belong to Equisetaceae, Gleicheniaceae, Dicksoniaceae and Cyatheaceae. Gymnosperms were only represented in the microflora, with pollen grains of Podocarpaceae and Araucariaceae. Angiosperm diversity is dominated by pollen grains assigned to Proteaceae, Arecaceae and Liliaceae, while leaf imprints show affinities with Lauraceae, Rosaceae and monocot imprints tentatively classified as Typhaceae. The dicot leaves are notoriously mesophyll-sized (*sensu* Ellis et al., 2009), with remarkable preservation of details such as 5th order venation and areolation. Monocot leaf fragments are large, with a broad midrib and parallel venation (Fig. 2, g), typical of perennial, hydrophytic to helophytic aquatic herbs.

Leaf impressions, abundant stems, roots, and tree branch parts are also found in this layer, with lengths reaching 25 cm, some of these related to angiosperm taxa with attached petiolate dicot leaves (Fig 2, h). These suggest an autochthonous to parautochthonous deposition (*sensu* Gastaldo, 2001) with virtually *in situ* or no distant source, especially in the riparian elements of the flora (i.e. Typhaceae and Equisetaceae).



Supplementary Fig.2 Location and stratigraphical context of the finding of *Stegouros elengassen* holotype. a, Map of Chile highlighting the location of Río de las Chinas Valley in Chilean Patagonia. b, Areal distribution of the Magallanes Basin formations in the sector of Rio de las Chinas Valley, with the studied locality (SP17). c, General stratigraphic column of 'Sauropodo sector'. d, detail section showing the fossiliferous horizon. e-h, In-situ plant fossil outcrops at Saurópodo locality. e, Sterile and fertile fern pinnae. Arrows indicate reproductive structures. f, Tree branch with an attached angiosperm leaf. g, Large leaf assigned to Typhaceae. Arrows indicate the wide leaf midrib. h, Very well-preserved large dicot leaf of indeterminate affinity. Arrows indicate areolation and tooth venation.

3. Additional comparisons of *Stegouros elengassen* with *Antarctopelta oliveroi*

Besides the comparisons mentioned in the main text, our direct examination of *Antarctopelta oliveroi* MLP 86-X-28-1 and *Stegouros* revealed other similarities. In both, the cervical centra have concave lateral surfaces (a character usually found in Stegosauria; Pereda-Suberbiola, 2013), and the first dorsosacral centrum has an expanded border in the anterior articular face, which has previously been described as an unusual feature for an ankylosaur (Arbour and Currie, 2016; but see Rozadilla et al., 2015 and Lamanna et al., 2019). The morphology of anterior and posterior caudal vertebrae of *Stegouros* is similar to proposed homologous elements of MLP 86-X-28 according to Salgado and Gasparini (2006). A proximal caudal vertebra of MLP 86-X-28 has been argued to be a pygal (anterior caudal) vertebra of a mosasaur, based on the triangular lateral outline (in cranial view) of a preserved half centrum, and the ventralized position of the transverse process (Arbour and Currie, 2016). However, the centra of pygal vertebrae in mosasaurs and other squamates are markedly procoelous (Estes et al., 1998), whereas the centra of anterior caudals of *Stegouros* also have the roughly triangular lateral outline, and a very similar inclination of the posterior articular surface (Extended Data Fig. 7k). The only notable difference is that the transverse processes in *Antarctopelta* are more ventrally placed. A proposed distal caudal centrum of MLP 86-X-28-1 was also suggested to be a cervical centrum of an elasmosaurian plesiosaur, based on the combined presence of long articulations for the ribs, and the binocular shape (‘dumbbell-shape’ of Gasparini et al., 2003) of the centrum (Arbour and Currie, 2016: Fig. 10). However, elasmosaur cervical centra bear paired foramina on the ventral surface (Welles, 1962), and the presence of ossified tendons on the ventral surface of the proposed distal caudal centrum of MLP 86-X-28 precludes an assignment to marine reptiles (Rozadilla et al., 2015). In turn, this centrum of MLP 86-X-28 resembles the posterior caudals of *Stegouros*, being dorsoventrally compressed (flat), with antero-posteriorly wide transverse process, and a ventral sulcus (Extended Data Fig. 7h-o). The main noticeable difference is that in *Stegouros* ossified tendons are absent. Although appendicular remains of MLP 86-X-28-1 are highly fragmentary, some similarities with *Stegouros* can be noted. Metatarsal IV of both taxa has a laterally expanded proximal epiphysis, with a convex dorsal surface and a slightly concave plantar surface (Extended Data Fig. 7p-t). The preserved diaphyseal portion of metatarsal IV of *Antarctopelta* tapers significantly respect to the epiphysis, which along with an extended contact surface with metatarsal III, suggests a gracile foot as in *Stegouros*, unlike the distally spreading foot of other ankylosaurs and stegosaurs (Galton and Upchurch, 2004; Currie et al., 2011). One preserved pedal phalanx in MLP 86-X-28-1 is very flat, similar to the phalanges of toes three and four of *Stegouros* (Extended Data Fig. 7u). Unlike *Kunbarrasaurus* and other Ankylosauria, large osteoderms that encircle the neck are not known for *Stegouros* and *Antarctopelta*. Although this could be a preservation artifact, it is worth noting that such osteoderms are present in *Scelidosaurus* and are likely primitive for Ankylosauria. If actually absent in *Stegourus* or *Antarctopelta*, this would be a derived condition. MLP 86-X-28-1 also comprises large elements identified as cranial bones by Salgado and Gasparini (2006, fig. 3) which have an osteoderm-like texture of pits and striae on their external surface. These were compared by Salgado and Gasparini with *Edmontonia*, an ankylosaur whose skull bones are fused to osteoderms (Gilmore, 1930; Burns, 2015). However, these elements do not compare well with skull bones of *Kunbarrasaurus*, which are not fused to osteoderms; further, comparison to *Stegouros* suggests these elements may correspond to osteoderms of the caudal weapon (Extended Data Fig. 8). When compared to the most proximal (1st) pair of large osteoderms of the weapon, the putative supraorbital bone figured by Salgado and Gasparini (2006, Fig 3 a, b) shares a strongly concave medial surface, and a dorsal surface that is flatter than the convex ventrolateral surface; both surfaces are separated by a long acuminate keel with a backwardly slanted apex (Extended Data Fig. 8a, d). The element originally identified as a putative parietal bone (Salgado and Gasparini 2006, Fig 3 d) also bears an internally concave surface and resembles an osteoderm of the second pair in the caudal weapon of *Stegouros*, which is larger and has a flatter dorsal surface (Extended Data Fig. 8e-j).

4. Phylogenetic analyses

In order to resolve the phylogenetic relationships of *Stegouros elengassen*, we carried out five cladistic analyses based on different datasets. The first analysis was made using the data matrix of Han et al. (2018) which is based on 383 characters, and includes a large sample of ornithischian dinosaurs, including several thyreophorans. The second dataset is a version of the data matrix of Raven and Maidment (2017) modified by Raven and Maidment (2018) which is focused on Stegosauria, comprising 118 characters to which we added 10 new characters. The third dataset used was that of Arbour et al. (2016), which is an expanded version of the matrix of Arbour and Currie (2016) focused on ankylosauria, originally with 177 characters, to which we added 12 new characters. The fourth analysis was based on the matrix built by Loewen and Kirkland (2013) but published by Wiersma and Irmis (2018), which is focused on Ankylosauria and comprises 295 characters, to which we added 13 new characters. The fifth dataset is from Norman (2020a) which tests the position of *Scelidosaurus* and includes 115 characters, to which we added 12 new characters.

4.1. Protocol of analysis

All matrices were analyzed in TNT 1.5 (Goloboff et al., 2016) following the same steps as the original publications. In the analysis by Han et al. 2018, characters 2, 23, 31, 39, 125, 163, 196, 203, 204, 222, 227, 238, 243, 247, 268, 292, 296, 302, 306, 320, 361 were treated as ordered (Han et al., 2018). The search for more parsimonious trees (MPTs) was done by traditional search (heuristic) with 1000 replicas of tree bisection and reconnection (TBR) maintaining 100 trees per replica. The trees obtained were used as a starting point for a second round of TBR by Traditional Search. In the matrix of Raven and Maidment (2018) characters 1-24, 29, 112 and 113 were treated as ordered (Raven and Maidment, 2017; 2018). A New Technology Search was made with 1 random addition seed and 1000 replicas, and the trees obtained were used for a second round of TBR using Traditional Search. In the analysis by Arbour et al. (2016), all characters were treated as unordered, and the search for MPTs was carried out using TBR with 1000 replicas, keeping 10 trees per replica, and then a second search was carried out with the trees saved in memory. The analysis by Loewen and Kirkland

(2013) was carried out following Wiersma and Irmis (2018), considering characters 1, 2, 3, 7, 10, 13, 16, 18, 23, 25, 30, 36, 38, 48, 49, 54, 64, 87, 98, 101, 103, 104, 105 140, 141, 143, 145, 148, 149, 156, 162, 165, 174, 177, 194, 201, 205, 209, 217 , 229, 231, 232, 236, 237, 238, 268, and 279 as ordered. To obtain MPTS, Traditional Search was used, with 10,000 TBR replicas with 10 trees saved per replica. The analysis of the Norman (2020) matrix was caried out by traditional search with 10000 replicates holding 10 trees. All results were analyzed with Bootstrap resampling (1000 pseudo-replicas) and Bremer support values.
We used a Templeton test to assess the significance of the phylogenetic position of *Stegouros* closer to Ankylosauria than to Stegosauria (Extended Data Table I). For this we used the resulting trees and a forced topology, where Stegouros is closer to Stegosauria than to Ankylosauria, and applied a one-sided Wicoxon signed rank test to the differences in character transformations between these trees. Templeton tests were carried out using TNT 1.5 and script available at http://www.anbg.gov.au/cpbr/tools/templetontest.tnt.

4.2. Estimation of divergence times.

The stratigraphic adjustment and estimation of the divergence times of the calibrated phylogenies was performed by calculating MSM (Manhatan Stratigraphic Measure) and GER (Gap Excess Ratio) (Siddall, 1998; Wills, 1999; Pol and Norrell, 2001; Pol et al., 2004) using the TNT script implemented by Pol and Norrell (2006). Divergence times were not estimated for the Han et al. matrix which only comprises a small sample of armoured dinosaurs.

4.3. List of modifications to the data matrix of Han et al. (2018)

Character 45 – *Kunbarrasaurus* changed from ? to 1, based on Leahey et al. (2015).

Character 46 – *Kunbarrasaurus* changed from ? to 0, based on Leahey et al. (2015).

Character 47 – *Kunbarrasaurus* changed from ? to 1, based on Leahey et al. (2015).

Character 103 – *Kunbarrasaurus* changed from ? to 1, based on Leahey et al. (2015).

Character 104 – *Kunbarrasaurus* changed from ? to 0, based on Leahey et al. (2015).

Character 123 – *Kunbarrasaurus* changed from ? to 0, based on Leahey et al. (2015).

Character 126 – *Kunbarrasaurus* changed from ? to 0, based on Leahey et al. (2015).

Character 128 – *Kunbarrasaurus* changed from ? to 0, based on Leahey et al. (2015).

Character 130 – *Kunbarrasaurus* changed from ? to 0, based on Leahey et al. (2015).

Character 132 – *Kunbarrasaurus* changed from ? to 2, based on Leahey et al. (2015).

Character 133 – *Kunbarrasaurus* changed from ? to 0, based on Leahey et al. (2015).

Character 205 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996).

Character 206 – *Kunbarrasaurus* changed from ? to 0, based on Molnar (1996).

Character 207 – *Gargoyleosaurus* changed from ? to 0 based on Ősi et al. (2017); *Pinacosaurus* changes from 0 to 1 based on Gilmore (1933) and Ősi et al. (2017); *Kunbarrasaurus* changed from 0 to 1, based on Molnar (1996).

Character 208 – *Gargoyleosaurus* changed from ? to 0 based on Ősi et al. (2017); *Pinacosaurus* changes from 0 to 1 based on Gilmore (1933) and Ősi et al. (2017); *Kunbarrasaurus* changed from 0 to 1, based on Molnar (1996).

Character 214 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996).

Character 219 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996).

Character 220 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996).

Character 224 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996).

Character 252 – Redefinition (new character state added): Distal caudal centra, proportions: length greater than width and height (0), lenght subequal to width and height (1), length subequal to width but greater than height ("flat" centrum) (2)

Character 253 – *Kunbarrasaurus* changed from 2 to ?, based on Molnar (1996).
Character 256 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996) and Molnar (2001).

Character 257 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996) and Molnar (2001).

Character 258 – *Kunbarrasaurus* changed from ? to 0, based on Molnar (1996) and Molnar (2001).

Character 270 – *Kunbarrasaurus* changed from ? to 0, based on Molnar (1996).

Character 281 – *Kunbarrasaurus* changed from ? to 1, based on Molnar (1996).

Character 305 – *Kunbarrasaurus* changed from 1 to ?, based on Molnar (1996).

Character 381 (NEW) - Form of pelvic osteoderms: no osteoderms (0) unfused, but tightly interlocking osteoderms (1), coossified osteoderm rosettes (2), coossified evenly-sized polygons of similar size (3), coosified irregular osteoderms into a thin sheet-like sacral shield, forming a bony bridge between de sacral spines and the ilium (4) (Arbour et al., 2014a: 140)

Character 382 (NEW) - Osteoderms on limbs: absent (0), present on the proximal limbs segments (1), present on proximal ans distal limb segments (2) (modified from Arbour et al., 2016: 166).

Character 383 (NEW) - Shape and texture of millimeter-sized ossicles: amorphous or polygonal ossicles with irregular texture (0), oblate spheroid to squared ossicles with conspicuous orthogonal fibers on the inner surface (1).

4.4. List of modifications to the data matrix of Raven and Maidment (2018)

The taxa *Adratiklit bouhlafa* (following Maidment et al., 2020), *Antarctopelta oliveroi*, *Kunbarrasaurus ieversi* and *Stegouros elengassen* were added to this matrix.

Character 2 - *Scelidosaurus* recoded from? to 18. Based on description by Norman (2020b).

Character 27 - *Lesothosaurus* changed from 0 to 1, based on Sereno (1991); *Scelidosaurus* changed from ? to 1 based on Norman (2020b); *Huayangosaurus* changed from 1 to 0 based on Sereno and Dong (1992) and Raven and Maidment (2018) where the description in the text does not coincide with coding in the matrix.

Character 29 - The row of encoded taxa published by Raven and Maidment (2018) is switched with that of character 30. This was corrected keeping the order of the character list.

Character 30 - The state of the characters published by Raven and Maidment (2018) is inverted, it was corrected keeping the order as follows: Striation continues with denticles do not extend to cingulum (0); striations extend to cingulum (1). *Lesothosaurus* is recoded from 1 to 0, based on Sereno (1991); *Scutellosaurus* changed from 1 to 0 based on Colbert (1981); *Kentrosaurus* changed from? a 1 based on Galton (1988) and Raven and Maidment (2018).

Character 53 - *Kentrosaurus* changed from 1 to 0 based on Raven and Maidment (2018); *Hesperosaurus* changed from? a 0 based on Carpenter et al (2001); *Gastonia* changed from? a 1 based on Kinner et al. (2016). *Sauropelta* changed from 1 to 0 based on Coombs (1990).

Character 53 - *Kentrosaurus* changed from ? to 1 based on Galton (1988); *Hesperosaurus* changed from ? to 0 based on Carpenter et al (2001); *Gastonia* changed from? to 0 based on Kinner et al. (2016).

Character 80 - A new character state was added : 2, Equally long as wide but low in height ("flat" morphology) . *Alcovasaurus* changed from 0 to 1 based on Galton et al. (2016).

Character 102 - *Sauropelta* changed from 0 to [0 1] based on Ostrom (1970), Carpenter (1984) and Currie et al. (2011); *Euoplocephalus* changed from 2 to 1 based on Coombs (1986) and Currie et al. (2011).

Character 122 (NEW) - Position of the caudal end of the maxillary tooth row relative to the rostral border of the orbit: posterior (0), anterior or just below (1).

Character 123 (NEW) - Sacrum, number of fused sacrodorsals in the presacral rod: (0) fused sacrodorsals absent; (1) 1 or 2 sacrodorsals; (2) 3 sacrodorsals ; (3) 4 fused sacrodorsals (4) 5 or more fused sacrodorsals .

Character 124 (NEW) - Sacrum, number of fused sacrocaudal incorporated in the synsacrum : (0) no sacrocaudals ; (1) 1 or more sacrocaudals.

Character 125 (NEW) - Presence of a longitudinal ventral concavity or sulcus in mid-posterior caudal vertebrae: absent (0); present (1).

Character 126 (NEW) - Manual digit II phalangeal formula: three phalanges (0); two or less phalanges (1).

Character 127 (NEW) - Pedal digit II, phalangeal formula: three phalanges (0); two or fewer phalanges (1).

Character 128 (NEW) - Side trunk keeled scutes or osteoderms, over the rib cage: present (0); absent (1).

Character 129 (NEW) - Form of pelvic osteoderms: no osteoderms (0) unfused, but tightly interlocking osteoderms (1), coossified osteoderm rosettes (2), coossified evenly-sized polygons of similar size (3), coosified irregular osteoderms into a thin sheet-like sacral shield, forming a bony bridge between de sacral spines and the ilium (4) (Arbour et al., 2014a: 140).

Character 130 (NEW) - Osteoderms on limbs: absent (0), present on the proximal limbs segments (1), present on proximal and distal limb segments (2) (modified from Arbour et al., 2016: 166).

Character 131 (NEW) - Shape and texture of millimeter-sized ossicles: amorphous or polygonal ossicles with irregular texture (0), oblate spheroid to squared ossicles with conspicuous orthogonal fibers on the inner surface (1).

4.5. List of modifications to the data matrix of Arbour et al. (2016)

New taxa added are *Paranthodon africanus* (Raven and Maidment, 2018), *Zuul cruravastator* (Arbour and Evans, 2017), *Jinyunpelta sinensis* (Zheng et al., 2018), *Borealopelta markmitchelli* (Brown et al., 2017), *Akainacephalus johnsoni* (Wiersma and Irmis, 2018; Parks et al., 2020), *Antarctopelta oliveroi* (Salgado and Gasparini, 2006) and *Stegouros elengassen*.

Character 15 - *Tsagantegia longicranialis* changed from 1 to 0 according to Parks et al. (2020).

Character 103 - Salitral Moreno (Argentinean) ankylosaur changed from 1 year, since the specimen does not preserve sacral vertebrae (Coria et al., 2001).

Character 115 - *Hylaeosaurus* changed from 1 to 0 based on Raven et al. (2020).

Character 156 - *Kunbarrasaurus* changed from 1 to [1 2] based on Molnar (2001).

Character 166 - A new state was added: 2, present on proximal ans distal limb segments (2).

Character 168 - *Kunbarrasaurus* changed from 2 to 1, based on Molnar (2001).

Character 170 - *Kunbarrasaurus* changed from 2 to 1, based on Molnar (2001).

Character 171 - *Kunbarrasaurus* changed from? to 0, based on Molnar (2001).

Character 172 - A new state was added: 4, Coosified irregular osteoderms into a thin sheet-like sacral shield, forming a bony bridge between de sacral spines and the ilium.

Character 1 78 (NEW) - Caudal end of maxillary tooth row relative position to the rostral border of the orbit: caudal (0), rostral to or just below (1).

Character 1 79 (NEW) - Tooth crowns: asymmetric (0); symmetric (1).

Character 1 80 (NEW) - Tooth crowns: do not extend to cingulum (0); striations extend to cingulum (1).

Character 1 81 (NEW) - Tooth crowns: striations not confluent with denticles (0); confluent with denticles (1).

Character 1 82 (NEW) - Sacrum, number of fused sacrodorsals in the presacral rod: (0) fused sacrodorsals absent; (1) 1 or 2 sacrodorsals ; (2) 3 sacrodorsals ; (3) 4 fused sacrodorsals (4) 5 or more fused sacrodorsals .

Character 1 83 (NEW) - Sacrum, number of fused sacrocaudal incorporated in the synsacrum: (0) no sacrocaudals; (1) 1 or more sacrocaudals.

Character 1 84 (NEW) - Presence of a longitudinal ventral groove or sulcus in mid to posterior caudal vertebrae (haemal canal): absent (0); present (1).

Character 1 85 (NEW) - Posterior caudal vertebrae: centra are elongate (0); equidimensional (length, height and width roughly equivalent) (1); Equally long as wide but low in height ("flat") (2).

Character 1 86 (NEW) - Humerus: triceps tubercle and descending ridge posterolateral to the deltopectoral crest: absent (0), present (1). [Raven and Maidment, 2017: 80 Based on Sereno 1999: 38]"

Character 1 87 (NEW) - Manual digit II phalangeal formula: three phalanges (0); two or less phalanges (1).

Character 1 88 (NEW) - Pedal digit II, phalangeal formula: three phalanges (0); two or fewer phalanges (1).

Character 1 89 (NEW) - Shape and texture of millimeter-sized ossicles: amorphous or polygonal ossicles with irregular texture (0), oblate spheroid to squared ossicles with conspicuous orthogonal fibers on the inner surface (1).

4.6. List of modifications to the data matrix of Loewen and Kirkland (2013)

The taxa *Stegouros elengassen*, *Antarctopelta oliveroi* and *Isaberrysaura mollensis* were added to this matrix. The taxon '*Tarchia gigantea'* (originally *Dyoplosaurus giganteus*, Maleev, 1954) was removed, as the holotype consists of a fragmentary postcranium lacking autapomorphies (Arbour and Currie, 2016). Also, the PIN 3142/250 specimen, on which the coding of '*Tarchia gigantea'* is based in part, was referred to *Saichania chulsanensis* by Arbour and Currie (2016), but later designated as a holotype of *Tarchia teresae* by Penkalski and Tumanova (2017).

The following taxa included in this analysis have been synonymized in recent reviews: *Zhongyuansaurus lauyangensis*, considered a junior synonym of *Gobisaurus domuculus* (Arbour and Currie, 2016); *Tianzhenosaurus youngi*, considered as a junior synonym of *Saichania chulsanensis* (Arbour and Currie, 2016); *Shanxia tianzhenensis*, considered as a junior synonym of *Saichania chulsanensis* (Arbour and Currie, 2016); *Minotaurasaurus ramachandrani*, considered as a junior synonym of *Tarchia kielanae* (Arbour and Currie, 2016; however, see also Parks et al., 2020); *Oohkotokia horneri*, considered as a junior synonym of *Scolosaurus cutleri* (Arbour and Currie, 2016; however, see also Penkalski, 2018). However, when removed from the analysis, this did not affect the position and stability of Parankylosauria. We therefore decided to keep them as separate OTUs.

Character 140 – Character state 1 was divided into three states: Sacrum, number of fused sacrodorsals in the presacral rod: fused sacrodorsals absent (0); 1 or 2 sacrodorsals (1); 3 sacrodorsals (2).

Character 141 - *Cedarpelta bilbeyhallorum* changed from 1 to 2 based on Carpenter et al. (2008); *Crichtonpelta benxiensis* changed from 1 to 2 based on Lü et al. (2007); *Pinacosaurus mephistocephalus* changed from 2 to 1 based on Godefroit et al. (1999); *Tianzhenosaurus youngi* changed from 2 to 1 based on Pang and Cheng (1998), *Scolosaurus cutleri* changed from 1 to 2 based on Penkalski and Blows (2013); *Anodontosaurus lambei* changed from 1 to 2 based on Penkalski (2018); *Oohkotokia horneri* changed from 1 to 2 based on Penkalski (2018); *Euoplocephalus tutus* changed from 1 to 2 based on Arbour and Currie (2013) and Penkalski (2018); *Dyoplosaurus acutosquameus* changed from 1 to 2 based on Parks (1924), Arbour et al. (2009) and Penkalski (2018).

Character 260 - A new state was added to the character: Thin sacral shield composed covering just the space between ilia and sacral spines (3). It was treated as unordered.

Character 293 - *Kunbarrasaurus* changed from 0 to ?, since the distal end of the tail is unknown (Molnar, 1996; 2001).

Character 294 (NEW) - Caudal end of maxillary tooth row relative position to the rostral border of the orbit: caudal (0), rostral to or just below (1).

Character 295 (NEW) - Tooth crowns: asymmetric (0); symmetric (1).

Character 206 (NEW) - Tooth crowns: do not extend to cingulum (0); striations extend to cingulum (1).

Character 297 (NEW) - Tooth crowns: striations not confluent with denticles (0); confluent with denticles (1).

Character 298 (NEW) - Sacrum, number of fused sacrocaudal incorporated in the synsacrum: (0) no sacrocaudals; (1) 1 or more sacrocaudals.

Character 299 (NEW) - Presence of a longitudinal ventral groove or sulcus in mid to posterior caudal vertebrae (haemal canal): absent (0); present (1).

Character 300 (NEW) - Posterior caudal vertebrae: centra are elongate (0); equidimensional (length, height, and width roughly equivalent) (1); Equally long as wide but low in height ("flat") (2)

Character 301 (NEW) - Humerus: triceps tubercle and descending ridge posterolateral to the deltopectoral crest: absent (0), present (1). [Raven and Maidment, 2017: 80 Based on Sereno 1999: 38].

Character 302 (NEW) - Manual digit II phalangeal formula: three phalanges (0); two or less phalanges (1).

Character 303 (NEW) - Pedal digit II, phalangeal formula: three phalanges (0); two or fewer phalanges (1).

Character 304 (NEW) - Osteoderms on limbs: absent (0), present on the proximal limbs segments (1), present on proximal and distal limb segments (2) (modified from Arbour and Currie, 2016: 166).

Character 305 (NEW) - Osteoderms: mosaic of small osteoderms between larger osteoderms on the ventral surfaces of the neck, trunk, and proximal portions of the limbs absent (0); present (1).

Character 306 (NEW) - Shape and texture of millimeter -sized ossicles: amorphous or polygonal ossicles with irregular texture (0), oblate spheroid to squared ossicles with conspicuous orthogonal fibers on the inner surface (1).

4.7. List of modifications to the data matrix of Norman (2020a)

The taxa *Antarctopelta oliveroi* and *Stegouros elengassen* were added to the original matrix.

Character 5 - *Kunbarrasaurus* changed from 2 to ?, trait is not preserved in specimen (Molnar, 1996; Leahey et al., 2015).

Character 36 - *Kunbarrasaurus* changed from 0 to 1 based on Leahey et al. (2015).

Character 39 - *Kunbarrasaurus* changed from 2 to ?, predentary is not preserved in specimen (Leahey et al., 2015).

Character 52 - *Kunbarrasaurus* changed from 0 to 2 based on Molnar (1996).

Character 58 - *Huayangosaurus* changed from 0 to 1 based on Maidment et al. (2006); *Kentrosaurus* changed from 0 to 1 based on Mallison (2011); *Stegosaurus* changed from 0 to 1 based on Gilmore (1914) and Maidment et al. (2015).

Character 110 - Definition of the character was modified: osteoderms on limbs: absent (0), present on limb proximal segments (1) present on proximal and distal limb segments (2) (modified from Arbour et al 2016: 166).

Character 116 (NEW) - Caudal end of maxillary tooth row relative position to the rostral border of the orbit: caudal (0), rostral to or just below (1).

Character 117 (NEW) - Tooth crowns: asymmetric (0); symmetric (1).

Character 118 (NEW) - Tooth crowns: striations not confluent with denticles (0); confluent with denticles (1).

Character 119 (NEW) - Sacrum, number of fused sacrodorsals in the presacral rod: (0) fused sacrodorsals absent; (1) 1 or 2 sacrodorsals; (2) 3 sacrodorsals; (3) 4 fused sacrodorsals (4) 5 or more fused sacrodorsals.

Character 120 (NEW) - Sacrum, number of fused sacrocaudals incorporated in the synsacrum: (0) no sacrocaudals; (1) 1 or more sacrocaudals.

Character 121 (NEW) - Presence of a longitudinal ventral groove or sulcus in mid to posterior caudal vertebrae (haemal canal): absent (0); present (1).

Character 122 (NEW) - Posterior caudal vertebrae: centra are elongate (0); equidimensional (length, height and width roughly equivalent) (1); Equally long as wide but low in height ("flat") (2).

Character 123 (NEW) - Humerus: triceps tubercle and descending ridge posterolateral to the deltopectoral crest: absent (0), present (1). [Raven and Maidment, 2017: 80 Based on Sereno 1999: 38].

Character 124 (NEW) - Manual digit II phalangeal formula: three phalanges (0); two or less phalanges (1).

Character 125 (NEW) - Pedal digit II, phalangeal formula: three phalanges (0); two or fewer phalanges (1).

Character 126 (NEW) - Millimeter -sized ossicles abundant in spaces between osteoderms in thoracic or caudal regions (excluding pelvic region), absent (0), present (1). [Based on observations presented in Arbour et al. (2014b)].

Character 127 (NEW) - Shape and texture of millimeter -sized ossicles: amorphous or polygonal ossicles with irregular texture (0), oblate spheroid to squared ossicles with conspicuous orthogonal fibers on the inner surface (1).

4.8. Results

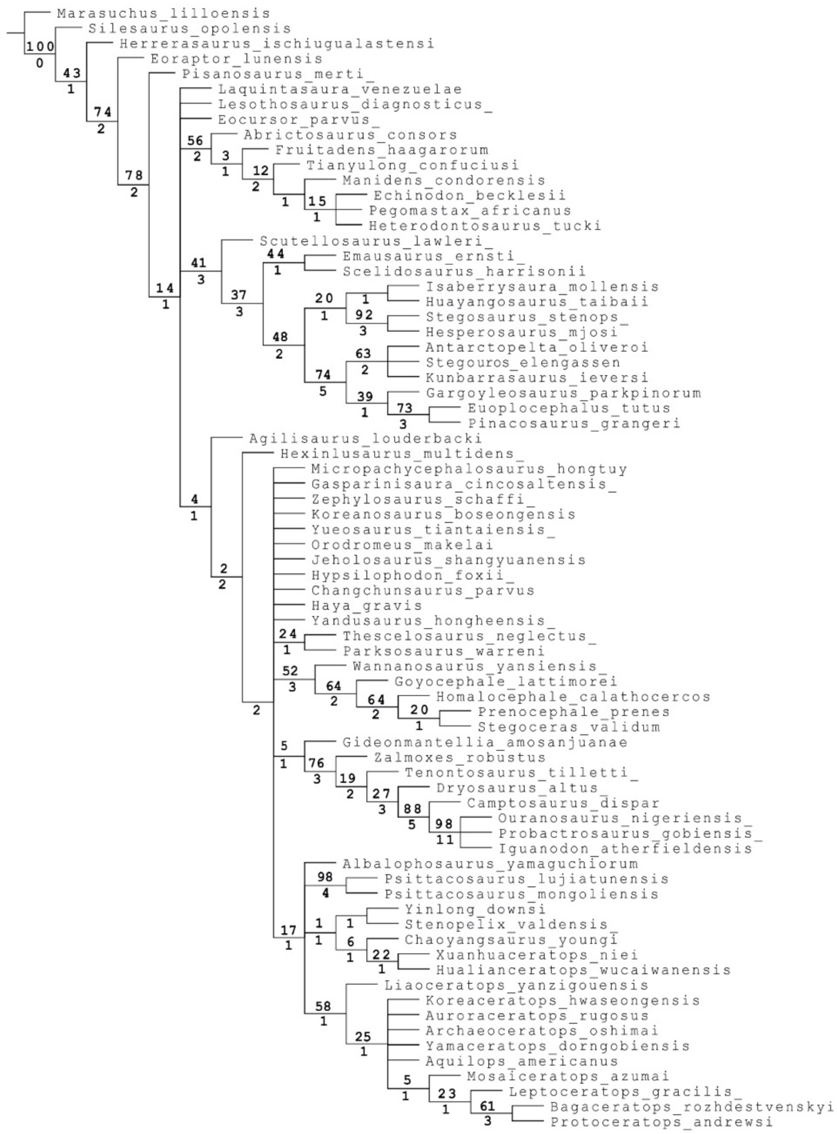


Fig. 3. Strict consensus of 13392 MPTs resulting of the analysis of Han et al matrix. Values above nodes represents bootstrap proportions (1000 pseudoreplicates). Values beneath nodes represents Bremmer support.

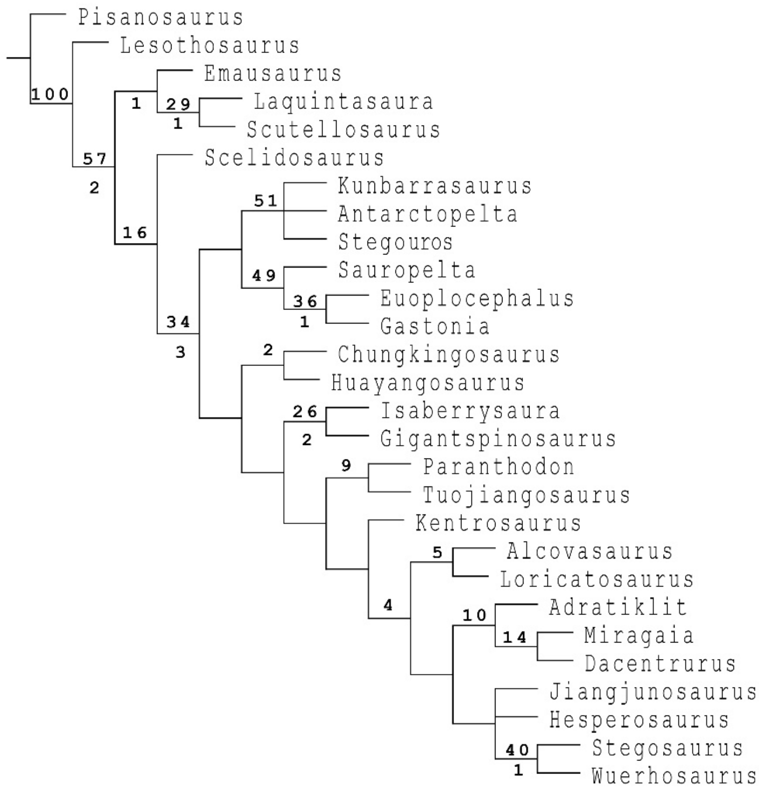


Fig. 4. Strict consensus of 2 MPTs resulting of the analysis of Raven and Maidment matrix. Values above nodes represents bootstrap proportions (1000 pseudoreplicates). Values beneath nodes represents Bremmer support.

Fig. 5. Strict consensus of 20 MPTs resulting of the analysis of Arbour et al matrix. Values above nodes represents bootstrap proportions (1000 pseudoreplicates). Values beneath nodes represents Bremmer support.

Fig. 6. Strict consensus of 16 MPTs resulting of the analysis of Loewen and Kirkland matrix. Values above nodes represents bootstrap proportions (1000 pseudoreplicates). Values beneath nodes represents Bremmer support.

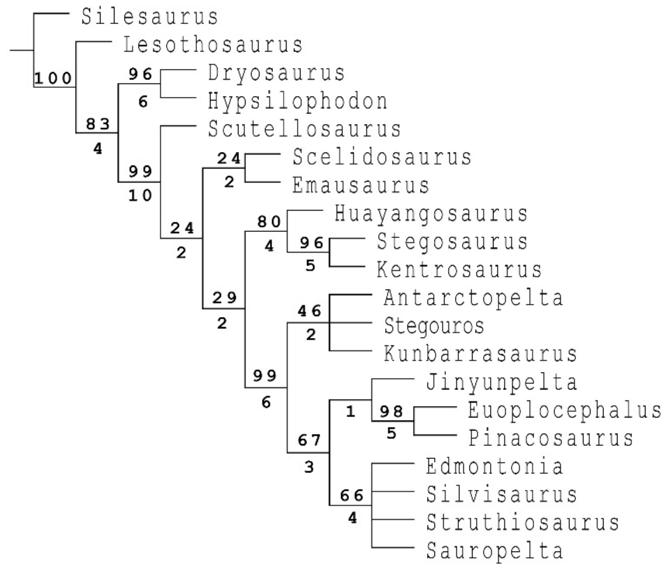


Fig. 7. Strict consensus of 4 MPTs resulting of the analysis of Norman matrix. Values above nodes represents bootstrap proportions (1000 pseudoreplicates). Values beneath nodes represents Bremmer support.

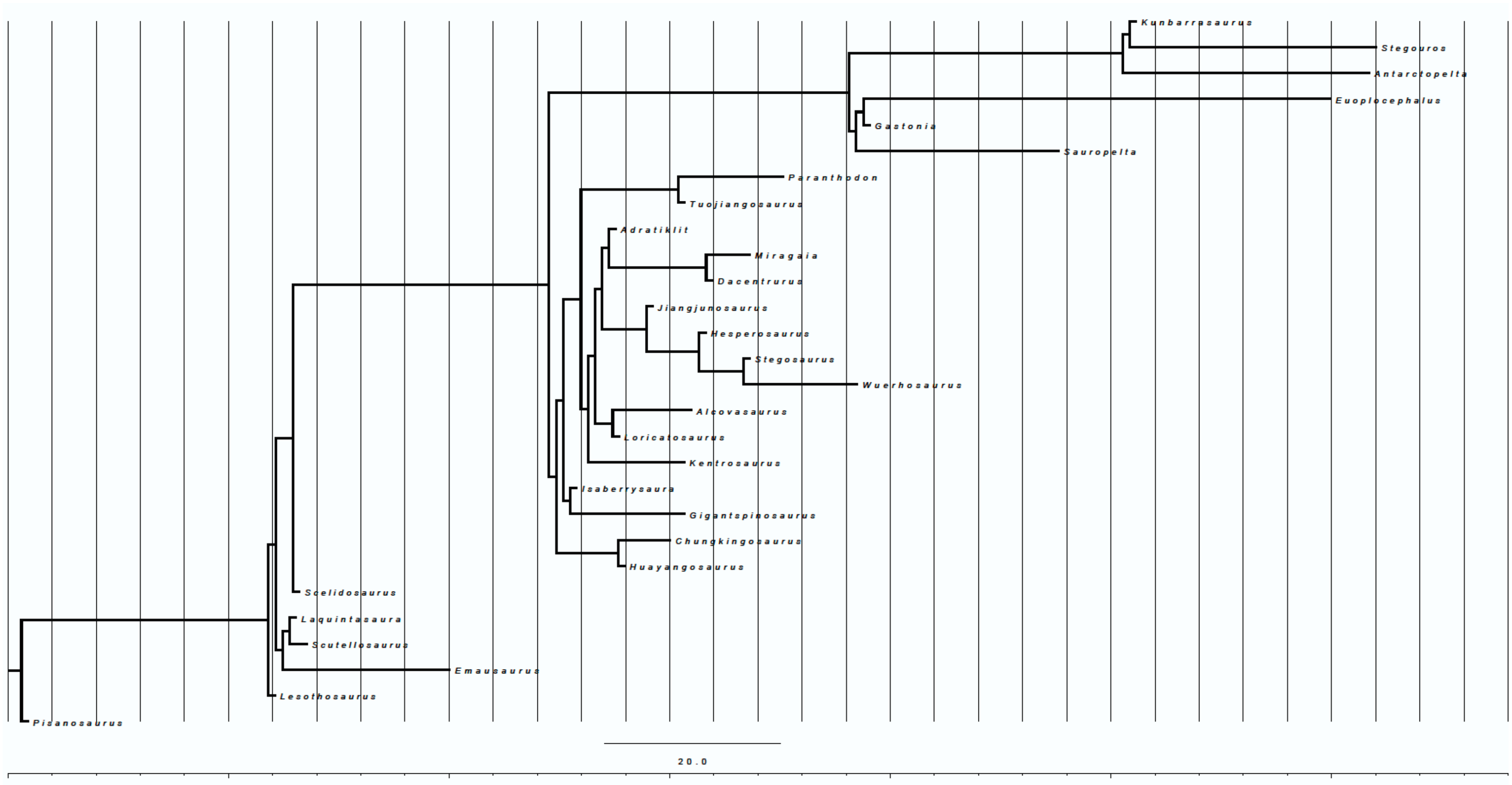


Fig. 8. Time-calibrated subtree from analysis of Raven and Maidment matrix. Subtree number 2.

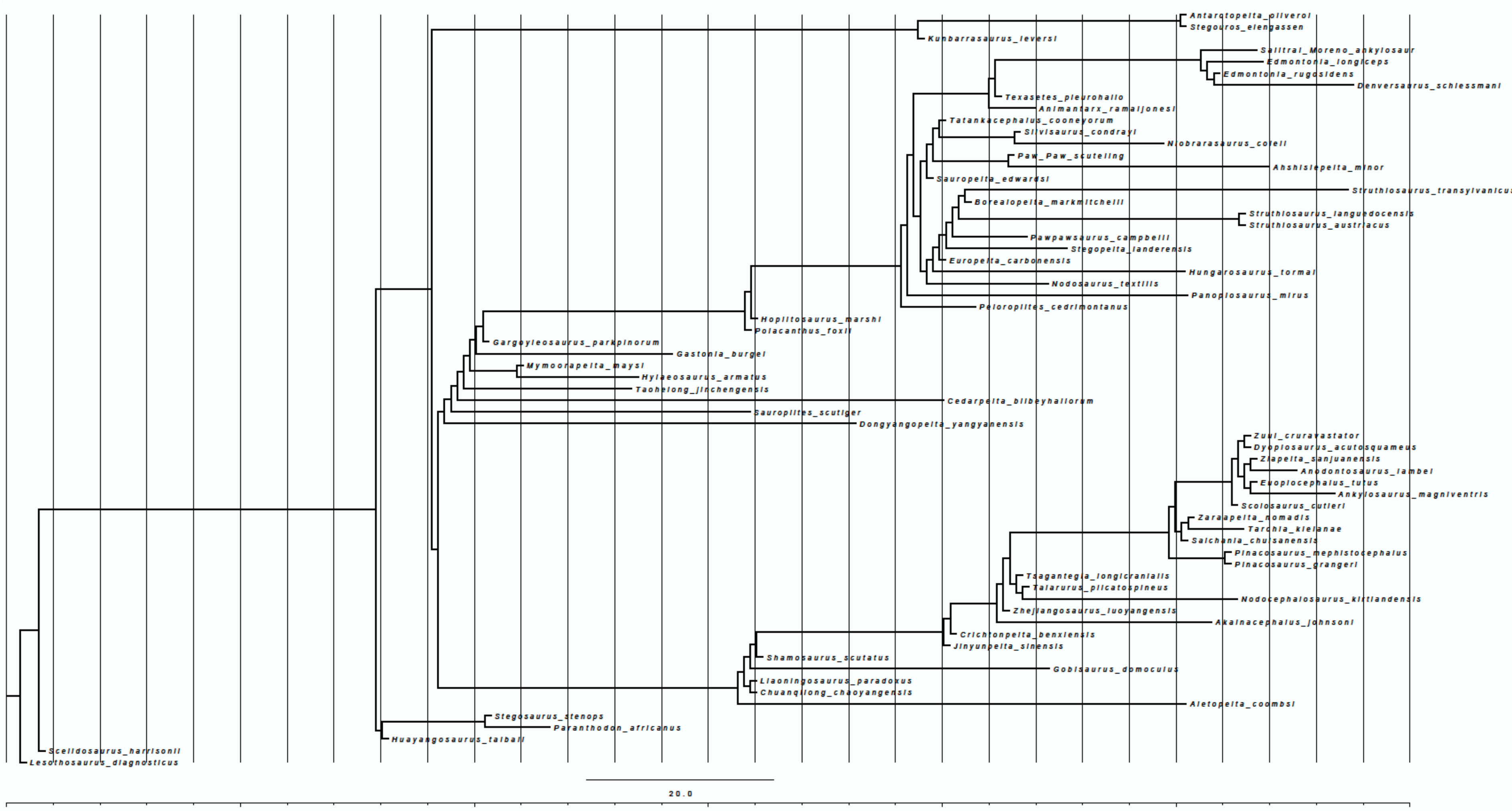


Fig. 9. Time-calibrated subtree from analysis of Arbour et al matrix. Subtree number 1.

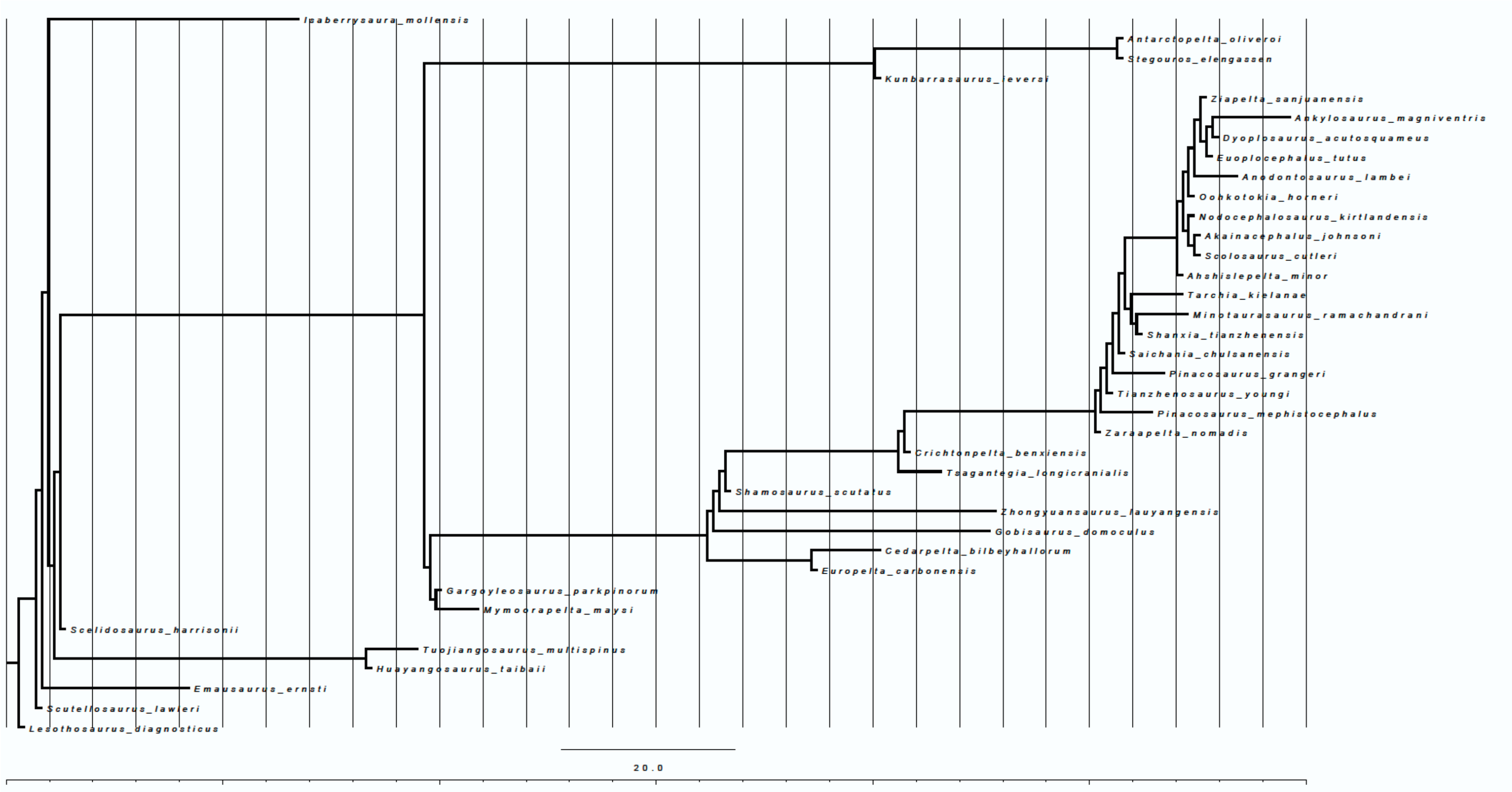


Fig. 10. Time-calibrated subtree from analysis of Loewen and Kirkland matrix. Subtree number 1.

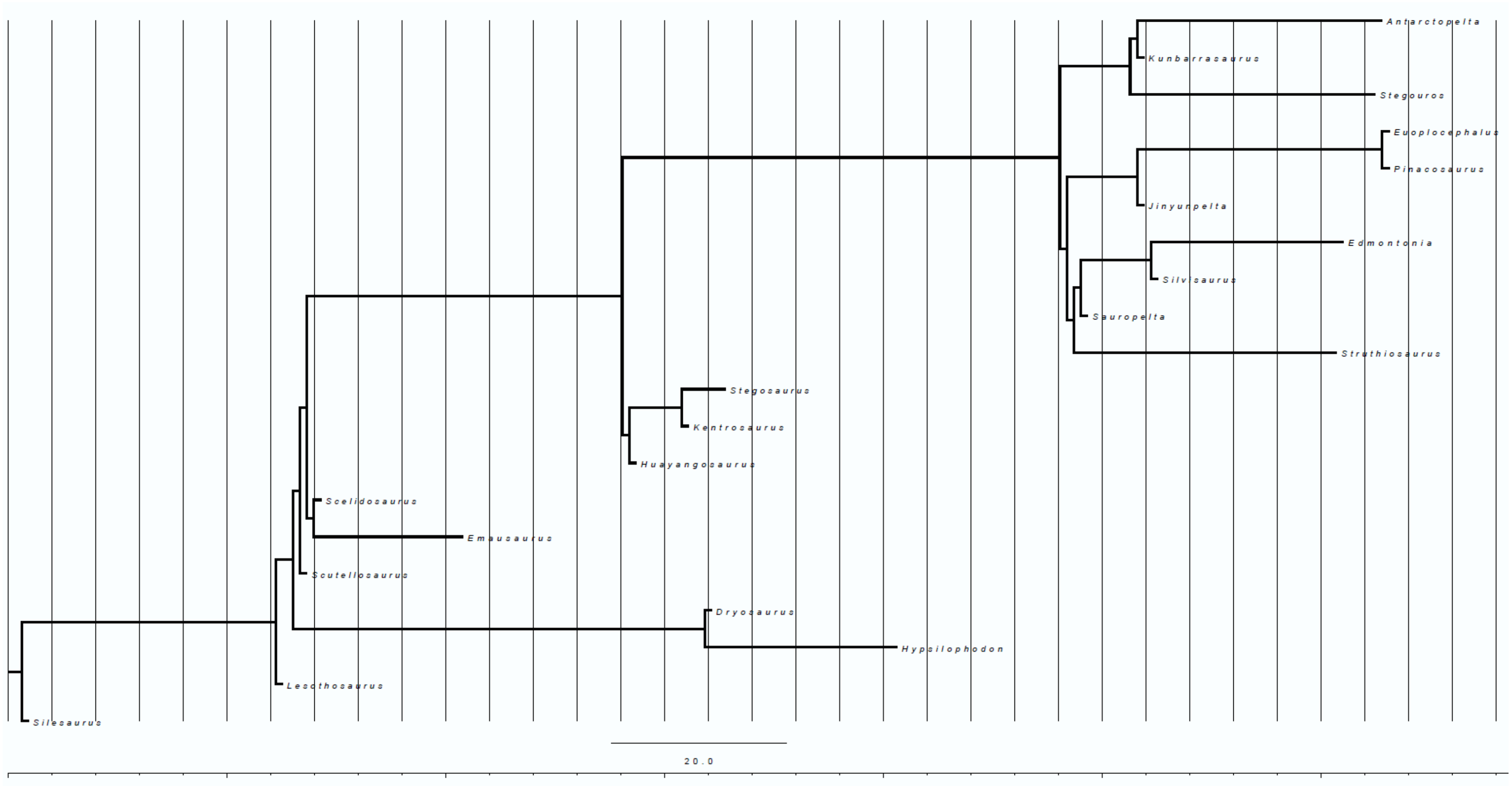


Fig. 11. Time-calibrated subtree from Norman matrix. Subtree number 2.

Han et al Matrix

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Silesaurus_opolensis

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Eoraptor_lunensis

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Herrerasaurus_ischiugualastensis

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Yueosaurus_tiantaiensis_

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Gideonmantellia_amosanjuanae

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Koreanosaurus_boseongensis

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Parksosaurus_warreni

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Zephylosaurus_schaffi_

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Thescelosaurus_neglectus_

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Gasparinisaura_cincosaltensis_

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Dryosaurus_altus_

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11101011101001

Zalmoxes_robustus

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0111011?00001111?200103?00????0????1????????????110?000??0?0?01????????????????
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Tenontosaurus_tilletti_

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1111?1110120001011101200002000011000101110000000000100?01??000000100000000
00000110001?0003010020000?0?1?101110000001010111000011011010111202011112101
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Iguanodon_atherfieldensis

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0010000000110000010000000000000111100000?0??000000??0122201110020200000?02
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11111211112000001?111200103000210000101101000000010011000001000010110111100
102101110111310010100200000?0?110011100011010111?111000120111101112020111121
01021000101?201001

Probactrosaurus_gobiensis_

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12??0??????????0103?0021??00?01??100000010?1?0?0?01000??01????11?1?2?11110111
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1001

Ouranosaurus_nigeriensis_

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Camptosaurus_dispar

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21101100?001?111?00102?0021?00030110100000???01000010102000011011110101011
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0101?100001

Stenopelix_valdensis_

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Yinlong_downsi

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00010001100010001100000021010010001010000?101010011001 01?100010?102110010
11000000000?1010001101 0?10000000?10100011010000111001003110120001 00?00??11

0011110111 0?10000101011000103100000000101100000 0????0000000000?0001000000
?0000000000?????0211001100100102111000010100 0??1?1?0010200?011?12020000121
0?0?1??0001?000001

Hualianceratops_wucaiwanensis

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10110?0?00000010???0????????0????????????10?1100??????????????????0???????????
1?100?1101??10001001?1010?01?010??0????01?????????001?0?0????10?111?0?11?????
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Chaoyangsaurus_youngi

221?11?01??0??00??1001?1?????00?????????11??????????10001011???01200????
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10000011010?10000000110100???01000011100100410010100100?000?11001111011100
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Xuanhuaceratops_niei

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Liaoceratops_yanzigouensis

210?11100000?0001010001001000111010111 1?1000100110100000020011200 01
000001011001110010000000210101101011110 00?111211000101011110110010110111?
1110000000 0?10101011010010000000110110??01000100110020031001210111111110 1
1001111001 10??????????????????????????????1???0000?????????????????????????????????
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Aquilops_americanus

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Yamaceratops_dorngobiensis
2???111?0????????????????????21?10111?01000?????01000100200010000110 00
0100100111101100??00?101011010??1??00?1???110?01?101??11?1??101?0111?11?0?00
0000?1?100???1101200011 1?101101??0010100100020 0?1?01?0??11111110110011110 0
1102????????????????????????1????????0000??
?0211???????0??0211110???0????
Archaeoceratops_oshimai
2101111101021000?010001000000121010111 1?1000100110120000120 01?0002??
00?0100100111101000 2?0021010110101?????0????21?00???10??1?111?010?1??1101??0
?000000?11101011010010001000110110???10101001000200310012100111111101100 11
11111101????0?0?0??0?000310?????????????0000???????????????????????????????????
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Auroraceratops_rugosus
210111110102100000100010000000111110111 1?100010011012001012001100021
100001001001?110110000002101011010111110 0?111211000??101111111??10???1110?
110?000000?111000110100100110001101100111010100100020031001210011111111011
0011110111 0?211?0101011110103100210101101100000000010100001000000000100000
000000000000?1100020100101110?1021111 0?0110000?11110001020000111121201001 2
101021??00?1?100001
Koreaceratops_hwaseongensis
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Albalophosaurus_yamaguchiorum
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Protoceratops_andrewsi
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10000100100111101100000021010110001[0
1]11100?1112100001?10??111110?101??11101??0?000000?11101011011010010111101
101??00001101000200410011?00111111101100111111111022?1??10101?0001031002101
0100110000000??1010000001?00000100000000000000000012100201001000?0?1021111
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Bagaceratops_rozhdestvenskyi
	21011?1100?2?00000100011001001211101112?100?10011012101002 0?01000011
00001001001111011002000210101100 01?11100?1111100001?101?111110?101?01?1?10
10?000000?111010?1011010010000?101101???0001101000201??????001111111011001
111111102?????????????????3??????????????????0???????????????????????????????????
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Leptoceratops_gracilis_
	2101111100?2?000001000100000012111011111?100?100??0121010120001000011
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???11111111101100111111111012?1???01011000103???21?1010011000000000100?0001
1100000001000000000010100000011000201001000?0?10211110001000?0??11100010?001
111?1212001012 10?02?1?00011100001
Psittacosaurus_mongoliensis
	22111000111210001010012100010 0?0???????0110010011??21010001100101010
0011000000011000001010020000010001110000?1010000001?10?00011100200000 1101
100?000000?10000001011010000111?1011001?010100?0000101??????0011111100110
01111011101?00001010110000030000?00?0101100000000001010000010000000 1000000?
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Psittacosaurus_lujiatunensis

2211100011121000101001210001000????????110?10011??2101000110010101000110000000110000010100200000100011100000?1010000001?1010001110?2000001101100?000000?100000010110100001111101101 1?010100?0000101??????001111?1001100111101110???0??

Mosaiceratops_azumai

21011011?0?21000001?0?110?01?1211101111?10???????0120000100 1??00001000010?01??1?1?????????????????0????????????????????????????111??20?????????????????1110101101?010010011?1011?01??0??1001?00201???????????1?111???0?111??11??01001????????21???????1??????????????????01?????2?????????????????????????

Scelidosaurus_harrisonii

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Scutellosaurus_lawleri_

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Emausaurus_ernsti_

010?0????0?0?00000?100000?0000?110001020100010000001000002?000100000000010000?00000??0??????100000010???0?00?0??00?00?????????????0??00????????????10000??????????1001100000?10?10000000100000?000001?0010???100?00??110011110

11100??????????1??????????????10????100?0?????????????????1???0???????????????
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Kunbarrasaurus_ieversi

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Gargoyleosaurus_parkpinorum

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Pinacosaurus_grangeri

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1112111?00010??110?010000??0??001?000000000?0100????????0???0?????????????011
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Euoplocephalus_tutus

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1221?????1????10?01???????????1????????????1??????????22?????????????????????10
1??????????????1?????????1?????????????21?1?????0????????????????????????????0???
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Huayangosaurus_taibaii

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0?000000?1000000?01000100000??00100010000 00000?1000000000 10022100?00??11001

11101110?11??0?01011??1012?00?1?101?011??110?1???111001??0?0?01101?????????
?1????????021111201 0?0?00000000?0????????11?01110001 1100?0??0??00121??0??1?11
11?21?111
Hesperosaurus_mjosi
0????????0?????00???????0000?0?1????????10??1?1????1??0002?00020000000??
0?0?00010?1?????1???10?0000?01?000?0?0??0??000??00???????1????????????????????
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0000?01?001012??0210?11?0110011????????????0?1??0?????????????????????????0??1
112010?0?0000000??00??2?0??11001?100???1???????????1?????????11?????????
Stegosaurus_stenops_
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00000000001001?0001101100000000 01?00000?0??00?000??000?1011010200??000?00?
10000000?1000000?012001000000?0?10001000000000?10001???????2211011 00001??1?
1?0111002100000?0012010120002101111011001100000?011010021000??111100001100
0102??1?110002111120 10?0?000000000000020??1110011110011100002 00??0?121??0??
111110?211111
Wannanosaurus_yansiensis_
???0??000001???00????0000001?
12???????????????????00?0?0110?001010011001 1?10?????????????????????????00000?1
????????00?0000000??100001?000010??0?0020?????????0110?00??01??11110?110?????
??01?????????????????????????0000??????????????110?100??????????????????????????????
?1????????????????????????????????????0010?21101???2?1??????????????????
Homalocephale_calathocercos
0??00?????????????????????0?????????????10??111????000001200102000000000
1112001100010000100000000001111000110100110111?1000110101011101110110??0?0
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????????????10003 10110??00?0111100000 01?????????????????????????????????????0
2010011 11011?1201110111 00000?1111100113 1120???1??100?012?1?0????0????0?????
Goyocephale_lattimorei
0???0?????????0?1?0???????00??????????????????111????????????????????000?????1
?2?????????????????0000000?111000010100 1??011?1?????????????10??1???????????0000?

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Stegoceras_validum

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0001112001100010000000?0??1000111100011110011001 1?1000110?01?1110111?10021
0?000000??????????0??0000100??100001?0010?0100000?103000100111001 00??112?111
1011101????????????1000????10?000?0111100000????1?000?0?11??101??????????????
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Prenocephale_prenes

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000111200110001000010 00???1??0111100011110011011 1?1000110001011101 1101?011
0?000000??03?00?1?1?1?0??????12?11110?1
101?????????????1???31?11????????1?1???0?0???
??2?1001111011?12??110111000?0??????????????0?1????1?0??????????????????????

Micropachycephalosaurus_hongtuyanensis

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Laquintasaura_venezuelae

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Isaberrysaura_mollensis

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Stegouros_elengassen

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000001111011110000000010??????????????????????????1101100???1001?110?1100??0?0
001010?0001200010000010??101?1??01????0???1100?00110?00000100010???1????0021
1112010?0?000000100100200??????????????10000200?0001210102000110112100 01

Antarctopelta_oliveroi

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Raven and Maidment Matrix

Pisanosaurus ? 15.0 ? 8.3

Lesothosaurus 0.5 16.0 6.0 0.1 9.0 1.0 3.2 3.2 14.0 ? 2.8 0.2 0.5 0.2 0.57 0.64 0.17 ? 2.1 ? 2.7 1.6 0.78 5.3

Scutellosaurus ? 18.0 4.0 0.1 7.0 1.0 3.0 3.0 ? 0.8 2.0 0.2 0.6 ? ? 0.83 0.23 ? ? ? ? 1.2 0.87 5.5

Emausaurus 0.59 19.0 6.0 0.65 ?

Scelidosaurus 0.5 18 7.0 0.4 8.0 1.07 2.46 2.56 16.0 0.6 2.68 0.35 ? ? ? ? ? 0.8 2.4 0.25 1.9 1.25 1.11 2.70

Huayangosaurus 0.8 21.0 6.0 0.5 8.0 ? ? 1.6 16.0 1.25 2.7 0.4 0.8 ? ? ? ? 1.7 2.11 ? 2.0 1.3 ? ?

Dacentrurus ? ? ? ? ? 2.6 0.8 2.2 ? ? 1.9 0.3 0.6 0.3 0.78 0.7 ? 1.6 ? 0.7 2.1 1.4 ? 1.4

Miragaia ? ? 5.0 0.2 17.0 1.14 1.53 1.8 ? ? 2.0 0.4 ? 0.5 0.71 ? ? 1.5 ? ? ? ? 1.75 1.49

Loricatosaurus ? ? ? ? ? 1.91 0.99 1.9 ? ? 2.06 0.35 ? 0.3 0.94 ? ? ? ? ? ? 1.7 ? ?

Kentrosaurus ? ? ? ? ? 1.27 0.45 0.62 ? 1.1 2.5 0.46 0.9 0.3 0.95 0.72 ? 1.6 4.57 1.1 1.6 1.69 1.47 1.45

Chungkingosaurus ? ? ? ? ? 3.2 1.1 3.6 ? ? ? ? ? ? ? ? ? 1.4 4.2 ? ? ? ? ?

Tuojiangosaurus ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? 2.28 3.6 ? ? ? ? ?

Gigantspinosaurus ? 30.0 ? ? ? ? ? ? 16.0 ? ? 0.36 ? ? 0.8 0.7 ? ? ? ? ? 1.6 1.57 ?

Wuerhosaurus ? ? ? ? ? 3.2 0.9 2.7 ? ? ? ? ? ? ? ? ? 1.5 9.3 ? ? ? ? ?

Stegosaurus 0.3 23.0 6.0 0.3 11.0 3.52 0.8 2.5 14.0 1.6 2.1 0.43 0.97 0.41 0.94 0.67 ? 1.81 6.1 0.71 2.05 1.94 1.72 1.1

Hesperosaurus ? ? ? ? 13.0 1.37 1.73 2.51 16.0 ? 2.3 0.5 1.0 0.4 0.93 ? ? 1.48 4.42 0.7 1.8 1.8 1.8 ?

Gastonia ? ? ? ? 8.0 1.0 3.1 3.1 ? ? 2.5 0.5 1.1 0.6 0.81 ? ? 1.3 ? ? ? 1.9 ? ?

Sauropelta ? ? 5.0 ? 8.0 1.0 1.95 1.95 16.0 0.99 2.9 0.3 ? 0.5 0.8 0.82 0.23 ? ? ? ? 1.5 1.3 ?

Euoplocephalus ? 21.0 6.0 ? 8.0 1.0 2.83 2.83 ? 0.9 2.5 0.3 1.4 0.4 0.83 0.58 ? 2.4 2.8 2.5 0.2 ? ? ?

Jiangjunosaurus ? 21.0 7.0 ? 11.0 ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

Laquintasaura ? ? 4.0 ?

Alcovasaurus ? ? ? ? 8.0 ? ? ? ? ? ? ? ? ? ? ? ? ? 1.8 ? ? ? ? ? ?

Adratiklit ? ? ? ? ? 1.45 1.47 2.14 ? ? 1.92 0.32 ? ? ? ? ? ? ? ? ? ? ? ?

Isaberrysaura ? 30 7 ? ? 6 ? ? ? 15 ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?

Paranthodon ? ? 6.0 ?

Stegouros ? ? 6.0 ? ? 1.35 1.80 1.84 ? ? 2.63 0.17 1.02 0.3 0.76 0.67 0.24 2.33 3.33 ? ? 1.03 1.12 2.83

Antarctopelta ? ? 8 ?

Kunbarrasaurus ? 25 ?

&[num]

Pisanosaurus

?????????0????????????10?0?1????????10???????????????????????????0??????0??????????0000000?????00???1???

Lesothosaurus

111?000??00?000??0000?00?000001000?111?00000?1???1010?10000100000000?
0?0111??00000100100?00000???000000100?

Scutellosaurus

0010?0???01??00?????0????00101?0010011??0?00??00?????1?0000?000?000100?
0110??000001?01???10000??0?000000?0?

Emausaurus

0000?000??1000????????0??00100?00?????????????00?00???10????????0???????
????????????????10000???0??0??0?0?

Scelidosaurus

1?1010?1?010?10100100100100100?0010101000?01?100?10100100001000?0001
1010111000001000000010100??00000000120

Huayangosaurus

0100100110110111101011101001001001 0???001001?000?0011010001 1?1?01101
1000001000??11011?1??1100?0000100?0010?

Dacentrurus

????????????????????????????1????????1???111?11011??????????1???0111010?
010100101121????110??0?1?[1 2]0???110?

Miragaia

111010?0001????????????????????????1011?????????????????1?10?100?????????
?????????1??????11????0?1??1??1?0?

Loricatosaurus

??????????????????????????????????000001?01??2111?001?0?????1?????110???
?1??01101021????11??11????????????

Kentrosaurus

0????1????????01??????1??101011????101?01?0101110111101100110110101110
0010?1101101021?12211001001?1[0 1]??111??

Chungkingosaurus

??0??????????????????????????0??????????11012????10???10????????0?1011000?
0110?1??????????11?0?00??10????10?

Tuojiangosaurus

0??001????0?1?0??????11??10111??1??????????????????????????????0?1111000?0100????????????11????????0???110?

Gigantspinosaurus

??????????????????????0?011??1?1???????1?002100?10?10??000?01???0111000?0100??1???21????11001000?10???110?

Wuerhosaurus

??0110?????????????????1111111001 01????????????11???1???10????1??

Stegosaurus

00002100011001111110101101100 1?1110000010001201101101101101001 0?1111111100101011010211122110001 1111[0 1]111110?

Hesperosaurus

?000000???110111110101?????0001?10111011001?011011??111101?11??111111 11001010110102 1?1??110001?0110???110?

Gastonia

1111?01??11??10000?11??????10?1011????01?012000?1010110?1010000?0111000?0100111??11????10110???1310??0200

Sauropelta

1????01???1??10000111??0?00101?1111????01?012000?0010110011100011 0?110000010001110?01000[0 1]10110??013?0000100

Euoplocephalus

11112010?11??10000111?10?00111?1111????01?0120?????10110010110111111 10000010010?0101111011011 0???1210?00?00

Jiangjunosaurus

0????0????1????111??11?0100101011??111???0????????????????0?????????????????????????????1100??1?????????0?

Laquintasaura

0?0??1??????????????????????00??0??01??????0????????????0?0???????????????????101????????00????????????10??

Alcovasaurus

??0???211?1??001?????????????????????
???11??0?0????1???0????101??11??

Adratiklit

??01101????????????????????1???????????????
???????????????1???????????????1???

Isaberrysaura

0????0000?1001???????1??????00?01???0???
?????????????????????????0?????????

Paranthodon

011111?1??0????????????????0?11?11???
????????????????????????????????????

Stegouros

??11?1???01??10???????????001101??10?00101001210?00010012???00100111111
0011110011???11000010?1?0??0101100421

Antarctopelta

?????1?????????????????????00110?????????10?????1???????0?2????0?????????????1
????????????????1??1?0?0??01??04?1

Kunbarrasaurus

11111111??100101?0001111??011???110???????????1?????1?0?2?1???10?01111?0
?????00111?011????101100000??1??0421

Arbour et al. Matrix

Lesothosaurus_diagnosticus

000000???0000000???0000000000000000000000000000000000000?0000000000
000000?0000001?00000000000000000000?0?00000000000000000?0000?0000000000000
0100?00001000000000000000000000000000100?000??

Scelidosaurus_harrisonii

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??100100001?1100?00100000010110000??00?00000000?0000000?0010?00000011000??
000000001011[12]11110????1100101212000000000000000
Huayangosaurus_taibaii
000000000000000000?00000000010??0000?11000100000000000000??1110000000
0010010?000111?00001001???11111?010001100000?0001000000?1010000000010?0??
?2010100021221?????0000000000110100000010?01?0?
Paranthodon_africanus
??????1??01???0??0?????????10?0???
???????????11100??
??????????????????????111????????
Stegosaurus_stenops
00000010001000000?000000000100?0000?000001000000000000??1110000000
0010010?000111?0001110????11111?010001100000?0001000000?1010000000010?0???
2010100021221?????0000000000110100111O1[0 1]10111?
Ahshislepelta_minor
??
??001111?110?????????????0001????????????????22
121????????1???????????????????0??0
Akainacephalus_johnsoni
11110100?12100010??22212000111?11120211?1110?212010?10110101100001?
?11111000?11110?110???????1?0011111000111110?0?1?00110?1?11111100?00??100???1
011010????23??1?0231???1110??12221???31000???
Aletopelta_coombsi
??
???????????111??????????????0???0?0?????????????????1??????0??????????????1111??1?2?
?????2????1???3?1????001????0???
Animantarx_ramaljonesi
101?1?????????????????????????????????11??11?0011??0?0001101?111???????10
110??1111110????1?0????111111?1?????????1001111210I?1111?01111011011??????11
0??????????????????????????????0?1????0???

Ankylosaurus_magniventris

11110100?11?112101?231010111101110111?210?11101212010211111111000011
111111101111001?211111???1111111??000011311???01110010????0?????0110100???2
010111???122?????22100??????1??121000??000???

Anodontosaurus_lambei

11110100?11111110?1231010111111110111210111101212110211111111100001
1111111101111001?21111?????????1110?00?11111????????????1110011?101001??????
01011112?122??????220??????????23100131?00?0?

Borealopelta_markmitchelli

1?100000???0??01???22101102?1????011?2100??1012120010?????????????????
???????1??????1111??????????1???????????????????1????????????????????01?????????
?122?????3101101130??????1???????????

Cedarpelta_bilbeyhallorum

11100?00?01?0?0????10000?00?100?1000?1?0??1?0????000??101?11110??0???0
1?1111011??1????00??????1??????1100??0?0???11??????????????????011010????10101?
?????????????????????????????????320?0???

Chuanqilong_chaoyangensis

1??1??101?111??????????????
???1111?0???111????1??101???????000?1????0100001?11100011?0000100??2211?11102
??2?????0?????0????????001111???00???

Crichtonpelta_benxiensis

111101???????????1?100000011????000?211011?01211010111110???11000?1?0
11111????????????????????11011110010?0????00101111010?11100?1?1??0000????2010
1110??????????????????????????1???211?0???

Denversaurus_schlessmani

10101?0??120??00???2110100??1????0???11???1?001110??0?????1?00?????????1
11??
???????????????????????1011?????????

Dongyangopelta_yangyanensis

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?????????????????????11110??????????????????????????????????????1?????????122?
?????????12??2????????????????

Dyoplosaurus_acutosquameus

??1????????????????2?10??????????????11?1???0?????1021??????????????????
?????????????1?????????????010011?1????????????110011?101????0??2201?111121
122??????????1111??12211?1?13100??00

Edmontonia_rugosidens

10101000?12001000??2110100111110?0???111??1?0011100100???11?1?11???0
1111101?1111100?011110?111?0111111??2?1??0?????????????????????1????????????
??????121?????3102????????????1011[3 4]1??0???

Edmontonia_longiceps

11101000?12001000??2110100111110?01??11???11001110010 0?11?11111110???
11111????111100?011?1???????????11????????????????????11111?1011???11????????1
?????111??????10???????1?????101131??0???

Euoplocephalus_tutus

111101001111111101123101011111111011121111110121201021111111100001
11111111101111101121111 0??011111111000001111101101110010111100111101001 00
1?120101111211222112022 10?111??12?12110021000??0

Europelta_carbonensis

?0101??????????????2110????11?0??0???110????0111100101101 11???01??????1
01?1???101???10?1100??01?0101111002?100??0?0?1??????0??????1?00111?????1?1101
011??122????????????11?03???00000141100???

Gargoyleosaurus_parkpinorum

10100000011100000 0?2210110001 01??001?210??1101211000001 2?0111100?010
?0100101011111 10??000010101????1???0?0??????????????????????????0??????????211
001????122221??2100??10202?2???100121100???

Gastonia_burgei

10100101?11?11000??1000000001110100 0?110?1110121100000111001110000 1?
0111010001????????1000?????????1111010?0001?????11020?1?111000100101 00?0???2
01010????1222112 1?2?0?120202?2100100131000??0

Gobisaurus_domoculus

11100110?01101010??10000000101?1000?110?11101212010011?011110000??
00110100?1????????1???????????11????????11??????????????????0????0?0000???1?????
?????????????????0?????????0010????10????

Hungarosaurus_tormai

?0????01?0?10000????????????1?0??????????1?0??111?????0???101??0??????1?1
????1101110??0?00?1??11111111110001000?00111012001?1?10??1010?11000??121101
0????12???????10???11??0???00?00132?00???

Hylaeosaurus_armatus

???1?????????????????????????????
?????????????????01??00?0????0100011101?0100000??111?????????0???????????00??11
1???2??????????2??12?0?????????????0

Jinyunpelta_sinensis

111000011111??011??1000???011????000?21?0??????1?0??????????????????????
??????1????0101??????01??1?11??????0?1?1??????1??1????100?1??0?00?1?101????1???
???????????????1????1???111??????00??0

Liaoningosaurus_paradoxus

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??????????0111???????????0??0???01010????0?0??00?1110001100100000?102?00?111000
?????????????????????????111???0000?

Mymoorapelta_maysi

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?????????????????????11010?010?10010????????????1011010?01?00010??1??????????12
2???????????122?2?2?00??????00????

Niobrarasaurus_coleii

1???????????????????1000??????1????0???1????????11??????????????????????????
?????????????111????1?1???1111110000??????1???????1110??101??00011??2111010111
1112??????????010??????00?11131?00?0?

Nodocephalosaurus_kirtlandensis

111??????????????????2?21???1?1???1011?22????1012120?0??1??11????????????1?

111?????????????????????????????0??
2222120????0???????????1???????0???

Nodosaurus_textilis

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?????????????????????111111???000?0???????????111??1101????????1111?1?011?12
????2??????000?0312???????31100?30

Panoplosaurus_mirus

10101100???0??000??21101101?1???101??110??1?0011100100?01011111111??0
1111101?1111?101211???0111????1?11?????????1000110200l???????????1101?1?1???
????1??121????12100???????????1001?10?00??

Paw_Paw_scuteling

??????????????????????????11????????????????????????0?0?1?????????????11?
????????????111???01?11?????????0????000?0??21???1?100??????0000??????0?1??????
???????????????????????1?1????0???

Pawpawsaurus_campbelli

10101000?02?00010??2221110211000101l?1101111011110010011001111111110
1110110101????????01???
????????????????0???????????1?0?????????

Peloroplites_cedrimontanus

?0101?00?111???????2?10??????????????110?01?00111000011 0?0101?0???????1
1?1???0???000??1000???01?10011?1012?0?????1??1112101?111000111????????0110111
000???????????????????????????000?1?00???

Pinacosaurus_grangeri

111101001111 10101?01000200?1111011?2022101100121101??111111111000011
1011011101111100111111 0??01?11111100?0011111010011?10?0111100111101001 0010
1201011112112 2????022101010 20?12212101 13??0000?

Pinacosaurus_mephistocephalus

11110100??????101???0?010???11???0?1?211?1100222101??1?0???????????????
???????1?10???1111101????????11????011111????1111??0?11100????????10?10???????
????122????022100???1???????1011?1?0????

Polacanthus_foxii

???1???211??????????????????????????

??????????0??????01??1?01?110101000?1100?11??????101000101 1???????121101011?

?122100???101?0202021??00????4100???0

Hoplitosaurus_marshi

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??????????????????????????????????1000110200???????????????10???210110?1??121

??????????020??2?????????????0????

Saichania_chulsanensis

1111000111111111??2222110111011101112110111012121101111111111110001

1101111111111110112111101111111??11?????????????1??1?110?01???????????10100101?

?????????122????0222000??10??????11113110 0?0?

Sauropelta_edwardsi

101010??????????????????0??????0??10???1100111011110 1?0001101111 1??11??1

001?101111110?1?1101110?0110101111000001010001112101011101010110100111 0211

10100111122????13201?0113011110011013?100000

Sauroplites_scutiger

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?????????12??2?????????????????

Scolosaurus_cutleri

11110?????????1??1?23101?1111????011?211??110121211021111111110???????

111111????????????111???????1???100?0011111011?1110??0?1110011010?001????1????

11?121122?????221011111011221210113 1??0??0

Shamosaurus_scutatus

11100110?011?1010??1000000000101?1000?110?11101212010111010111110011?

0011011??1111000?11??

?????1???????2210?????????????1???????????

Silvisaurus_condrayi

10101000?02000000??21101???0100?10???110?11?0011100?00011011111 1?11?0

1101101011111????01111???111111010?1??0???????????????0???????????????????????
?????122?????3101????????????1111?1??????

Stegopelta_landerensis

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???????????1?????00?1?1????????????????????20?1???????????????1?????????????????
?????10??????13??????001????????

Struthiosaurus_austriacus

?01?1??????????????2?10??????????????11?????0?????01100?0?1???????????111
10?0?111????0?1??????0?10?111?1???1????????11020?0?11100?1??0????????1211010??
??121?????3101??00?????????000??100???

Struthiosaurus_languedocensis

???
???????????111??????10111111???1000?????????????111?1?1000???????????????????12
1???????????10?????????00041?0????

Struthiosaurus_transylvanicus

?01?0??????????????2?1?????????????????1????0?????0101????????1???????1111
??????????????????000????1????????????????11120?0????????????????????????????????
?????????????????????????????????

Talarurus_plicatospineus

111100???????????102?21??0???????0?1?210?1?1012??01021?1??????0???????11
11110??????????????????11?0111000001111101101111000?111001111010010010120101111??12????????2?0?????0??????1??????0????

Taohelong_jinchengensis

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??????????????????????1????10??????????????????1?1?1?10?????????????????????12??
??????????12??2?????????????????

Tarchia_kielanae

11110001111?1?111??22221202111?1122?221?1101222110101010111110000?0
10111111111111011211110??
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Tatankacephalus_cooneyorum

?0101???????1??????2110????0111??????11??1?101111?0?00?1??????1?01?1?0?0
10010?????????0111??
??2?????????????????????1100????????

Texasetes_pleurohalio

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???????????111????1???????1????0????1001111210?????????????0?111???1101??01????
???????????????????????001??110???

Tsagantegia_longicranialis

11100000?11111000??22101001111101011?210?1110121?010111111111110001?
001111?10??????????11??0??
????????????????????????????1???????????

Zaraapelta_nomadis

111?00????????????02?22???2?1???1?221220?1110121211000111111111001?1??
1111110??
????????????????????????????????????

Zhejiangosaurus_luoyangensis

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????????????????????1???1101?001????????????????11100?111?1???????1211011?12???
???????????????????????????11????

Ziapelta_sanjuanensis

1111010??11??1110??2310101111 1??011?211?11101???01021??????1?0?0?1???
1111??0?????????1???
?1?2??????220????????????1???????????

Zuul_cruravastator

11110100?110?1110??23101011111?1012?211111101212110211111111100001?
00111111?1111000?001000??0???1?1??0?0?011111????????????1??0011???????????????
???????122????1?????1112??122111100???0???0

Salitral_Moreno_ankylosaur

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???????????????????01111??012?0?????????????????????????????????111110????1?1
??????1???????????????011??1?????

Kunbarrasaurus_ieversi

111000????????0????2???????1101?10???210??1??????00???001111110???1??010
01010?1?11?????11?0??01??????10?????0??1????0???????0010???0?00?000???????????
??12[1 2]????111002111104212??0011??121??1

Stegouros_elengassen

??????01???0??00????0??????11????????11?????????????00???????????0????1000
01???011??00?1000??0100111010002100O??101?0??????011101001?10??010101011010
000012[1 2]?????????2111?042120000111 0121101

Antarctopelta_oliveroi

???
????1??????100????1????1?100?21????1???001???????????????????????????????????[1
2]2??4??????111?042?2???011?012???1

Loewen and Kirkland Matrix

Lesothosaurus_diagnosticus

000000000000000000000000000?00000000000000????00?0000000000??0????0
00000000000000000000010?0000000000????????????????????00000100?0100000000000
00010000000000000000?0000100000??00?00000000000000000000000010000?1100010?0000
0000?0???0000000000000??1???????0001
0?000?00?

Scutellosaurus_lawleri

0???????????????0??0000???00?1???????????????????0????????00???0?01?0000??
???????0?00000????????000000?????????????????00??00000010?0000000000000000102
000000000000?00000000001000?00000000?0000001000000100000000000000000100000
000110????????????????????00??0000000????0???000000000000000?101????00100000
00000?

Emausaurus_ernsti

1100000000??00000??0000???00?10000010000000????00?0000??0???????00?000
00?????????011101010?0000000000????????????????00???00?????????000??????????
?00000000000??????????????????????????0?????????????????????????????????000100
????????????????????1????0?????????????000??????0??????????????0000?00??????

Huayangosaurus_taibaii

003001?000000000000000000000?1000002120000????00?0000?0011100001000
001100?1000200011020000?0000011000????????????????10??01010000?0011001111100
200201???000000000?0010110000101101001000?1110011010000000000????01100010
00000100100????????????????????120010??00?0???0???100100000?110010000[0 1]0[0
1]0100000?01?000?

Tuojiangosaurus_multispinus

00300000000?000000???????00?1?????21?00000????00?0000?????1000?000?01
1100????????01000????????011000????????????????10??000110???1?1?00?111100201
00000???0????0?0021110000201101?10000?1?111011010000000000????01?010100000?
?00100????????????????????10??10??00?????????011?1110001110100000[0
1]0????1110?????0??

Scelidosaurus_harrisonii

00000000000001000000000000000?1000002120101010????00?0000000000??00000
000000?0000001010011110110001000 1??0??00000?0000001100000000000?00000011011
??00011000100?000011?00010000000??0000100100100101010000111000010001000000
10100000000111000000000000000000100111001000000010000???000000000000000?101??
??0000000000110

Mymoorapelta_maysi

?????00?0????0?????????????????????????1?11101002011020 0?0011?0?01000011
000??????????????????????1?121111?????????1???1???00?11110?00000011?1101111120
0210010010?2100??1????01??1?11100101?00101110100111000111221????????1000?00
011111100011000??????100111010000120100000??????000000000?0?101????0?????00?
?????

Gargoyleosaurus_parkpinorum

100100000000201001000100100 0?20110021201011101002011 0200???110000100

0011000000???1011201110110100111211111000100010001101001111110???????1?211
0011?1?002100?0?10???????1?0100??11?1?10010??0????????0011100011????121010???
????0001111110001100 0??????100111010000120100?????000?0???00????0??01????010
011100?????
Europelta_carbonensis
103001?00???2111??????????010201000212010100000011000210111111 0000000
011111??0???101120?????1?001011210000???00?010100110101011101110100111 31121
1102121110010110 0??????0?1?1?1?00?1?1?01???11101011111112111210011111010101
1000100111?1???0????0????0?????1100001011111000???0000000000????0?101????000
011100?????
Cedarpelta_bilbeyhallorum
1010?1?0?00021110??001001001?2?????212010100000011000000011 01???00000
001111000110??????0110110??111120000?11?00?0?000011?????11000?1000???1321?11
10220001???0?????????????????????11110100???????????????????00000110101011????
???0000000?????????????????10?0????
?
Gobisaurus_domoculus
2010001010012012020201101001021111021201110000011100100101110100010
?001110100011?????????????11?01112000??10000?0001002?????????????????????????
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??10???????????
Zhongyuansaurus_lauyangensis
10110010110120120202011010010211110212011100000111 00??????001010100
001110100????????????????11??2112000??1100100010002?????????????100???????????
???????112?1111?????????????????1????????1??????????????????0000?????????????100
10???????????????????????????0?????????????????000??????????1?????1????100??0??
Shamosaurus_scutatus
20010010110120120202011010010211110212011100000111001001011001010 00
?0011101000?1?1111?0111011111??112000??100010001100210 1?????????1?1?01??????
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?00102111001110 01??????0??000??00?????????????0000?000??0000????1?????1???????
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Tsagantegia_longicranialis

1001002011012012120211101001021111021201110000011100111 10??00101010
00011101000100????????????11?1111212101110010000100 2??????????????????????????
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???0?????????????????????1????????????

Crichtonpelta_benxiensis

11000010100?201212021??0100??2111102121111111003210 01?001??01110001?
0111101000?00????????????11???112121111100100001002??????11000?101?011122100
101110111???0????210001001?100112?1?111101??11110211??????????????0210112111
11??0010212200122001??????0??010??000000010111000????00000000000?101????01??
?11?0?????

Zaraapelta_nomadis

310000101???2012??????????0??21111?21201011110032100100011010111001?0
111101????0?????????????????211212201?????00001102?????????????????????????????
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Pinacosaurus_mephistocephalus

3200002012012012120211101 0?112111?021211111110032100?0??111??????????
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001????01121?111?????100001??????11?10??01?111102?1???????????????????????????
0010212200122001??????0??000??000000?????100??00?????0?????0?101????010111?0?
??0??

Tianzhenosaurus_youngi

310000201001201212021110100112111?121211?111100321001100111100 1200?
0011110?000100??11??00100?11?1211213321?111100001002???01111?00?1?0?0111211
0010012???0112111112100010 01?10011211??11?001111110?1?11112000210000 0?1?11
?1?111?1????????????????????????????0??0?0000?????100??00000000?0000????1????010
??1100??00?

Pinacosaurus_grangeri

3101001?12012012121202111010011211111212111111100221001110111001110000
00011101000100111110001001111121121331111111000000021010??1?200?101?011131
100100120??01121111121000100 1?100112111010000111111021011??200021????02101
1?1?111110010212210122101??????0??000??000000?101110110000000000000000?101??
??01011??000010?

Saichania_chulsanensis

310100101211201212021110100112111112121111111003210011111111110011001
0011110100010011111000110111112112123111111100001002101111111210?1?0101113
2100100120100112111112100010001100112111010000111111021111112111210000021
0112111111100112100000000000??????0??100??000000010111001000000000000000?10
1????01?111100?000?

Ahshislepelta_minor

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???210001101?101111?10000000??????????????????????????????????????0011?????????
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Scolosaurus_cutleri

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???11100?10????1132100?0?110000???
1?1???????101?111111?1101100011010102101111211121000101101121111111002121
2210122100??????0??000??00000000???????????0???00????0?101?????10111??0??110

Shanxia_tianzhenensis

?????0101?????12???????????????????????11?111100321?????????1?11200100011
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???021011????????00???????
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Akainacephalus_johnsoni

2200101010112012120211101001121111121211011111022100110001110112000
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Nodocephalosaurus_kirtlandensis
31001010101120121?02111??00112?11??212110111110321001000010 1????0010
01111?????????????????????????1???211213321111100001002????????????????????????????
11110???0022
??????????????????????0?????????????????????0????00????????1?????1?????????0??
Minotaurasaurus_ramachandrani
310110100211201212021110100112111112121111111003210010001111112001
00011101000100111110001101111121121332111111000011121111 11?????????????????
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00??2?22001??????????????????????????????????0000????????????????????1011???????
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Tarchia_kielanae
??0??0101????01???????????????????????01?1111001?????1?????00112???0001?
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Anodontosaurus_lambei
22011020121120121202111010 01?211111212011110100221?0110011110111000
?0111101000?00111?1?00100111?12112111011101100001102111??????????????1?132?0
020011000?112111?1???????????????????01?0????1111021???????????0201011011?????
???00212122?0022?00??????0??100??00000000???1121?000????00????0?101????010011
?00?0???
Oohkotokia_horneri
22011010121120121202111010011211111212111111100321001 10?11?10112000
?01111010?0??????????????????1???211211101110120000 1102??????11???????????132100
21011011????1????21000???1???
0021212110021100??????0??000??0??????0???1011???00???00????????1????0?011100??
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Euoplocephalus_tutus

220110201211201212021110100112111112121111111003210011001111011 2000
0011110100010011111000110111112112111011111200001002111 0??11110?100001112
21002011200001121111121000110011 1?11111101000?1111110211111121112 10000011
011211111?10021210000000000??????0??000??00000000???1011000000000000000?101
????010001000???10

Dyoplosaurus_acutosquameus

??0??0101?????1?????????????????????????1?1??????????????????????????????????
??????????????????????11211?01???????00??????????????????????1321??2011200001
1211111?????????????????1?????0??10101021 1??????????????1110112111111?0021????
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Ankylosaurus_magniventris

3201101010112012120211101001121111121201111110032100100011110111000
0011110100010011111000100111112112111011100200001002111???11110?1010011???
???20111000011211111210001101?111????1?01010??1????0?????????????000111101 1??
?1???10010211??0010001??????0??000??0000000101110110000000000000000????1????01
000?000??0??

Ziapelta_sanjuanensis

110?1010121120121202111010011211 1?12120101111103210 0???????101110000
011110?000????????????????11??211211101100120000100 2??????????????????????????
?????????????????????????????0???0021
210000022200??????0??100???????????????????????0????00????????1?????1????????????

Kunbarrasaurus_ieversi

100100000000201 00???0?00?00??20100021101011101002000 02?00000110000 00
001000?0000???01??01110?1???10011??0???0?00?0000001100 0??1?????00011011???00
????????1?0?0??011?0000?01?0?????0000001001?01110100001110000100110000???0?0
00?000111010?00?1?0000?000100110??01000301 0000????000?000??00000?101?????00
11?121??211

Stegouros_elengassen

????????0000?????0???0000????2?????21???????????????????????011 0000000010
000??????1011101???????1100?100???1????????????11??0??11000?001??0111111011011

?21100?0?00???????????0?1011000??0100111110100?????????0011001010101000010
011?????????????????????1?????0003010010???000??11110????1001?????00011012110
211
Antarctopelta_oliveroi

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???????1?10?????????10???????????????????????????11000????????1????011??????1???
0???1??????1???00??11??????????
????????????1???????0301????????00??????0???????????????011012????11

Isaberrysaura_mollensis

000?000?????0000??00???????0?1?0???21?0???0???????000???????????????????
??????????1?????????00?10?00?0????????????0?????????????????????????????????????
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Norman Matrix

Silesaurus

00000000000000000000000000?000??00000??00000000001000000000000010?0
???00000000000000000001010010000000000000000011?10000?00?

Lesothosaurus

00001000001000000000000100001200100000000000000000010001000000020001
00001011000000010101110010200101000100000000000000100?000???

Hypsilophodon

00001000011000000000000100022011000000000001101300010012000000020001
00001011030011010101210010200101001100000000000000011000000?

Dryosaurus

00002000111000000000000100012011000000100011013020100120000000020001
0???101103111101010111011020010100110000000000001011000?00?

Scutellosaurus

0?00?0??01?010001?100010000?101?????????0??1????001000100?0?0?201010?0
0111100000??10101??00102111010001111?1??101000100000000??

Emausaurus

000010??012110001?10001000??11???1??????11?10?100010001 0???1??????2???

??????????????????????????????111????10100000??00?????

Scelidosaurus

000010001121110021 1?001000011111010110111111011100100010000100201 12

0100112100000101010111101021111100011111211010000000000000?0

Huayangosaurus

000010000121000000?0000?01001111110?00?1100111001000111010?1000010?111

1???021110???110201111011111121200?1102000011001000 10?01?0??

Kentrosaurus

00???????1??00?00???00?010??11110000????01?110???12210100100 1?11011111

210211100?1110201111021111121200??102000?11001?101[0 1]111?10?

Stegosaurus

0000200011210000000000010100011120000111001111010212210100100101 1012

11121021110001110201111021111212002010200001100011 01[0 1]111110?

Sauropelta

011??????1??111131??11???11??1??1?1????112?11112?1222010110 10??2112012

201221221???1131232103?11121201211111 32?101001113?100000?

Struthiosaurus

011??????1??11?131?111??????????1?1?????12?1??????2220??0?110?12?0?0????

1???221????????????31111?1?0?2?11?112?1010??0041100????

Silvisaurus

011010012 1?11111312111200113110111101221120111 2?0122201111?10???????

?12????1?2????????????10321112 1???2?111132??0100111?1???????

Edmontonia

0110200121211111312111200113110111101221120111222122201111110112112

??22012212212222113123210321112121121111132110100101[3 4]1??0??0?

Jinyunpelta

01?1211?112111??2????0200003?1????????211?0111?12???????1???0?10??201??

0111??00??????????1?321112120??1111??1?100101????00??10

Pinacosaurus

1101211121211122312112200013110101001221120111122121201111110110112
0122012212112221131232123202121211211111311100101013??0000??

Euoplocephalus

1101211121211122312112200013110101001221120111122121201111110110112
0122012212112221131232123202121211211111311100101010021000???0

Kunbarrasaurus

0100?111212111?21??12200001?11?00011??11??1112021222 0??0?010?1??1???
??0111??000??1010232?031????????11111112101000 01??121??11

Stegouros

??????0??12?1???1?????????????1?0001??1112?11?11?02220??110?00??1110012
0121111022???????1031111211001?1?1?1?21010?001101211011

Antarctopelta

??????????????????????????????????????12?1?????02220??11??0?????????????
???????????????????????????1?1??1??1010??01?012???11

Age character matrix for the calculation of the modified MSM or the GER (Raven & Maidment matrix)

Pisanosaurus	1
Lesothosaurus	2
Scutellosaurus	3
Emausaurus	4
Scelidosaurus	3
Huayangosaurus	8
Dacentrurus	9
Miragaia	A
Loricatosaurus	7
Kentrosaurus	9
Chungkingosaurus	9
Tuojiangosaurus	9
Gigantspinosaurus	9

Wuerhosaurus	C
Stegosaurus	A
Hesperosaurus	9
Gastonia	D
Sauropelta	E
Euoplocephalus	G
Jiangjunosaurus	8
Laquintasaura	2
Alcovasaurus	9
Adratiklit	6
Isaberrysaura	5
Paranthodon	B
Stegouros	H
Antarctopelta	H
Kunbarrasaurus	F

```
set age[0] 237;
set age[1] 229;
set age[2] 201;
set age[3] 199;
set age[4] 182;
set age[5] 170;
set age[6] 168;
set age[7] 166;
set age[8] 163;
set age[9] 157;
set age[10] 152;
set age[11] 145;
set age[12] 139;
set age[13] 136;
set age[14] 113;
set age[15] 105;
```

set age[16] 83;

set age[17] 77;

Age character matrix for the calculation of the modified MSM or the GER (Arbour & Currie matrix)

Lesothosaurus_diagnosticus	1
Scelidosaurus_harrisonii	2
Huayangosaurus_taibaii	3
Paranthodon_africanus	6
Stegosaurus_stenops	5
Ahshislepelta_minor	I
Akainacephalus_johnsoni	I
Aletopelta_coombsi	I
Animantarx_ramaljonesi	D
Ankylosaurus_magniventris	K
Anodontosaurus_lambei	J
Borealopelta_markmitchelli	B
Cedarpelta_bilbeyhallorum	C
Chuanqilong_chaoyangensis	A
Crichtonpelta_benxiensis	C
Denversaurus_schlessmani	K
Dongyangopelta_yangyanensis	B
Dyoplosaurus_acutosquameus	I
Edmontonia_rugosidens	H
Edmontonia_longiceps	I
Euoplocephalus_tutus	I
Europelta_carbonensis	B
Gargoyleosaurus_parkpinorum	4
Gastonia_burgei	8
Gobisaurus_domoculus	E
Hungarosaurus_tormai	G

Hylaeosaurus_armatus	7
Jinyunpelta_sinensis	C
Liaoningosaurus_paradoxus	A
Mymoorapelta_maysi	5
Niobrarasaurus_coleii	F
Nodocephalosaurus_kirtlandensis	I
Nodosaurus_textilis	D
Panoplosaurus_mirus	H
Paw_Paw_scuteling	C
Pawpawsaurus_campbelli	C
Peloroplites_cedrimontanus	C
Pinacosaurus_grangeri	I
Pinacosaurus_mephistocephalus	I
Polacanthus_foxii	9
Hoplitosaurus_marshi	9
Saichania_chulsanensis	H
Sauropelta_edwardsi	B
Sauroplites_scutiger	A
Scolosaurus_cutleri	I
Shamosaurus_scutatus	A
Silvisaurus_condrayi	C
Stegopelta_landerensis	D
Struthiosaurus_austriacus	H
Struthiosaurus_languedocensis	H
Struthiosaurus_transylvanicus	J
Talarurus_plicatospineus	D
Taohelong_jinchengensis	7
Tarchia_kielanae	I
Tatankacephalus_cooneyorum	B
Texasetes_pleurohalio	C
Tsagantegia_longicranialis	D

Zaraapelta_nomadis	H
Zhejiangosaurus_luoyangensis	D
Ziapelta_sanjuanensis	I
Zuul_cruravastator	I
Salitral_Moreno_ankylosaur	I
Kunbarrasaurus_ieversi	C
Stegouros_elengassen	I
Antarctopelta_oliveroi	I

set age[0] 205;

set age[1] 201;

set age[2] 199;

set age[3] 163;

set age[4] 157;

set age[5] 152;

set age[6] 145;

set age[7] 139;

set age[8] 136;

set age[9] 129;

set age[10] 125;

set age[11] 113;

set age[12] 105;

set age[13] 100;

Age character matrix for the calculation of the modified MSM or the GER (Loewen & Kirkland matrix)

Lesothosaurus_diagnosticus	1
Scutellosaurus_lawleri	2
Emausaurus_ernsti	3
Huayangosaurus_taibaii	5
Tuojiangosaurus_multispinus	6

Scelidosaurus_harrisonii	2
Mymoorapelta_maysi	7
Gargoyleosaurus_parkpinorum	6
Europelta_carbonensis	9
Cedarpelta_bilbeyhallorum	A
Gobisaurus_domoculus	C
Zhongyuansaurus_lauyangensis	C
Shamosaurus_scutatus	8
Tsagantegia_longicranialis	B
Crichtonpelta_benxiensis	A
Zaraapelta_nomadis	D
Pinacosaurus_mephistocephalus	E
Tianzhenosaurus_youngi	D
Pinacosaurus_grangeri	E
Saichania_chulsanensis	D
Ahshislepelta_minor	E
Scolosaurus_cutleri	E
Shanxia_tianzhenensis	D
Akainacephalus_johnsoni	E
Nodocephalosaurus_kirtlandensis	E
Minotaurasaurus_ramachandrani	E
Tarchia_kielanae	E
Anodontosaurus_lambei	F
Oohkotokia_horneri	E
Euoplocephalus_tutus	E
Dyoplosaurus_acutosquameus	E
Ankylosaurus_magniventris	G
Ziapelta_sanjuanensis	E
Kunbarrasaurus_ieversi	A
Stegouros_elengassen	E
Antarctopelta_oliveroi	E

Isaberrysaura_mollensis	4

```
set age[0] 205;
set age[1] 201;
set age[2] 199;
set age[3] 182;
set age[4] 170;
set age[5] 163;
set age[6] 157;
set age[7] 152;
set age[8] 125;
set age[9] 113;
set age[10] 105;
set age[11] 100;
set age[12] 93;
set age[13] 83;
set age[14] 77;
set age[15] 72;
set age[16] 68;
```

Age character matrix for the calculation of the modified MSM or the GER (Norman matrix)

Pisanosaurus	1
Lesothosaurus	2
Scutellosaurus	3
Emausaurus	4
Scelidosaurus	3
Huayangosaurus	8
Dacentrurus	9
Miragaia	A
Loricatosaurus	7

Kentrosaurus	9
Chungkingosaurus	9
Tuojiangosaurus	9
Gigantspinosaurus	9
Wuerhosaurus	C
Stegosaurus	A
Hesperosaurus	9
Gastonia	D
Sauropelta	E
Euoplocephalus	G
Jiangjunosaurus	8
Laquintasaura	2
Alcovasaurus	9
Adratiklit	6
Isaberrysaura	5
Paranthodon	B
Stegouros	H
Antarctopelta	H
Kunbarrasaurus	F

```
set age[0] 237;
set age[1] 229;
set age[2] 201;
set age[3] 199;
set age[4] 182;
set age[5] 170;
set age[6] 168;
set age[7] 166;
set age[8] 163;
set age[9] 157;
set age[10] 152;
```

```
set age[11] 145;
set age[12] 139;
set age[13] 136;
set age[14] 113;
set age[15] 105;
set age[16] 83;
set age[17] 77;
```

Supplementary Table II: Selected postcranial measurements of the holotype of *Stegouros elengassen* gen. et sp. nov

Bone	Total lenght	Proximal width	Distal width	Bone	Total lenght	Proximal width	Distal width
Left humerus	158,00	-	57,00	Right metacarpal I	33,90	16,00	12,10
Left radius	105,50	20,20	31,90	Right phalanx I-1	14,40	13,60	-
Left ulna	120,70	41,30	27,80	Right phalanx I-2	18,70	-	-
Left metacarpal I	34,20	15,60	13,90	Right metacarpal II	39,20	14,20	14,50
Left metacarpal II	37,50	16,20	15,20	Right phalanx II-1	11,20	11,60	-
Left metacarpal III	34,40	19,90	16,30	Right phalanx II-2	19,80	-	-
Left metacarpal IV	28,10	13,30	11,50	Right ilium	241*		
Left metacarpal V	19,30	11,80	10,00	Right ischium	157,00	59,30	
Left ilium	275,00			Right femur	163,00	47,20	52,70
Left ischium	141*	54,40		Right tibia	-	54,40	57,10
Left femur	150,60	47,70	51,50	Right metatarsal I	36,50		
Left tibia	144,90	58,70	51,50	Right phalanx I-1	16,40		
Left metatarsal I	35,00	-	-	Right phalanx I-2	20,60		
Left phalanx I-1	15,60	-	-	Right metatarsal II	68,90		
Left phalanx I-2	20,10	-	-	Right phalanx II-1	24,00		
Left metatarsal II	59,90	-	-	Right phalanx II-2	13,40		
Left phalanx II-1	23,20	-	-	Right phalanx II-3	25,50		
Left phalanx II-2	14,20	-	-	Right metatarsal III	72,80		
Left phalanx II-3	22,40	-	-	Right phalanx III-1	19,60		
Left metatarsal III	70,10	-	-	Right phalanx III-2	12,50		
Left phalanx III-1	20,10	-	-	Right phalanx III-3	9,30		

Left phalanx III-2	12,40	-	-	Right phalanx III-4	29,70		
Left phalanx III-3	10,20	-	-	Right metatarsal IV	65,90	24,07	17,00
Left phalanx III-4	16,2*	-	-	Right phalanx IV-1	21,20		
Left metatarsal IV	59,10	20,86	15,70	Right phalanx IV-2	9,00		
Left phalanx IV-1	12,40			Right phalanx IV-3	6,50		
Left phalanx IV-2	9,80			Right phalanx IV-4	5,50		
Left phalanx IV-3	7,00			Right phalanx IV-5	21,5*		
Left phalanx IV-4	6,00			Right metatarsal V	23,10		
Left phalanx IV-5	19,10						

.

References

Alarcón-Muñoz, J., Soto-Acuña, S., Manríquez, L., Fernández, R., Bájor, D., Guevara, J.P. & Suazo, F. Freshwater turtles (Testudines: Pleurodira) in the Upper Cretaceous of Chilean Patagonia. Journal of South American Earth Sciences, 102: 102652. DOI: 10.1016/j.jsames.2020.102652 (2020).

Arbour, V. M., Burns, M. E. & Sissons, R. L. A redescription of the ankylosaurid dinosaur Dyoplosaurus acutosquameus Parks, 1924 (Ornithischia: Ankylosauria) and a revision of the genus. Journal of Vertebrate Paleontology, 29, 1117-1135 (2009).

Arbour, V. M. & Currie, P. J. Euoplocephalus tutus and the diversity of ankylosaurid dinosaurs in the Late Cretaceous of Alberta, Canada, and Montana, USA. PLOS ONE, 8, e62421 (2013).

Arbour, V. M., Burns, M. E., Bell, P. R. & Currie, P. J. Epidermal and dermal integumentary structures of ankylosaurian dinosaurs. Journal of Morphology, 275, 39-50. (2014).

Arbour, V.M. & Currie, P.J. Systematics, phylogeny and palaeobiogeography of the ankylosaurid dinosaurs. Journal of Systematic Palaeontology 14, 385e444. https://doi.org/10.1080/14772019.2015.1059985 (2016).

Arbour, V.M. & Evans D.C. A new ankylosaurine dinosaur from the Judith River Formation of Montana, USA, based on an exceptional skeleton with soft tissue preservation. Royal Society Open Science 4(5):161086 DOI 10.1098/rsos.161086 (2017).

Arbour V.M., Zanno L.E. & Gates T. Ankylosaurian dinosaur palaeoenvironmental associations were influenced by extirpation, sea-level fluctuation, and geodispersal. Palaeogeogr. Palaeoclimatol. Palaeocol. 449, 289–299 (2016).

Auchter, N.C., Romans, B.W. & Hubbard, S.M. Influence of deposit architecture on intrastratal deformation, slope deposits of Tres Pasos Formation, Chile. Sedimentary Geology 341, 13-26 (2016).

Barral, A., Gomez, B., Legendre, S., & Lécuyer, C. Evolution of the carbon isotope composition of atmospheric CO2 throughout the Cretaceous. Palaeogeography, Palaeoclimatology, Palaeoecology, 471, 40-47 (2017).

Barrera, E., & Savin, S. M. Late Campanian-Maastrichtian marine climates and oceans. In Geol. Soc. Amer. Ann. Meeting, Abs. Prog., Toronto, Canada, A-282 (1998).

Barrett PM, Butler RJ, Mundil R, Scheyer TM, Irmis RB, Sánchez-Villagra MR. A paleoequatorial ornithischian and new constraints on early dinosaur diversification. Proceedings of the Royal Society: B 281:20141147 (2014).

Barrett, P. M., Rich, T. H., Vickers-Rich, P., Tumanova, T. A., Inglis, M., Pickering, D., Kool, L. & Kear, B. P. Ankylosaurian dinosaur remains from the Lower Cretaceous of southeastern Australia. Alcheringa, 34, 205-217 (2010).

Behrensmeyer, A.K. The taphonomy and paleoecology of plio-pleistocene vertebrate assemblages East of lake Rudolf, Kenya. Bulletin of the Museum of Comparative Zoology 146, 473e578 (1975).

Bell, P.R., Burns, M.E. & Smith, E.T. A probable ankylosaurian (Dinosauria, Thyreophora) from the Early Cretaceous of New South Wales, Australia. Alcheringa 48, 120–124 (2018).

Bice, K. L., Huber, B. T., & Norris, R. D. Extreme polar warmth during the Cretaceous greenhouse? Paradox of the late Turonian δ18O record at Deep Sea Drilling Project Site 511. Paleoceanography, 18(2) (2003).

Biddle, K.T., Uliana, M.A., Mitchum, R.M.Jr., Fitzgerald, M.G. & Wrighr, R.C. The stratigraphic and structural evolution of the central and eastern Magallanes Basin, southern South America. In P.A. Allen and P. Homewood (eds.), Foreland Basins. Special Publication of the International Association of Sedimentologists 8, 41-61 (1986).

Bonaparte, J.F. Cretaceous tetrapods of Argentina. Münchner Geowissenschaftliche Abhandlungen A 30: 73–130 (1996).

Boyd CA. The systematic relationships and biogeographic history of ornithischian dinosaurs. PeerJ. 3:1–62 (2015).

Brown, C.M., Henderson, D.M., Vinther, J., Fletcher, I., Sistiaga, A., Herrera, J. & Summons, R.E. An Exceptionally Preserved Three-Dimensional Armored Dinosaur Reveals Insights into Coloration and Cretaceous Predator-Prey Dynamics. Current Biology. doi:10.1016/j.cub.2017.06.071 (2017).

Camacho, H.H., Chiesa, J.O., Parma, S.G. & Reichler, V. Invertebrados marinos de la Formación Man Aike (Eoceno Medio), Provincia de Santa Cruz, Argentina. Boletín de la Academia Nacional de Ciencias 64, 187 – 208 (2000).

Cantrill, D.J. Cretaceous to Paleogene vegetation transition in Antarctica. In Transformative Paleobotany (pp. 645-659). Academic Press (2018).

Carpenter, K. Skeletal reconstruction and life restoration of Sauropelta (Ankylosauria: Nodosauridae) from the Cretaceous of North America. Canadian Journal of Earth Sciences 21: 1491–1498 (1984).

Carpenter, K., Miles, C. & Cloward, K. New primitive stegosaur from the Morrison Formation, Wyoming. Pp. 55–75 in K. Carpenter (ed.) The Armored Dinosaurs. Indiana University Press, Bloomington (2001).

Carpenter, K., Bartlett, J., Bird, J. & Barrick, R. Ankylosaurs from the Price River Quarries, Cedar Mountain Formation (Lower Cretaceous), east-central Utah. Journal of Vertebrate Palaeontology, 28, 1089-1101 (2008).

Case, J.A. Paleogene floras from Seymour Island, Antarctic Peninsula. Geological Society of America Memoirs, 169, 523-540 (1988).

Cerda, I.A., Paulina-Carabajal, A., Mendez, A., Lee, Y.-L. Paleohistology of the first ankylosaur (Dinosauria: Ornithischia) interstitial ossicles registered in South America (Cerro Fortaleza, Argentina), and the most austral continental record of the clade ? Reunión Virtual de Comunicaciones de la Asociación Paleontológica Argentina, p. 23 (2020).

Charrier, R., Pinto, L. & Rodriguez, M. P. Tecnostratigraphic evolution of the Andean Orogen in Chile, In: T. Moreno y W. Gibbons eds.), The Geology of Chile, pp. 21-114; The Geological Society (Londres) (2007).

Clyde, W.C., Krause, J.M., de Benedetti, F., Ramezani, J., Cúnero, N.R., Gandolfo, M.A., Haber, P., Whelan, C., Smith, T. New South American record of the Cretaceous–Paleogene boundary interval (La Colonia Formation, Patagonia, Argentina). Cretaceous Research, 104889. 10.1016/j.cretres.2021.104889 (2021).

Colbert, E. H. A primitive ornithischian dinosaur from the Kayenta Formation of Arizona. Museum of Northern Arizona Bulletin 53:1–61 (1981)

Coombs Jr WP. A juvenile ankylosaur referable to the genus Euoplocephalus (Reptilia, Ornithischia). Journal of Vertebrae Paleontology 6:162-173 (1986).

Coombs WP Jr. Teeth and taxonomy in ankylosaurs. In: Carpenter K, Currie PJ, eds. Dinosaur Systematics: Approaches and Perspectives. Cambridge: Cambridge University Press, 269–279 (1990).

Coombs, W. P., Jr. & Maryanska, T. Ankylosauria. Pp. 456-483 in D. B. Weishampel, P. Dodson & H. Osmolska (eds) The Dinosauria. 1st edition. Berkeley, CA: University of California Press (1990).

Coria, R. A. & Salgado, L. South American ankylosaurs. Pp. 159-168 in K. Carpenter (ed.) The armored dinosaurs. Indiana University Press, Bloomington (1990).

Cortés, R. Informe Geológico del área Río Las Chinas–Río Bandurrias (Última Esperanza). Empresa Nacional del Petróleo, Magallanes, Punta Arenas, Chile, 33 pp (1964).

Covault, J. A., Romans, B. W., & Graham, S. A. Outcrop expression of a continental-margin-scale shelf-edge delta from the Cretaceous Magallanes Basin, Chile. Journal of Sedimentary Research 79(7), 523-539 (2009).

Crisci, J. V., de la Fuente, M. S., Lanteri, A. A., Morrone, J. J., Ortiz Jaureguizar, E., Pascual, R., Prado, J.L. Patagonia, Gondwana Occidental (GW) y Oriental (GE), un modelo de biogeografía histórica. Ameghiniana 30: p. 104 (1993).

Cruzado-Caballero, P., Powell, J. *Bonapartesaurus rionegrensis*, a new hadrosaurine dinosaur from South America: implications for phylogenetic and biogeographic relations with North America. J. Vertebr. Paleontol. 37, e1289381 (2017).

Currie, P. J., Badamgarav, D., Koppelhus, E. B., Sissons, R. & Vickaryous, M. K. Hands, feet, and behaviour in Pinacosaurus (Dinosauria: Ankylosauridae). Acta Palaeontologica Polonica, 56, 489-504 (2011).

Daniels, B. G., Auchter, N. C., Hubbard, S. M., Romans, B. W., Matthews, W. A. & Stright, L. Timing of deep-water slope evolution constrained by large-n detrital and volcanic ash zircon geochronology, Cretaceous Magallanes Basin, Chile. GSA Bulletin 130(3-4), 438-454 (2018).

Daniels, B.G., Hubbard, S.M., Romans, B.W., Malkowski, M.A., Matthews, W.A., Bernhardt, A., Kaempfe, S.A., Jobe, Z.R., Fosdick, J.C., Schwartz, T.M., Fildani, A., & Scheirer, A.H. Revised chronostratigraphic framework for the Cretaceous Magallanes-Austral Basin, Última Esperanza Province, Chile. Journal of South American Earth Sciences: Vol: 94 (2019).

de Klerk, W.J. South Africa's first dinosaur revisited – history of the discovery of the stegosaur *Paranthodon africanus* (Broom). Annals of the Eastern Cape Museums. 1: 54–60 (2000).

Dieudonné, P. -E., Cruzado-Caballero, P., Godefroit, P. & Tortosa, T. A new phylogeny of cerapodan dinosaurs, Historical Biology, DOI: 10.1080/08912963.2020.1793979 (2020).

Eagles, G., & Jokat, W. Tectonic reconstructions for paleobathymetry in Drake Passage. Tectonophysics, 611, 28-50 (2014).

Ellis, B., Daly, D.C., Hickey, L.J., Mitchell, J.D., Johnson, K.R., Wilf, P. & Wing, S.L. Manual of Leaf Architecture. Ithaca, NY: Cornell University Press (2009).

Énay, R., Cariou, E., Mangold, C., Thierry, J., Guiraud, R., Bellion, Y. Callovian (162-158 Ma). En: Dercourt, J., Ricou, L.E., Vrielynck, B. (Eds.), Atlas Tethys Paleoenvironmental Maps. Beicip-Franlab, Rueil-Malmaison, France. (1993)

Estes, R., De Queiroz, K., Gauthier, J. Phylogenetic Relationships within Squamata, in R. Estes & G. Pregill (eds.), Phylogenetic Relationships of the Lizard Families: Essays Commemorating Charles L. Camp pp. 119–281. Stanford University Press, (Stanford, California) (1988).

Fildani, A., Cope, T.D., Graham, S.A. & Wooden, J.L. Initiation of the Magallanes foreland basin: Timing of the southernmost Patagonian Andes orogeny revised by detrital zircon provenance analysis. Geology 3, 1081–1084 (2003).

Fildani, A.; Romans, B.W.; Hubbard, S.M. & Fosdick, J.C. Tectonic setting of the Magallanes Basin, Chile. SEPM Field. Vol. 10: 7 p (2009).

Friedrich, O., Norris & R.D., Erbacher, J. Evolution of middle to Late Cretaceous oceans–A 55 m.y. record of Earth's temperature and carbon cycle. Geology 40, 107–110 (2012).

Galton, P.M. Fabrosauridae, the basal family of ornithischian dinosaurs (Reptilia: Ornithopoda). Paliontologische Zeitschrift 52:138-159 (1978).

Galton, P.M. The postcranial anatomy of stegosaurian dinosaur Kentrosaurus from the Upper Jurassic of Tanzania, East Africa. Geologica et Palaeontologica 15: 139–160 (1982).

Galton, P.M. Skull bones and endocranial casts of the stegosaurian dinosaur Kentrosaurus Hennig, 1915 fromthe Upper Jurassic of Tanzania, East Africa. Geologica et Paleontologica 22, 123–143 (1988).

Galton, P. M. Earliest record of an ankylosaurian dinosaur (Ornithischia: Thyreophora): Dermal armor from Lower Kota Formation (Lower Jurassic) of India. Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen, 205-219 (2019).

Galton, P.M. & Ayyasami, K. Purported latest bone of a plated dinosaur (Ornithischia: Stegosauria), a "dermal plate" from the Maastrichtian (Upper Cretaceous) of southern India. Neues Jahrbuch fur Geologie und Palaontologie, 285(1), 91-96 (2017).

Galton, P.M. & Upchurch, P. Stegosauria. In: Weishampel DB, Dodson P, Osmólska, eds. The Dinosauria. second edition. Berkeley: University of California Press, 343-362 (2004).

Galton, P. M., & K. Carpenter. The plated dinosaur Stegosaurus longispinus Gilmore, 1914 (Dinosauria: Ornithischia; Upper Jurassic, western USA), type species of Alcovasaurus n. gen. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen 279:185–208 (2016).

Galton, P.M. & Coombs, W.P. *Paranthodon africanus* (Broom) a stegosaurian dinosaur from the lower cretaceous of South Africa. Geobios 14(3):299-309 DOI 10.1016/S0016-6995(81)80177-5 (1981).

Gasparini, Z., Olivero, E., Scasso, R. & Rinaldi, C. Un ankilosaurio (Reptilia, Ornithischia) Campaniano en el continente antártico. In: Anais do X Congresso Brasileiro de Paleontologia, pp. 131-141. Río de Janeiro (1987).

Gasparini, Z., Pereda-Suberbiola, X. & Molnar, R. E. New data on the ankylosaurian dinosaur from the Late Cretaceous of the Antarctic Peninsula. Memoirs of the Queensland Museum, 39, 583-594 (1996).

Gasparini, Z., Sterli, J., Parras, A., O'Gorman, J. P., Salgado, L., Varela, J. Pol, D. Late Cretaceous reptilian biota of the La Colonia Formation, central Patagonia, Argentina: Occurrences, preservation and paleoenvironments. Cretaceous Research, 54, 154-168 (2015).

Gastaldo, R.A. Terrestrial plants: in Briggs, D.E.G. and Crowther, P.R., eds. Palaeobiology II: Blackwell Scientific, Oxford, UK. p. 312-315 (2001).

Gayet, M., Rage, J. C., Sampere, T., and Gagnier, P. Y. Modalité des exchanges de vertebrés continentaux entre l'Amerique du Nord et l'Amerique du Sud au Cretacé superior et au Paleocene: Bulletin de la Société Géologique de France, v. 163, p. 781–791 (1992).

George, S. W., Davis, S. N., Fernández, R. A., Manríquez, L. M., Leppe, M. A., Horton, B. K., & Clarke, J. A. Chronology of deposition and unconformity development across the Cretaceous–Paleogene boundary, Magallanes-Austral Basin, Patagonian Andes. Journal of South American Earth Sciences, 102237 (2020).

Ghiglione, M. C. Orogenic growth of the Fuegian Andes (52–56) and their relation to tectonics of the Scotia Arc. In Growth of the Southern Andes (pp. 241-267). Springer, Cham (2016).

Gilmore, C.W. Osteology of the armoured Dinosauria in the United States National Museum, with special reference to the genus Stegosaurus. United States National Museum Bulletin 89, 1–143 (1914).

Gilmore, C. W. On dinosaurian reptiles from the Two Medicine Formation of Montana. Proceedings of the United States National Museum, 77, 1-39 (1930).

Gilmore, C. W. Two new dinosaurian reptiles from Mongolia with notes on some fragmentary specimens. American Museum Novitates, 679, 1-20 (1933).

Godefroit, P., Pereda-Suberbiola, X., Li, H. & Dong, Z.-M. A new species of the ankylosaurid dinosaur Pinacosaurus from the Late Cretaceous of Inner Mongolia (P. R. China). Bulletin de l'Institut Royal des Sciences Naturelles de Belgique 69 (Suppl. B), 17e36 (1999).

Goin, F.J., Martinelli, A.G. Soto-Acuña, S., Vieytes, M.C., Manríquez, L.M.E., Fernández, R.A., Pino, J.P., Trevisan, C., Kaluza, J., Reguero, M.A., Leppe, M., Ortiz, H., Rubilar-Rogers, D. & Vargas, A.O. First Mesozoic mammal from Chile: the southernmost record of late Cretaceous gondwanatherian. Boletín del Museo Nacional de Historia Natural, Chile, 69(1): 5-31 (2020).

Goloboff, P.A. & Catalano, S.A. TNT version 1.5, including a full implementation of phylogenetic morphometrics. Cladistics 32: 221–238 (2016).

González, E. J. Estratigrafía secuencial y sedimentología de la Formación Dorotea (Maastrichtiano), sector Río de las Chinas, Región de Magallanes y Antártica Chilena, Chile (50°S). Universidad de Chile (Thesis): 1-153 (2015).

Gutiérrez, N.M., Le Roux, J.P., Vásquez, A., Carreño, C., Pedroza, V., Araos, J., Oyarzún, J.L., Pino, J.P., Rivera, H.A. & Hinojosa, L.F. Tectonic events reflected by palaeocurrents, zircon geochronology, and palaeobotany in the Sierra Baguales of Chilean Patagonia. Tectonophysics 695, 76-99 (2017).

Hallam, A. Early and mid-Jurassic molluscan biogeography and the establishment of the Central Atlantic seaway. Palaeogeography, Palaeoclimatology, Palaeoecology 43: 181–193 (1983).

Hammer, Øyvind, Harper, David A.T., & Paul D. Ryan. Past: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica, vol. 4, issue 1, art. 4: 9pp., 178kb.http://palaeo-electronica.org/2001_1/past/issue1_01.htm (2001).

Han, F.-L., Forster, C.A., Xu, X. & Clark, J.M. Postcranial anatomy of *Yinlong downsi* (Dinosauria: Ceratopsia) from the Upper Jurassic Shishugou Formation of China and the phylogeny of basal ornithischians. J. Syst. Palaeontol. 16, 1159–1187 (2018).

Hennig, E. Kentrosaurus aethiopicus, der stegosauridae des Tendaguru. Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin 1915, 219–247 (1915).

Hennig, E. Kentrurosaurus aethiopicus, die Stegosaurier-funde von Tendaguru, Deutsch-Ostafrika. Palaeontographica, Supplement 7: 103–254 (1925).

Holz, M. & Barberena, M.C. Taphonomy of the south Brazilian Triassic paleoherpetofauna: pattern of death, transport and burial. Palaeogeography, Palaeoclimatology, Palaeoecology. 107, 179-197 (1994).

Hubbard, S. M., Romans, B. W., & Graham, S. A. Deep-water foreland basin deposits of the Cerro Toro Formation, Magallanes basin, Chile: architectural elements of a sinuous basin axial channel belt. Sedimentology 55(5), 1333-1359 (2008).

Hubbard, S.M., Fildani, A., Romans, B.W., Covault, J.A. & Mchargue, T.R. High-relief slope clinoform development: Insights from outcrop, Magallanes Basin, Chile. Journal of Sedimentary Research 80, 357–375 (2010).

Huber, B. T., Hodell, D. A., & Hamilton, C. P. Middle–Late Cretaceous climate of the southern high latitudes: stable isotopic evidence for minimal equator-to-pole thermal gradients. Geological Society of America Bulletin, 107(10), 1164-1191 (1995).

Huber, B. T., Norris, R. D., & MacLeod, K. G. Deep-sea paleotemperature record of extreme warmth during the Cretaceous. Geology, 30(2), 123-126 (2002).

Huber, B. T., MacLeod, K. G., Watkins, D. K., & Coffin, M. F. The rise and fall of the Cretaceous Hot Greenhouse climate. Global and Planetary Change, 167, 1-23 (2018).

Huene, F. von. Los Saurisquios y Ornithisquios de Cretacéo Argentino. Anales del Museo de La Plata (serie 2) 3: 1–196 (1929).

Hünicken, M. Depósitos neocretácicos y terciarios del extremo SSW de Santa Cruz. Cuenca carbonífera de Río Turbio. Revista del Instituto Nacional de Investigaciones de las Ciencias Naturales y Museo Argentino de Ciencias Naturales "Bernardino Rivadavia". Ciencias Geológicas, 4 (1), 1-164 (1955).

Iturralde-Vinent, M.A. Meso-Cenozoic Caribbean Paleogeography: Implications for the Historical Biogeography of the Region. International Geology Review, 48, 791–827 (2006).

Iturralde-Vinent, M., & MacPhee, R.D.E. Paleogeography of the Caribbean region: Implications for Cenozoic biogeography: American Museum of Natural History Bulletin, v. 238, p. 1–95 (1999).

Jujihara, T., Soto-Acuña, S., Vargas, A., Stinnesbeck, W., Vogt, M., Rubilar-Rogers, D. & Leppe, M. The southermost Dinosaurs of South America. XXIII Latin American Colloquium LAK 2014, Heidelberg, Alemania. p. 88 (2014).

Kaluza, J., Soto-Acuña, S., Manríquez, L., Otero, R., Fernández-Jiménez, R., Aravena, B., Suazo Lara, F., Alarcón-Muñoz, J., Milla, V., Pino, J. & Ortiz, H. Excavación de un nuevo dinosaurio de la Formación Dorotea (Cretácico Superior), Valle del Río de Las Chinas, Provincia de Última Esperanza. In: Libro de resúmenes del I Congreso Chileno de Paleontología, Punta Arenas: 18-20 (2018).

Katz, H. Revision of Cretaceous stratigraphy in Patagonian Cordillera of Última Esperanza, Magallanes province, Chile. American Association of Petroleum Geologist Bulletin, v 47, 5'6-524 (1963).

Kaufmann, C., Gutiérrez, M.A., Álvarez, M.C., González, M.E. & Massigoge, A. Fluvial dispersal potential of guanaco bones (Lama guanicoe) under controlled experimental conditions: the influence of age classes to the hydrodynamic behavior. Journal of Archaeological Science, 38: 334-344 (2011).

Keller, G., Punekar, J., & Mateo, P. Upheavals during the late Maastrichtian: Volcanism, climate and faunal events preceding the end-Cretaceous mass extinction. Palaeogeography, Palaeoclimatology, Palaeoecology, 441, 137-151 (2016).

Kilbourne, B. & Carpenter, K. Redescription of *Gargoyleosaurus parkpinorum*, a polacanthid ankylosaur from the Upper Jurassic of Albany County, Wyoming. Neues Jahrbuch für Geologie und Paläontologie - Abhandlungen 237: 111–160 (2005).

Kinneer, B., K. Carpenter, & A. Shaw. Redescription of Gastonia burgei (Dinosauria: Ankylosauria, Polacanthidae), and description of a new species. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen 282:37–80 (2016).

Lamanna, Matthew C., Roberts E M., Arbour VM, Salisbury SW., Clarke J, Malinzak E, and. O'connor PM. "Late Cretaceous non-avian dinosaurs from the James Ross Basin, Antarctica: description of new material, updated synthesis, biostratigraphy, and paleobiogeography." *Advances in Polar Science* (2019): 228-250.

Leahey, L.G., Salisbury, S.W., First evidence of ankylosaurian dinosaurs (Ornithischia: Thyreophora) from the mid–Cretaceous (late Albian–Cenomanian) Winton Formation of Queensland, Australia. Alcheringa 37, 249–257 (2013).

Leahey, L.G., Molnar, R.E., Carpenter, K., Witmer, L.M. & Salisbury, S. W. Cranial osteology of the ankylosaurian dinosaur formerly known as Minmi sp. (Ornithischia: Thyreophora) fromthe Lower Cretaceous Allaru Mudstone of Richmond, Queensland, Australia. PeerJ 3: e1475 (2015).

Leahey, L. G., Molnar, R. E. and Salisbury, S. W. More than Minmi: A new Australian ankylosaurian dinosaur from the Lower Cretaceous (Albian) Of Queensland, with implications for understanding global thyreophoran diversity. In: Program and Abstracts, 79th Annual Meeting of the Society of Vertebrate Paleontology, Brisbane, Australia. Journal of Vertebrate Paleontology, 139 (2019).

Leppe, M., Stinnesbeck, W., Hinojosa, L.F., Nishida, H., Dutra, T., Wilberger, T., Trevisan, C., Pino, J.P., Mansilla, H. & Garrido, S. Paleoclimatic estimations in the Upper Cretaceous of Magallanes Region, Southern South America. In "10th International Symposium on the Cretaceous", Vienna, Austria (2017).

Li, L., & Keller, G. Maastrichtian climate, productivity and faunal turnovers in planktic foraminifera in South Atlantic DSDP sites 525A and 21. Marine Micropaleontology, 33(1), 55-86 (1998).

Linnert, C., Robinson, S. A., Lees, J. A., Bown, P. R., Pérez-Rodríguez, I., Petrizzo, M. R., Falzoni, E., Littler, K., Arz, J.A. & Russell, E. E. Evidence for global cooling in the Late Cretaceous. Nature communications, 5(1), 1-7 (2014).

Linnert, C., Engelke, J., Wilmsen, M., & Mutterlose, J. The impact of the Maastrichtian cooling on the marine nutrient regime—Evidence from midlatitudinal calcareous nannofossils. Paleoceanography, 31(6), 694-714 (2016).

Loewen M.A. & Kirkland J.I. The evolution and biogeographic distribution of Ankylosauria: New insights from a comprehensive phylogenetic analysis. Journal of Vertebrate Paleontology, Program and Abstracts 2013:25 (2013).

Lü, J., Ji, Q., Gao, Y. & Li, Z. A new species of the ankylosaurid dinosaur Crichtonsaurus (Ankylosauridae: Ankylosauria) from the Cretaceous of Liaoning province, China. Acta Geologica Sinica, 81, 883-897 (2007a).

Lull, R. The Cretaceous armored dinosaur, Nodosaurus textilis Marsh. American Journal of Science, Series 5, 1, pp. 97-126 (1921).

Macellari, C.E., Barrio, C.A. & Manassero, M.J. Upper Cretaceous to Paleocene depositional sequences and sandstone petrography of southwestern Patagonia (Argentina and Chile). Journal of South American Earth Sciences 2(3), 223-239 (1989).

Maidment, S.C.R., Norman, D.B., Barrett, P.M. & Upchurch, P. Systematics and phylogeny of Stegosauria (Dinosauria: Ornithischia). J. Syst. Palaeontol. 6, 367–407 (2008).

Maidment, S. C. R., Brassey, C. & Barrett, P.M. The postcranial skeleton of an exceptionally complete individual of the plated dinosaur Stegosaurus stenops (Dinosauria: Thyreophora) from the Upper Jurassic Morrison Formation of Wyoming, U.S.A. PLoS One 10(10): e0138352 (2015).

Maidment, S.C.R., Wei, G.-B. & Norman, D.B. Re–description of the postcranial skeleton of the Middle Jurassic stegosaur Huayangosaurus taibaii. Journal of Vertebrate Palaeontology 26, 944–956 (2006).

Maidment, S.C.R., Raven, T.J., Ourhache, D. & Barrett, P.M. North Africa's first stegosaur: Implications for Gondwanan thyreophoran dinosaur diversity. Gondwana Research 77: 82–97 (2020).

Maleev, E. A. The Armored dinosaurs of the Cretaceous period in Mongolia (Family Syrmosauridae). Doklady Akademii Nauk, SSSR, 48, 142-170 (1954).

Maleev, E.A. [Armored dinosaurs of the Upper Cretaceous of Mongolia, Family Ankylosauridae]. Trudy Palaeontologicheskoi Instytuta, Akademiia Nauk SSSR 62, 51-91 (In Russian; translation by R Welch) (1956).

Mallison, H. The real lectotype of Kentrosaurus aethiopicus Hennig 1915, Neues Jahrb. für Geol. Paläontol. Abh., 259, 197–206 (2011).

Mallon, J.C., Henderson, D.M., McDonough, C.M. & Loughry, W.J. A “bloat-and-float” taphonomic model best explains the upside-down preservation of ankylosaurs. Palaeogeography, Palaeoclimatology, Palaeoecology 497, 117e127. https://doi.org/10.1016/j.palaeo.2018.02.010 (2018).

Malumián, N. Foraminíferos de la Formación Man Aike (Eoceno, sureste lago Cardiel), Provincia de Santa Cruz. Revista de la Asociación Geológica Argentina 45 (3-4), 364 – 385. Buenos Aires (1990).

Manriquez, L. M., Lavina, E. L., Fernández, R. A., Trevisan, C. & Leppe, M. A. Campanian-Maastrichtian and Eocene stratigraphic architecture, facies analysis, and paleoenvironmental evolution of the northern Magallanes Basin (Chilean Patagonia). Journal of South American Earth Sciences, 93, 102-118 (2019).

Marenssi, S. A., Casadío, S. & Santillana, S. N. Estratigrafía y sedimentología de las unidades del Cretácico superior-Paleógeno aflorantes en la margen sureste del lago Viedma, provincia de Santa Cruz, Argentina. Revista de la Asociación Geológica Argentina 58(3), 403-416 (2003).

Martinelli, A., Soto-Acuña, S., Goin, F.J., Kaluza, J., Bostelman, N, J.E., Fonseca, P.H.M., Reguero, M.A., Leppe, M. & Vargas, A.O. New cladotherian mammal from southern Chile and the evolution of mesungulatid meridiolestidans at the dusk of the Mesozoic era. Scientific Reports, https://doi.org/10.1038/s41598-021-87245-4 (2021)

Maryanska, T. Ankylosauridae (Dinosauria) from Mongolia. Palaeontologia Polonica, 37, 85-151 (1977).

Mateo, P., Keller, G., Punekar, J., & Spangenberg, J. E. Early to Late Maastrichtian environmental changes in the Indian Ocean compared with Tethys and South Atlantic. Palaeogeography, Palaeoclimatology, Palaeoecology, 478, 121-138 (2017).

Mella, P. Control tectónico en la evolución de la Cuenca de antepaís de Magallanes, XII Región, Chile. Memoria para optar al Título de Geólogo. Universidad de Concepción, Departamento de Ciencias de la Tierra (Inédito), 149 pp (2001).

Molnar, R. E. An ankylosaur (Ornithischia: Reptilia) from the Lower Cretaceous of southern Queensland. Memoirs of the Queensland Museum, 20, 77-87 (1980).

Molnar, R.E. Preliminary report on a new ankylosaur from the Early Cretaceous of Queensland, Australia. Memoirs of the Queensland Museum 39: 653–668 (1996).

Molnar, R.E. Armor of the small ankylosaur Minmi. In: Carpenter K, ed. The armored dinosaurs. Bloomington: Indiana University Press, 341–362 (2001).

Muir, R.A., Bordy, E.M., Mundil, R. & Frei, D. Recalibrating the breakup history of SW Gondwana: U–Pb radioisotopic age constraints from the southern Cape of South Africa. Gondwana Research 84: 177–193 (2020).

Murray, A., Riguettu, F., Rozadilla, S. New ankylosaur (Thyreophora, ornithischia) remains from the Upper Cretaceous of Patagonia. Journal of South American Earth Sciences 96: 102320 (2019).

Nath, T.T., Yadagiri, P. y Moitra, A.K. First record of armoured dinosaur from the Lower Jurassic Kota Formation, Prahita-Godivari Valley, Andhra Pradesh. Journal of the Geological Society of India 59: 575–577 (2002).

Norman, D.B. *Scelidosaurus harrisonii* (Dinosauria: Ornithischia) from the Early Jurassic of Dorset, England: biology and phylogenetic relationships. Zoological Journal of the Linnean Society. DOI: 10.1093/zoolinnean/zlaa061(2020a).

Norman, D.B. *Scelidosaurus harrisonii* Owen, 1861 (Dinosauria: Ornithischia) from the Early Jurassic of Dorset, England: cranial anatomy. Zoological Journal of the Linnean Society 188: 1–81 (2020b).

Norman, D.B. *Scelidosaurus harrisonii* Owen, 1861 (Dinosauria: Ornithischia) from the Early Jurassic of Dorset, England: postcranial endoskeleton. Zoological Journal of the Linnean Society 189: 47–157 (2020c).

Norman, D.B. *Scelidosaurus harrisonii* Owen, 1861 (Dinosauria: Ornithischia) from the Early Jurassic of Dorset, England: dermal skeleton. Zoological Journal of the Linnean Society 190: 1–53. doi/10.1093/zoolinnean/zlz085 (2020d).

Novas, F.E. The Age of Dinosaurs in South America. Indiana University Press, Bloomington, 452 p (2009).

Ősi, A., Prondvai, E., Mallon, J., & Bodor, E.R. Diversity and convergences in the evolution of feeding adaptations in ankylosaurs (Dinosauria: Ornithischia). Historical Biology, 29: 539–570. DOI: 10.1080/08912963.2016.1208194 (2017).

Ostrom, J. Stratigraphy and paleontology of the Cloverly Formation (Lower Cretaceous) of the Bighorn Basin area, Wyoming and Montana. Peabody Museum of Natural History, Yale University, Bulletin 35, 234 p (1970).

Otero, R.A., Oyarzún, J.L., Soto-Acuña, S., Yury-Yáñez, R., Gutiérrez, N., Le Roux, J., Torres, T. & Hervé, F. Neoselachians and Chimaeriformes (Chondrichthyes) from the Upper Cretaceous-Paleogene of Sierra Baguales, southernmost Chile. Chronostratigraphic, paleobiogeographic and paleoenvironmental implications. Journal of South American Earth Sciences 48: 13-30. 10.1016/j.jsames.2013.07.013 (2013).

Otero, R.A., Salazar C.S., Yury-Yáñez, R. Soto-Acuña, S. & Oyarzún, J.L. New elasmosaurids (Plesiosauria, Sauropterygia) from the Upper Cretaceous of the Magallanes Basin, Chilean Patagonia: Evidence of a faunal turnover during the Maastrichtian along the Weddellian Biogeographic Province. Andean Geology, 42(2): 237-267 (2015).

Pang, Q. & Cheng, Z. A new ankylosaur of Late Cretaceous from Tianzhen, Shanxi. Progress in Natural Science, 8, 326-334 (1998).

Parks, W. A. Dyoplosaurus acutosquameus, a new genus and species of armored dinosaur, and notes on a skeleton of Prosaurolophus maximus. University of Toronto Studies Geological Series, 18, 1-35 (1924).

Park, Y.Y., Lee, Y.-N., Currie, P.Y., Kobayashi, Y., Koppelhus, E., Barsbold, R., Mateus, O., Lee, S. & Kim, S.-W. Additional skulls of Talarurus plicatospineus (Dinosauria: Ankylosauridae) and implications for paleobiogeography and paleoecology of armored dinosaurs. Cretaceous Research 104340 (2020).

Prasad, G.V. & Parmar, V. First Ornithischian and Theropod Dinosaur Teeth from the Middle Jurassic Kota Formation of India: Paleobiogeographic Relationships. In: Prasad, G.V.R., Patnaik, R. (eds.) Biological Consequences of Plate Tectonics. Springer, Cham, 1-30 (2020).

Penkalski, P. Revised systematics of the armoured dinosaur Euoplocephalus and its allies. Neues Jahrbuch für Geologie und Pal€aontologie – Abhandlungen 287, 261e306 (2018).

Penkalski, P. & Blows, W. T. Scolosaurus cutleri from the Dinosaur Park Formation of Alberta, Canada. Canadian Journal of Earth Sciences, 50, 171-182 (2013).

Penkalski, P. & Tumanova, T. The cranial morphology and taxonomic status of Tarchia (Dinosauria: Ankylosauridae) from the Upper Cretaceous of Mongolia. Cretaceous Research 70, 117e127 (2017).

Pereda-Suberbiola, X., Díaz-Martínez, I., Salgado & L. de Valais, S. Síntesis del registro fósil de dinosaurios tireóforos en Gondwana. Publicación Electrónica de la Asociación Paleontológica Argentina, 15(1) (2015).

Pereda-Superbiola, X., Galton, P.M., Mallison, H., Novas, F. A plated dinosaur (Ornithischia, Stegosauria) from the Early Cretaceous of Argentina, South America: an evaluation. Alcheringa 37, 65–78 (2013).

Pereda-Suberbiola, X., & P. M. Barrett. A systematic review of ankylosaurian dinosaur remains from the Albian–Cenomanian of England. Special Papers in Palaeontology 60:177–208 (1999).

Pino, J.P., Leppe, M., Trevisan, C., Wilberger, T., Manríquez, L., Mansilla, H. & Lobos, V. Los ensambles vegetales fósiles del Complejo Cerro Guido – Las Chinas: Cambios en la composición florística y fisionomía foliar asociados al enfriamiento del Cretácico Superior. In “I Congreso de Paleontología de Chile”, 238-241, Punta Arenas, Chile (2018).

Piveteau, J. Contribution à l'étude des formations lagunaires du Nord-Ouest de Madagascar. Bulletin de la Societé Géologique de France 5 (26): 33–38 (1926).

Poropat, S.F., Martin, S.K., Tosolini, A.-M.P. Wagstaff, B.E., Bean, L.B., Kear, B.P., Vickers-Rich, P., Rich, T.H. Early Cretaceous polar biotas of Victoria, southeastern

Australia—an overview of research to date, Alcheringa: An Australasian Journal of Palaeontology, DOI: 10.1080/03115518.2018.1453085 (2018).

Porro, L.B., Witmer, L.M. & Barrett, P.M. Digital preparation and osteology of the skull of *Lesothosaurus diagnosticus* (Ornithischia: Dinosauria). PeerJ. 3:e1494 (2015)

Raven, T.J. & Maidment, S.C.R. A new phylogeny of Stegosauria (Dinosauria: Ornithischia). Palaeontology 60, 401–408 (2017).

Raven, T.J. & Maidment, S.C.R. The systematic position of the enigmatic thyreophoran dinosaur Paranthodon africanus, and the use of basal exemplifiers in phylogenetic analysis. PeerJ 6, e4529 (2018).

Raven, T.J., Barrett, P.M., Pond, S.B. &. Maidment, S.C.R. Osteology and Taxonomy of British Wealden Supergroup (Berriasian–Aptian) Ankylosaurs (Ornithischia, Ankylosauria). Journal of Vertebrate Paleontology e1826956 DOI: 10.1080/02724634.2020.182695 (2020).

Rauhut, O.W.M., Carballido, J.L. & Pol, D. First Osteological Record of a Stegosaur (Dinosauria, Ornithischia) from the Upper Jurassic of South America, Journal of Vertebrate Paleontology, DOI: 10.1080/02724634.2020.1862133 (2021).

Reguero, M.A., Goin, F.J. Paleogeography and biogeography of the Gondwanan final breakup and its terrestrial vertebrates: New insights from southern South America and the “double Noah's Ark” Antarctic Peninsula. Journal of South American Earth Sciences, 108, 103358 (2021).

Ricqles, A. de, Pereda Suberbiola, X., Gasparini, Z. & Olivero, E. Histology of dermal ossifications in an ankylosaurian dinosaur from the Late Cretaceous of Antarctica. Asociación Paleontológica Argentina. Publicación Especial 7, 171e174 (2001).

Ridgwell, N. y Sereno, P.C. A basal thyreophoran (Dinosauria, Ornithischia) from the Tiouraren Formation of Niger. Journal Vertebrate Paleontology 30, Supplement: 150A–151A (2010).

Riguetti, F.J., Gallina, P, Apesteguía, S. & Canale, J.I. New Thyreophoran (Dinosauria, Ornithischia) remains from the Lower Cretaceous Bajada Colorada Formation (Neuquén, Argentina). Reunión Anual de Comunicaciones de la Asociación Paleontológica Argentina, R49 (2019).

Romans, B.W., Hubbard, S.M., & Graham, S.A. Stratigraphic evolution of an outcropping continental slope system, Tres Pasos Formation at Cerro Divisadero, Chile: Sedimentology, v. 56, p. 737–764, doi:10.1111/j.1365-3091.2008.00995.x. (2009).

Romans, B.W., Fildani, A., Hubbard, S.M., Covault, J.A., Fosdick, J.C. & Graham, S.A. Evolution of deep-water stratigraphic architecture, Magallanes Basin, Chile. Marine and Petroleum Geology 28(3), 612-628 (2011).

Royer, D. L. CO2-forced climate thresholds during the Phanerozoic. Geochimica et Cosmochimica Acta, 70(23), 5665-5675 (2006).

Rozadilla, S., Aranciaga Rolando, A.M., Motta, M.J. & Novas, F.E. On the validity of the Antarctic ankylosaur *Antarctopelta oliveroi* Salgado & Gasparini (Dinosauria, Ornithischia). In: XXX Jornadas Argentinas de Paleovertebrados, p. 39. Ciudad de Buenos Aires (2016).

Rozadilla, S., Agnolín, F., Manabe, M., Tsuihiji, T., Novas, F.E. Ornithischian remains from the Chorrillo Formation (upper Cretaceous), southern Patagonia, Argentina, and their Implications on ornithischian paleobiogeography in the southern hemisphere. Cretaceous Research, 104881 (2021).

Sanmartın, I. & Ronquist, F. Southern Hemisphere biogeography inferred by event-based models: plant versus animal patterns. Systematic Biology, 53, 216–243 (2004).

Salgado, L., Coria, R.A. First evidence of an ankylosaur (dinosauria, ornithischia) in South America. Ameghiniana 33 (4), 367–371 (1996).

Salgado, L. & Gasparini, Z. Reappraisal of an ankylosaurian dinosaur from the Upper Cretaceous of James Ross Island (Antarctica). Geodiversitas 28, 119e135 (2006).

Salgado, L., Canudo, J.I., Garrido, A., Moreno-Azanza, M., Martinez, L.C., Coria, R.A., Gasca, J.M. A new primitive neornithischian dinosaur from the Jurassic of Patagonia with gut contents. Sci. Rep. 7, 42778 (2017).

Schwartz, T.M. & Graham, S.A. Stratigraphic architecture of a tide-influenced shelf-edge delta, Upper Cretaceous Dorotea Formation, Magallanes-Austral Basin, Patagonia. Sedimentology 62(4), 1039-1077 (2015).

Schwartz, T. M., Fosdick, J. C. & Graham, S. A. Using detrital zircon U-Pb ages to calculate Late Cretaceous sedimentation rates in the Magallanes-Austral basin, Patagonia. Basin Research, 1-22, doi: 10.1111/bre.12198 (2016).

Sereno, P. Lesothosaurus, ‘fabrosaurids’, and the early evolution of Ornithischia. Journal of Vertebrate Paleontology 11: 168–197 (1991).

Sereno, P. The evolution of dinosaurs. Science 284: 2137–2146 (1999).

Sereno, P.C. & Dong, Z. The skull of the basal stegosaur *Huayangosaurus taibaii* and a cladistics diagnosis of Stegosauria. Journal of Vertebrate Paleontology 12(3):318-343 (1992).

Sickmann, Z. T., Schwartz, T. M. & Graham, S. A. Refining stratigraphy and tectonic history using detrital zircon maximum depositional age: an example from the Cerro Fortaleza Formation, Austral Basin, southern Patagonia. Basin Res, 30: 708-729. doi:10.1111/bre.12272 (2018).

Soto-Acuña, S., Jujihara, T., Novas, F.E., Leppe, M., González, E., Stinnesbeck, W., Isasi, M.P., Rubilar-Rogers, D. & Vargas, A.O. Hadrosaurios (Ornithopoda: Hadrosauridae) en el Cretácico Superior del extremo austral de América del Sur. Libro de Resúmenes del IV Simposio Paleontología en Chile, Universidad Austral de Chile, Valdivia, p. 56 (2014).

Soto-Acuña, S., Otero, R. & Rubilar-Rogers, D. First record of mosasaurs (Lepidosauria: Mosasauridae) from the late Cretaceous (Maastrichtian) of the Magallanes Basin. Boletín del Museo Nacional de Historia Natural, Chile, 64: 69-79 (2015).

Suazo Lara, F., Alarcón-Muñoz, J., Fernández-Jiménez, R., Kaluza, J., Manríquez, L., Milla, V., Soto-Acuña, S. & Leppe, M. Nuevos registros de anuros del Valle del Río de Las Chinas (Formación Dorotea, Cretácico Superior), Región de Magallanes, Chile. En: Libro de resúmenes del I Congreso Chileno de Paleontología, Punta Arenas: 331-333 (2018).

Suazo Lara, F., Fernández-Jiménez, R., Soto-Acuña, S., Manríquez, L., Alarcón-Muñoz, J., Aravena, B., Vargas, A. O. & Leppe, M. Primer registro de Calyptocephalellidae (Anura, Australobatrachia) en el Cretácico Superior de Chile. *In* Actas: Libro de Resúmenes de la I Reunión de Paleontología de Vertebrados de Chile. Santiago, Chile: 17 (2017).

Thulborn RA. The skull of *Fabrosaurus australis*, a Triassic ornithischian dinosaur. Palaeontology 13:414-432 (1970).

Trevisan, C., Dutra, T., Wilberger, T., Leppe, M. & Manríquez, L. An austral fern assemblage from the Upper Cretaceous (Campanian) beds of Cerro Guido, Magallanes Basin, Chilean Patagonia. Cretaceous Research, 106, 104215 (2020).

Van Den Ende, C., White, L. T., & van Welzen, P. C. The existence and break-up of the Antarctic land bridge as indicated by both amphi-Pacific distributions and tectonics. Gondwana Research, 44, 219-227 (2017).

Vogh, M., Leppe, M., Stinnesbeck, W., Jujihara, T., Mansilla, H., Ortiz, H., Manríquez, L. & González, E. Depositional environment of Maastrichtian (Late Cretaceous) dinosaur-bearing deltaic deposits of the Dorotea Formation, Magallanes Basin, Southern Chile. The 23rd Latin American Colloquium on Earth Sciences, Abstract with Program (2014).

Voorhies, M.R. Taphonomy and population dynamics of an Early Pliocene fauna, Knox County, Nebraska. Contributions to Geology, Special Paper, 1: 1-69 (1969).

Weigelt, J. Recent vertebrate carcasses and their paleobiological implications. University of Chicago Press, Chicago (1989).

Welles, S. A new species of elasmosaur from the Aptian of Colombia and the review of the Cretaceous plesiosaurs. University of California Publications in Geological Sciences 44:1-96 (1962).

Wiersma, J.P. & Irmis, R.B. A new southern Laramidian ankylosaurid, *Akainacephalus johnsoni* gen. et sp. nov., from the upper Campanian Kaiparowits Formation of southern Utah, USA. PeerJ 6, e5016. https://doi.org/10.7717/ peerj.5016 (2018).

Wilson, T. Transition from back arc to foreland basin development in the southern Andes: stratigraphic record from the Ultima Esperanza District, Chile. Geological Society of America Bulletin 103, 98–111 (1991).

Wood, J.M., Thomas, R.G. & Visser, J. Fluvial processes and vertebrate taphonomy: The Upper Cretaceous Judith River Formation, South-Central Dinosaur Provincial Park, Alberta, Canada. Palaeogeography, Palaeoclimatology, Palaeoecology. 66, 127-143 (1988).

Zheng W, Jin X, Azuma Y, Wang Q, Miyata K, Xu X. The most basal ankylosaurine dinosaur from the Albian-Cenomanian of China, with implications for the evolution of the tail club. Sci Rep UK 8:3711 (2018).

Zinsmeister, W. J. Biogeographic significance of the late Mesozoic and early Tertiary molluscan faunas of Seymour Island (Antarctic Peninsula) to the final breakup of Gondwanaland (pp. 349-355). Ohio State University, Institute of Polar Studies (1979).

Zinsmeister, W. J. Late Cretaceous-early Tertiary molluscan biogeography of the southern circum-Pacific. Journal of Paleontology, 84-102 (1982).