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Tiago R. Simões[1]*, Michael W. Caldwell[1,2], Mateusz Tałanda[3], Massimo Bernardi[4,5], Alessandro Palci[6], Oksana Vernygora[1], Federico Bernardini[7,8], Lucia Mancini[9] & Randall L. Nydam[10]

[1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada. [2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada. [3]Department of Palaeobiology and Evolution, Faculty of Biology, Biological and Chemical Research Centre, University of Warsaw, Warsaw, Poland. [4]MUSE, Museo delle Scienze di Trento, Trento, Italy. [5]School of Earth Sciences, University of Bristol, Bristol, UK. [6]College of Science and Engineering, Flinders University, Adelaide, South Australia, Australia. [7]Museo Storico della Fisica e Centro di Studi e Ricerche Enrico Fermi, Roma, Italy. [8]The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy. [9]Elettra Sincrotrone Trieste S.C.p.A., Trieste, Italy. [10]Department of Anatomy, Arizona College of Osteopathic Medicine, Midwestern University, Glendale, AZ, USA. *e-mail: tsimoes@ualberta.ca

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SKULL

One maxillary bone is preserved on the right side of the skull. It has the nasal process broken anteriorly and at least four maxillary teeth are preserved in situ. The suborbital ramus of the maxilla extends until the midorbital region and articulates with the ventral side of the jugal. The jugal forms the posteroventral margin of the orbit, and the jugal posterodorsal process extends for at least half the height of the postorbital bar. The jugal also has a short posteroventral process, thus not fully enclosing the lower temporal fenestra ventrally.

The prefrontal is relatively elongate anteroposteriorly, extending posteriorly half-way through the length of the orbit. The anteroventral margin of the prefrontal is poorly preserved and is crushed against the maxilla. Therefore, it is not possible to determine with certainty whether the lacrimal is present. The posterior opening of the lacrimal duct is not visible externally or medially on the prefrontal or maxillary border of the orbit; therefore, the posterior opening of the duct may have been fully enclosed by the lacrimal, though the latter is not preserved in the holotype.

The triradiate squamosal is preserved only on the right side of the skull. The posterior process of the squamosal fits into a groove on the cephalic condyle of the right quadrate (as observed in all squamates). The dorsal process, when in articulation with the parietal, contributed to the posterior border of the upper temporal fenestra. The anterior (postorbital) process articulated with the posterior process of the postorbitofrontal. The postorbital and the postfrontal are probably fused into a postorbitofrontal. There is no visible suture line, but it is possible that at earlier ontogenetic stages a suture between both elements would have been visible. The medial margin of the postorbitofrontal is concave, bearing two small processes: a longer frontal process anteromedially and a slightly shorter parietal process posteromedially. Its posterior (squamosal) process is relatively elongate, and independently contributed to about one-third to one-half of the upper temporal bar anterior of its articulation with the squamosal. The posterior process of the postorbitofrontal has a tongue-and-groove articulation with the squamosal via a dorsomedial groove, such that most of the posterior process of the postorbitofrontal was hidden in lateral view. This articulation differs from the one typically found in most rhynchocephalians [including *Gephyrosaurus* (Evans 1980) and TRS pers. obs.], in which the squamosal bears a large anteriorly concave facet that is visible in lateral aspect for articulation with the postorbital. The anterolateral process of the postorbitofrontal appears to be very reduced, but the exact length is unknown as this region is poorly preserved due to the compression of the postorbitofrontal against the palatine ventrally.

The frontal is partially broken on the left side, but the CT-scans reveal that both subolfactory processes are preserved on the ventral side of the frontal (Extended Data Figure 2), indicating the frontals are fully fused into a single element. Fused frontals are also observed in a large number of crown squamates and some early rhynchocephalians (*Gephyrosaurus*, *Diphyodontosaurus* and *Planocephalosaurus*), but are absent in most later evolving rhynchocephalians and other major groups of diapsids. The frontal is constricted anteriorly, expands posteriorly, but then narrows again near the frontoparietal suture.

The parietals are also fused into a single element, as observed among almost all squamates, *Gephyrosaurus*, and possibly in *Planocephalosaurus* among rhynchocephalians. Both lateral margins of the parietal are exposed in dorsal view and project ventrally. The parietal lateral margins are slightly concave contributing to a greatly expanded adductor chamber and wide upper temporal fenestra. Posteriorly, the parietal has a pair of very elongate supratemporal processes that form part of the posterior border of the upper temporal fenestra. It is not clear if the supratemporal bones were present in *Megachirella*. It is possible that those were absent, partially fused to the parietal supratemporal process, or simply not preserved.

The quadrates are well-preserved on both sides of the skull, having a strongly developed quadrate conch and suprastapedial process. The tympanic crest is relatively well-developed on the lateral margin of the quadrate, indicating the presence of a tympanic membrane in life. Ventromedially, the quadrates have very well-developed pterygoid processes that articulate with the quadrate rami of the pterygoids. Importantly, the CT-scans show a foramen lying close to the tympanic crests of both quadrates, and a suture line emerging from those foramina and extending dorsally and in parallel to the tympanic crest (Extended Data Figure 2). This anatomy resembles the condition seen in some early rhynchocephalians (e.g. *Diphyodontosaurus*), which have been interpreted as consisting of a partially fused quadratojugal (Whiteside 1986). The presence of a partially fused quadratojugal in *Megachirella* indicates that the earliest squamates still retained this element. It is important to point out that due to compression of the skull both quadrates have been rotated forward, and this is evident from the fact that the ventral condyle of the left quadrate is exposed posteriorly. A consequence of this is that, contrary to previous reconstructions, the suprastapedial process in life must have been oriented posteriorly rather than posterodorsally. As such, the morphology of the quadrate in lateral view closely resembles that of many squamates.

The pterygoids are the best-preserved elements of the palate. The left pterygoid is exposed dorsally in the holotype, but CT-scans reveal an equally well-preserved right pterygoid along with many other palatal elements. The pterygoids have well-developed transverse processes that bear ventrally projecting flanges. However, the exact depth of these flanges is unclear. The anterior (palatine) process of the pterygoids extend well anteriorly and, in ventral aspect, there are three longitudinal ridges representing rows that would have supported pterygoid teeth. Although the actual pterygoid dentition is not visible given the scan resolution, we are unaware of any other palatal structure that would produce this particular morphology. Also, very similar rows of pterygoid dentition are observed in *Sophineta* (TRS pers. obs.). The ectopterygoid is

preserved on the right side of the skull, it is elongated anteroposteriorly and has a semilunar shape. The portion of the ectopterygoid that articulates posteriorly with the pterygoid is expanded dorsoventrally, while the opposite portion is directed anteriorly, nearlycontacting the preserved part of the palatine. The ectopterygoid orientation (connecting the palatine and pterygoids) is similar to the condition observed among most squamates, and differs from the condition in rhynchocephalians (e.g. *Gephyrosaurus*, *Diphyodontosaurus*, *Planocephalosaurus*, *Clevosaurus* and *Sphenodon*) which have the ecytopterygoid laterally oriented, contacting the maxilla and jugal instead of the palatine [(Evans 1980; Fraser 1982; Whiteside 1986; Fraser 1988) and TRS pers. obs.].

The posterior end of the ectopterygoid also has a small ventral process that would have contributed to the formation of the attachment area of the pterygoideus muscle group along with the ventral flange of the transverse process of the pterygoid. The ventral extensions of these processes, as preserved, are shorter than those observed in rhynchocephalians and archosaurs, thus indicating a reduced participation of the pterygoideus muscle group in the jaw adductor system when compared to those clades. Along with the greatly expanded adductor chamber on the temporal region and the loss of a complete lower temporal bar, *Megachirella* had an adductor system characterized by the expansion of the adductor externus group and reduced participation of the pterygoideus system, as also observed in crown squamates (Haas 1973; Rieppel & Gronowski 1981; Simões *et al.* 2016). The ventral flanges of the pterygoid and ectopterygoid, however, are still larger than those seen in many squamate families, approaching the degree of development of those structures as seen in iguanians and teiids.

The border between the palatine and pterygoid is not clear on either side of the skull. However, considering the placement of the ectopterygoid on the right side of the skull, we infer that the palatal elements located anteriorly to it represent remains of the palatines. One such element on the right side seems to have been displaced posteriorly and it abuts against the right ectopterygoid. The anteriormost palatal elements preserved might represent remnants of the vomers given their position just anterior to the palatine elements and medial to the anterior half of the maxilla.

The braincase is poorly exposed in the holotype, but the CT-scans reveal a large amount of information, especially for the ventral and lateral aspects. The basioccipital forms a strongly developed occipital condyle, it has a relatively flat ventral surface, and it contributes to the formation of the sphenoid tubercles. The parasphenoid seems to be fully fused to the basisphenoid, as in most reptiles. The basisphenoid has a concave ventral surface and a well-developed, thick cultriform process. Anterolaterally, the basisphenoid bears a pair of strongly developed parabasiphenoid processes for articulation with the pterygoids. An open Vidian canal is located posterior to the parabasisphenoid processes and on the ventral margin of the lateral wall of the prootics.

The prootics are preserved on both sides of the skull and the prootic crest is either reduced or absent. The anterior semicircular canal is visible in the left prootic and a well-developed alar process is located just anterior to it. The opisthotics are preserved on both sides of the skull, and the left still preserves a widely expanded paroccipital process. The base of the opisthotics have been crushed against the prootics, thus concealing most of the fenestra ovalis and possibly and the entire occipital recess. The right exoccipital can be observed dorsal to the occipital condyle, but it is not possible to determine whether it is fused to the opisthotic.

Part of the hyoid apparatus is preserved, represented by a pair of rod-like elements ventral to the braincase and palate, which might represent the first pair of ceratobranchials, which is the most common hyoid element to ossify in lepidosaurs.

MANDIBLES

The dentaries are elongate and relatively slender. The CT-scans enable the reconstruction of most of the dentaries, although they do not provide enough resolution to identify the individual posterior processes. However, upon personal observation of the specimen (TRS, MWC) it was possible to detect the terminal end of the coronoid process of the right dentary, located just ventrally to the dorsal process of the coronoid bone (Extended Data Figure 1). The CT-scans also revealed that there was no contribution of the dentary to the coronoid apex. Therefore, the coronoid process of the dentary did not expand dorsally as observed in all rhynchocephalians, and it is rather similar to the posteriorly straight condition found in most squamates and other diapsid reptiles.

The splenials are present, and are dorsoventrally deep and anteroposteriorly elongate. This also differs from the condition of all known rhynchocephalians, in which the splenials are entirely absent, even in early forms such as *Gephyrosaurus, Diphydontosaurus* and *Planocephalosaurus* [(Evans 1980; Fraser 1982; Whiteside 1986) and TRS pers. obs]. The coronoid forms the entire coronoid apex of the lower jaws, having a tall dorsal process, and a posterodorsomedial process that is visible in dorsal aspect. The medial margin of the coronoid is damaged, and it cannot be determined if the anteromedial and posteroventromedial processes are present in *Megachirella*.

The surangular is elongate, but not very deep. The posterior surangular foramen is visible on the lateral margin of the right surangular, and the anterior foramen is undeterminable. Additionally, the surangular lacks a coronoid process extending onto the posterior border of the coronoid bone and contributing to the coronoid apex, thus differing from the condition seen in all rhynchocephalians and snakes. In the CT-scan, the angular could not be distinguished from the prearticular on the ventral margin of the jaw, and a suture between the articular and prearticular appears to be absent, but this may also be an artifact of the relatively low resolution of the CT scan in this region.

The articular (possibly fused to the prearticular) forms a small medial process (angular process), as observed in iguanians, teiids, borioteiioids and cordyloids, among crown squamates. A medial

process, possibly homologous to the “angular process” in squamates, also occurs in *Gephyrosaurus* (among rhynchocephalians), and as known in other diapsid lineages in taxa such as *Euparkeria, Erythrosuchus, and Lariosaurus*. Posteriorly, the retroarticular process is very expanded and forms a dorsal fossa.

DENTITION

Dentary teeth are exposed in the specimen and they can be observed both directly on the specimen and from the CT-scan images. The tooth attachment mode is pleurodont: teeth are located lingually to the labial parapet of the dentary (crista dorsalis); the labial wall is much higher than the lingual wall of the dentary, and there are no fully developed interdental ridges; also, there is no visible ankylosis of the tooth crowns to the apex of the dentary labial wall (Fig. 1 and Extended Data Figure 2). This anatomy of the dentition of *Megachirella* differs from all sphendodontians (with the exception of *Gephyrosaurus*), which possess acrodont (placed on and fused to the apex of the labial parapet of the dentary) teeth posteriorly along the marginal tooth row of the jaws. There is at least one, if not two, replacement teeth visible on the left dentary. The tooth crowns are short, roughly circular in cross section and heavily worn at their apices (possibly an artifact of preservation). Complete maxillary teeth could be observed in the CT scan images, and appear to be large and conical. The exact mode of tooth implantation on the maxilla is hard to verify due to poor preservation of the medial portion of this bone.

POSTCRANIUM

Six cervicals and thirteen (three as impressions) dorsal vertebrae are preserved. The atlas neural arches are visible on either side of the anterior cervical region. A small protuberance visible on the CT-scans near the contact with the axis might represent the atlas postzygapophyses. The axis has an elongate centrum and neural spine, and the axis intercentrum is located between the axis and the 3rd cervical. Four other cervicals follow with small ribs preserved on both sides. The seventh presacral has the first elongated rib (better seen in ventral view) lying medial to the right clavicle, which could have contacted the sternal plate, and it is thus considered to be the first dorsal. Six other dorsals follow, before a gap where the carbonic impression of three additional dorsals are visible on the holotype, and are followed by another three vertebrae.

The second dorsal vertebra is displaced dorsally, exhibiting the posterior cotyle, thus making clear the lack of a posterior condyle on the vertebral centrum. It also indicates the notochordal canal was fully closed, thus differing from all rhynchocephalians, which have a notochordal canal persistent into adulthood [(Hoffstetter & Gasc 1969), TRS, pers. obs]. The CT-scans also reveal the absence of anterior cotyles, indicating the amphicoelic condition of the pleurocentra. Later squamates, such as *Huehuecuetzpalli*, *Marmoretta* (TRS pers. obs.) and basal extant squamates (geckoes) also bear this condition. The neural arches are moderately developed, and they are better exposed on the second and third dorsals, which have been slightly displaced. The

third dorsal has the anterior border of the neural arch exposed, indicating the absence of accessory articulatory processes (zygosphenes)—also absent in *Huehuecutezpalli* and *Marmoretta*. The neural spines do not bear any kind of apical expansions. Intercentra are visible in the CT-scans on the cervical and dorsal region, always in an intervertebral position.

The first identifiable rib is on the second cervical (axis). All cervical ribs lack an anterior process (common in archosauriforms, protorosaurs, and some other diapsids). The dorsal ribs are significantly stouter than the cervical ribs, but not to the point that they could be considered pachyostotic, as their shafts are narrower than their heads. They decrease in robustness posteriorly, with the latest preserved dorsal ribs being much more gracile than the anterior dorsal ribs. Gastralia are visible on the left side of the specimen (a plesiomorphic condition in the context of Diapsida that is lost in crown squamates), in the gap area where the dorsals are preserved as impressions only. No traces of inscriptional ribs are visible.

The pectoral girdle preserves the right coracoid, part of the right scapula and both clavicles. The scapula is taller than wide and has a small contribution to the glenoid. A small anterior bony projection is seen anterior to the scapula, and it is part of left clavicle. The coracoid is larger than the scapula, and bears no fenestration, thus resembling more the coracoids of non-squamate diapsid reptiles. The body of the coracoid has the weakest degree of ossification, and is pierced by three holes that might be the result of poor preservation. The medial margin of the coracoid is thickened and bears a narrow groove. This is indicative of a cartilaginous element attaching to the medial aspect of the coracoid, such as the epicoracoid cartilage or the presternum. A highly mineralized area of similar density to the bone is visible in the CT-scans posterior to the coracoid, and may represent a calcified sternum. The right clavicle is located just medially to the scapula, and is visible in dorsal view on the holotype. The CT-scans reveal it extends ventrally and that it has a secondary curvature on the anteroposterior axis, as in most “scleroglossans” lizards.

Both forelimbs are well-preserved, with propodials and epipodials visible on both sides of the body. The autopodium is also preserved on both sides, but the right side is exquisitely preserved, and it is visible without the aid of CT-scan data. The humerus has a twist of almost 90 degrees between the humeral head and its distal end. The humeral proximal epiphysis is not yet fully ossified and fused to the humeral head, indicating secondary epiphysis ossification as seen in other lepidosaurs (including fossil taxa, such as *Homeosaurus*, *Kallimodon*, and fossil squamates such as *Tijubina pontei*—TRS pers. obs.). The distal ends are wide and carry well-developed epicondyles. In the latter, there is an ectepicondyle foramen and a fully open entepicondyle foramen. A complete entepicondylar foramen is absent in crown squamates. However, it is found in rhynchocephalians and *Huehuecuetzpalli*, making this a simplesiomorphy within Lepidosauria. The presence of these foramina in *Megachirella* and *Huehuecuetzpalli* indicate they were retained in stem squamates, but lost in the crown groups. Additionally, the humerus radial condyle (capitulum) is expanded, a feature common to squamates but poorly developed or absent in other lepidosaurs.

The radius is preserved in articulation with the humeri radial condyles on both sides, and their distal ends apparently lack a styloid process. The ulnae have well developed olecranon processes, and the right ulna has an ulnar patella preserved between the olecranon and the humerus. The ulnar patella is absent in *Sphenodon* and all other rhynchocephalians, but it is commonly observed in squamates (Regnault *et al.* 2016). The ulnar distal epiphysis is not expanded as in crown squamates, thus resembling the condition of other diapsids, as also is observed in *Huehuecuetzpalli* [(Reynoso 1998) and TRs pers. obs.].

The carpals preserve an intermedium between the radius and ulna, a small radiale (lying in articulation with the distal end of the radius) and a larger ulnare (lying in articulation with the distal end of the ulna). A wide medial centrale is located just distal to the anterodistal corner of the radius and near the proximal end of metacarpal II. A lateral centrale is located just lateral to it, and distal to the radiale (in contact with distal carpals 2 and 3). Distal carpals 2 and 3 lie in articulation with the proximal ends of metacarpals II and III. Distal carpals 4 and 5 are fused, forming a large distal carpal element in contact with metacarpals IV and V. Distal carpal 1 is missing and metacarpal 1 has an expanded head. The latter condition is also observed among most squamate lineages, and it represents the result of the fusion between the distal carpal 1 and metacarpal 1 (Carroll 1977; Gauthier *et al.* 1988a). Since the same morphology is observed in *Megachirella*, it is considered here that the proximal expansion of metacarpal 1, and the absence of distal carpal 1, is the result of their fusion. The metacarpals increase in length from digit 1 to 4, reducing again in length in digit 5. Metacarpal IV is slightly longer than metacarpal III, as in most squamate families. The total number of phalanges in each digit is not possible to determine with certainty.

Conclusions on comparative osteology and systematics

Megachirella is a lepidosaur because it has a well-developed quadrate conch, an ectepicondylar foramen in the humerus, and pleurodont dentition on both dentary and maxilla. The lepidosaur condition of *Megachirella* was recognized by Renesto & Posenato (2003) and Renesto & Bernardi (2014). Within lepidosaurs, *Megachirella* has a set of features only observed in squamates (and absent even among the earliest rhynchocephalians), such as: a triradiate squamosal (not tetraradiate as in most other diapsids, including rhynchocephalians), squamosal lacking an anteriorly concave articulatory facet for the postorbital (not contacting the maxilla and jugal as in rhynchocephalians), a well-developed alar process of the prootic, the ectoperygoids directed anteriorly (not laterally as in rhynchocephalians), a well-developed radial condyle on the humerus, presence of an ulnar patella, secondary curvature of the clavicles, and an expanded epiphysis of the first metacarpal along with absence of distal carpal 1 [suggesting the fusion of the first distal carpal to the first metacarpal, as observed in all squamates (Carroll 1977; Gauthier *et al.* 1988a)]. Finally, *Megachirella* has features that are absent in all rhynchocephalians (the sister-lineage to squamates), even among the earliest forms such as *Gephyrosaurus*, including:

presence of a splenial, presacral pleurocentra without a notochordal canal, and absence of a dorsal (coronoid) expansion of the surangular and dentary. Interestingly, most features that make it a squamate and not a rhynchocephalian are in the postcranium. The postcranium was also key to place *Huehuecuetzpalli* as a stem squamate (Reynoso 1998). Some plesiomorphic features (like the presence of gastralia and a quadratojugal) indicate the mosaic of conditions preserved in *Megachirella*, and the gradual acquisition of squamate features. These general diapsid characters are also retained (not exclusive to) in rhynchocephalians, and are now known to occur among the earliest known squamates.

The oldest known squamates.

Thus far, the oldest known squamates come from the Middle Jurassic of Britain, Morocco and Kyrgyzstan in central Asia (Evans & Jones 2010; Rage 2013; Haddoumi *et al.* 2016; Conrad 2017; Simões *et al.* 2017a). These include *Bellairsia graclis, Balnealacerta silvestris, Oxiela tenuis, Saurillodon marmorensis, Paramacellodus* sp., possible gekkotan vertebrae and *Eophis underwoodi* from the Bathonian of Oxfordshire (Evans & Milner 1994; Waldman & Evans 1994; Evans 1998; Caldwell *et al.* 2015); *Changetisaurus estesi* (Callovian) and other very fragmentary remains (Bathonian) from Kyrgyzstan (Nessov 1985; 1988; Fedorov & Nessov 1992); and fragmentary squamate remains, regarded as Scincomorpha indet., cf. *Parviraptor*, and a non-ophidian anguimorph, from the Bathonian of Morocco (Haddoumi *et al.* 2016). *Bharatagama*, from the Middle Jurassic of India (Evans *et al.* 2002), is another potential Middle Jurassic squamate. However, it has recently been suggested that it may actually represent a sphenodontian (Jones *et al.* 2013; Conrad 2017). *Tikiguana*, an acrodont jaw initially published as from the Triassic of India, was eventually found to be re-worked material from recent deposits (Hutchinson *et al.* 2012). Therefore, prior to this study, the oldest unquestionable squamates were from the Middle Jurassic, ranging from the Callovian to the Bathonian (168.3 – 166.1 million years ago) (Ogg *et al.* 2016). This was already a relatively diverse assemblage (Rage 2013) that included distinct lizard morphotypes, possible geckos, and snakes, distributed across two quite distant areas of the world.

Synapomorphies. Ancestral state reconstructions for key nodes at the origin of lepidosaurs and the origin of Squamata.

We report below the character state transformations that were recovered using both parsimony and likelihood ancestral state reconstructions for the relaxed clock Bayesian inference tree illustrated in figure 2.

Lepidosauromorpha (174)

Char. 3: 1 --> 0: Premaxillae, posterodorsal process: present → absent (0.915)

Char. 61: 0 --> 1: Postfrontals, medial forking: absent → present (0.945)

Char. 167: 0 --> 1: Dentaries, anterior end, split by Meckelian canal: absent → present (0.833)

Char. 212: 2 --> 0: Posterior dentary teeth, delimitation by tooth bearing bone: by a four-sided socket → by a labial wall only (0.999)

Char. 213: 2 --> 0: Posterior maxillary teeth, delimitation by tooth bearing bone: by a four-sided socket → by a labial wall only (0.981)

Char. 232: 0 --> 1: Presacral pleurocentra, midventral crest, dorsal vertebrae: absent → present (0.761)

Char. 309: 0 --> 3: Humeri, entepicondyle foramen: absent → present, fully open (0.979)

Lepidosauria (177)

Char. 67: 0 --> 1: Frontals, fusion to each other: absent → present (0.946)

Char. 236: 0 --> 1: Caudal vertebrae, autotomic septum: absent → present (0.877)

Char. 298: 0 --> 1: Ilia, anterior pubic process: absent → present (0.948)

Rhynchocephalia (180)

Char. 118: 1 --> 0: Quadrate foramen: present → absent (0.889)

Char. 173: 0 --> 1: Dentary, coronoid process, dorsal expansion: absent → present (0.934)

Char. 176: 1 --> 0: Splenials: present → absent (0.993)

Char. 229: 1 --> 0: Presacral pleurocentra, notochord, persistent in adults: absent → present (0.971)

Sphenodontia (181)

Char. 59: 2 --> 1: Postfrontals, medial margin, position, relative to parietal: lateral → dorsal (0.985)

Char. 92: 0 --> 1: Vomers, ventral surface, midline crest: absent → present (0.786)

Char. 210: 0 --> 1: Posterior dentary teeth, position, relative to dentary crista dorsalis (apex of labial wall) of dentary: lingual → apical (0.989)

Char. 211: 0 --> 1: Posterior dentary teeth, ankylosis to crista dorsalis (apex of labial wall) of dentary: absent → present (0.975)

Squamata (176)

Char. 50: 1 --> 0: Squamosals, anteroventral process: present → absent (0.952)

Char. 114: 1 --> 0: Ectopterygoids, lateral process: present → absent (0.719)

Char. 142: 0 --> 1: Prootics, alar crest: absent → present (0.943)

Char. 287: 0 --> 1: Clavicles, secondary curvature anteroposteriorly: absent → present (0.930)

Char. 310: 1 --> 0: Humeri, developed radial condyle (= capitelum): absent → present (0.962)

Char. 324: 0 --> 1: Distal carpal 1, fusion to first metacarpal: absent → present (0.944)

Squamata -1 (-Megachirella) (179)

Char. 38: 0 --> 1: Quadratojugals: present→ absent (0.908)

Char. 273: 0 --> 1: Mineralized poststernal inscriptional ribs: absent → present (0.829)

Char. 284: 0 --> 1: Procoracoid, coracoid emargination: absent → anterior emargination (0.813)

Char. 342: 1 --> 0: Gastralia: present→ absent (0.952)

Squamata -3 (-Megachirella, - Marmoretta, - Huehuecuetzpalli) = Crown Squamata (196)

Char. 52: 1 --> 0: Squamosals, dorsal process: present → absent (0.993)

Char. 304: 0 --> 1: Ischia, ischiadic tuberosity: absent → present (0.989)

Char. 319: 0 --> 1: Ulnae, large (ball-like) distal epiphysis: absent → present (0.996)

Char. 330: 0 --> 1: Tibiae, distal epiphysis, notch: absent → present (0.825)

Char. 331: 0 --> 1: Astragalus and calcaneum: as totally separate elements → fused astragalocalcaneum (0.834)

Part 2. Supplementary Methods

All taxa included in the phylogenetic analyses herein were personally observed by the authors for the collection of morphological data, during the period of nearly 400 days of collections visits in museums and universities around the world during the course of five years. TRS personally observed all but one (*P. problematicus*) taxa included herein, and MC and RLN personally observed *P. problematicus* and numerous other taxa already observed by TRS (ca. 50%), providing complementary information to the data collected by TRS.

All taxa were scored by a single author (TRS), and over 75% of taxa were scored in the data matrix while observing the specimens in their respective collections. In our experience, this practise increase efficiency and accuracy during data scoring by depending less on the information provided by anatomical drawings, pictures, personal notes and the availability of CT scan data.

Taxon choice

Broad level relationships among the major groups of reptiles remain unresolved, with many conflicting hypotheses proposed during the last decades, and quite disparate proposals for the internal composition of the Lepidosauromorpha (Benton 1985; Evans 1988; Laurin 1991; Caldwell 1996; Gower 1996; Rieppel & de Braga 1996; Motani *et al.* 1998; Lee 2001; Müller 2004; Hill 2005; Scheyer *et al.* 2017; Turner *et al.* 2017). Therefore, any assumptions regarding the internal composition of the Lepidosauromorpha would be necessarily based on a preference over one of such competing hypothesis. Therefore, we sampled diapsid reptile lineages from every major group of diapsids, including at least two (usually three or more) species from each of them: Araeoscelidids, "younginiforms", coelurosauravids, turtles, ichthyopterygians, sauropterygians, saurosphargids, thalattosaurs, "protorosaurs", kuehneosaurids, archosauriforms, rhynchosaurs, besides lepidosaurs (rhynchocephalians and squamates).

Importantly, all of the diapsid datasets above mentioned suffer from the two following caveats. Firstly, squamates, which comprehend over 10,000 extant lineages and hundreds of fossil ones over the past 250 million years are usually, are almost invariably represented as a single terminal taxon (Squamata). This extreme oversimplification on the diversity of morphotypes and genotypes within squamates is likely to affect what other diapsid lineages fall closer to squamates within lepidosauromorpha, and the overall composition of lepidosauromophs too. The only exception to this case that is known to us is the study of Hill (2005), which includes some squamate taxa at the species level. However, most of the taxa used in that study are from the same clades (mostly scincids, anguids and cordylids), thus still lacking many important lineages, including the putative earliest evolving crown squamates (iguanians, geckoes and dibamids—see more below), as well as snakes and amphisbaenians.

Secondly, there is no consensus on which squamate clade represents the earliest evolving squamate lineage. Thus far, all broad level analyses of squamate relationships using only morphological data have suggested iguanians are the earliest evolving crown group squamates [e.g. (Estes *et al.* 1988; Lee 1998; Lee & Caldwell 2000; Evans *et al.* 2005; Conrad 2008;

Gauthier *et al.* 2012; Simões *et al.* 2015a)]. However, the molecular signal has always indicated geckoes and dibamids to represent the earliest evolving forms, either in molecular only analyses (Townsend *et al.* 2004; Vidal & Hedges 2005; Hugall *et al.* 2007; Kumazawa 2007; Vidal & Hedges 2009; Wiens *et al.* 2010; Wiens *et al.* 2012; Pyron *et al.* 2013). Combined evidence studies have also suggested the earliest squamates to be geckoes and dibamids, likely because of the overwhelming influence of molecular characters, which are usually far greater in number than morphological characters (Wiens *et al.* 2010; Reeder *et al.* 2015; Pyron 2017), apart from one study known to us (Lee 2005), which yields a similar result to morphological data, but also has far less molecular loci than more recent combined evidence studies. Therefore, selecting a single crown group to represent the entire Squamata is also not trivial.

To address the two limitations above, we decided to include at least one taxon from every major squamate clade, including iguanians, geckoes, cordylids, scincids, lacertids, teiioids, anguids, varanoids, snakes, dibamids and amphisbaenians. We have also included numerous important fossil taxa that represent entirely extinct lineages (e.g. *Adriosaurus suessi*—dolichosaurids, *Aigialosaurus*—mosasauroids, *Gilmoreteius chulsanensis*—borioteiioids, *Priscagama gobiensis*—priscagamids), and other taxa that represent some of the oldest known fossils of their clades (e.g. *Igua minuta*—iguanians, *Spathorhynchus fossorium*—crown amphisbaenians, *Najash rionegrina*—snakes), and representing some of the oldest and most complete squamates that were known up to date (e.g. *Eichstaettisaurus schroederi*, *Ardeosaurus brevipes*, *Paramacellodus oweni*, and *Huehuecuetzpalli mixtecus*).

Outgroup choice

Considering the vast representation of diapsid lineages in the current dataset, we included four early reptiles (*Protorothyris archeri* and the captorhinids *Protocaptorhinus pricei*, *Captorhinus aguti*, and *Labidosaurus hamatus*) to contribute to the polarization of characters and divergence time estimates. We chose *Protorothyris archeri* as the designated outgroup for TNT, which allows testing the placement of the other three taxa and thus the outgroup composition.In all analyses, the four early reptiles were consistently found as outgroups to diapsids, as in all other reptile phylogenies they have been included thus far that are known to us, supporting their choice as outgroups. For Bayesian inference analyses in Mr, Bayes, we kept our ingroup monophyletic (important for appropriate divergence time estimates and reaching stationarity in reasonable amounts of time, which is especially lengthy for clock analyses), and designated *Protorothyris archeri* as the outgroup.

Character construction criteria and character selection

We have compiled characters from reptile phylogeny datasets, from broad level studies focusing on diapsid relationships, to studies focused on lepidosaurs. We have also created new characters, or highly modified previous ones, in order to better convey to the data matrix, the morphological attributes observed by us.

The character lists created herein specifically try to bring some support for the homology statements that support each of the morphological attributes used herein as morphological characters. In order to achieve this, our primary homology hypotheses follow the basic criteria of homology assessment for character construction presented in numerous previous studies (e.g. Patterson 1982; Hawkins *et al.* 1997; Lee & Bryant 1999; Strong & Lipscomb 1999; Forey & Kitching 2000; Rieppel & Kearney 2002; Freudenstein 2005; Kearney & Rieppel 2006; Rieppel 2006; Sereno 2007; Brazeau 2011; Simões *et al.* 2017b). These criteria, including similarity and conjunction, help to avoid logical and biological biases in dataset construction, overweighting of morphological attributes, among other issues. These criteria have been followed herein in order to minimize character constructions that provide weak primary homology statements (i.e. character types that fail basic criteria of character construction) as recently discussed and illustrated by Simões *et al.* (2017b). We refer the reader to the latter study for a thorough discussion of our philosophy and methodology behind character construction and character selection. Finally, all morphological characters were treated as unordered herein.

Calibrations used for relaxed clock analyses.

The analysis using tip-date calibration ages was based on updated information concerning the age of the stratigraphic layers from where all the fossils used herein originate from, which are all depicted in the Suppmemetary Table S2, and in the details in the taxonomic sampling section (below). As mentioned in our Methods, node calibrations were used for four well-supported clades (in all of our other analyses herein and by previous authors) for which we lacked some of their oldest fossils in our analyses, and therefore their divergence time estimates could be biased by unrealistically old divergence times (O'Reilly *et al.* 2015; O'Reilly & Donoghue 2016). These clades and calibrations are as follows: Serpentes: based on *Eophis underwoodi* (Bathonian, Middle Jurassic—UK) (Caldwell *et al.* 2015) → 168.3-166.1 MYA (166.1,168.3) (Ogg *et al.* 2016); Choristodera: based on *Cteniogenys* sp. (Bathonian, Middle Jurassic—UK) (Evans 1989) → 168.3-166.1 MYA (166.1,168.3) (Ogg *et al.* 2016); Rhynchocephalia: based on cf. *Diphyodontosaurus* (Ladinian, Middle Triassic—Germany) (Jones *et al.* 2013) → 241.5-237 MYA (237,241.5) (Ogg *et al.* 2016); Captorhinidae: based on *Euconcordia* (Stephanian of Europe [equivalent to the Kasimovian], Late Pennsylvanian, Carboniferous—Kansas, USA) → 307-303.7 MYA (Müller & Reisz 2005; Ogg *et al.* 2008; Ogg *et al.* 2016).

The age of the root was set with a soft lower bound, which gives a low (but non-zero) likelihood of the age being older than the lower bound value. Minimum and maximum root bounds were placed as follows: Minimum age—oldest possible age for the oldest known reptile, *Hylonomus* (from the Joggins Formation in Nova Scotia, Canada), which comes from the late Bashkirian Stage (early Pennsylvanian, Late Carboniferous) and is between 318 and 315 million years old (Ogg *et al.* 2016). Considering *Petrolacosaurus* may be as much as 307 million years old, placing the minimum age at 318 seems consistent, as the most recent common ancestor of diapsids and captorhinids must have been at least a few million years older than *Petrolacosaurus*; Maximum age—based on the maximum soft age for reptile-synapsid split (Benton *et al.* 2015): 332.9 million years ago.

Preferred phylogenetic hypotheses

We consider the trees inferred from combined evidence data under Bayesian inference analyses to be our preferred phylogenetic hypothesis (Fig. 2 and Extended Data Figures 7-9), because they consider different data types simultaneously, and Bayesian inference analyses take into consideration the different models of molecular evolution and variation in branch lengths. Statistical phylogenetic methods were found to be more accurate and efficient, especially in the analysis of molecular data (which is more prone to long branch attraction than morphological data) or when evolutionary rates vary among branches(Saitou & Imanishi 1989; Kuhner & Felsenstein 1994; Huelsenbeck & Rannala 1997; Yang & Rannala 2012). Bayesian inference has also been demonstrated to have superior performance over other statistical methods (Maximum likelihood approaches) and a maximum parsimony, in the analysis of molecular, morphological, and combined evidence data (Dwivedi & Gadagkar 2009; Wright & Hillis 2014; Guillerme & Cooper 2016; O'Reilly *et al.* 2016; Puttick *et al.* 2017).

Taxonomic sampling for phylogenetic analyses

A detailed list with information on each taxonomic unit used herein is provided. General remarks on the age, stratigraphic horizon and locality, holotype number (and if this was personally observed), additional materials that have been personally observed, and main references on the taxonomy and anatomy of each species are also provided. Mere references to the species without anatomical/taxonomic discussions, their mention or inclusion in phylogenetic datasets without further discussion on the taxon, and information from unpublished PhD theses are omitted. References to other species from the same genus that are not included herein are also not included. Although the reference list is not an exhaustive compilation of all studies mentioning or figuring the referred taxa, they comprehend what is considered herein the most relevant published studies on each referenced taxon, especially regarding their taxonomy and anatomy.

Fossil Taxa

Protorothyris archeri Price, 1937
Age. Sakmarian, Cisuralian, Lower Permian (Clark & Carroll 1973; Lucas 2006).
Horizon/Locality. Moran Formation, Wichita Group—Cottonwood Creek, Archer County, Texas, USA (Clark & Carroll 1973).
Holotype. MCZ 1532 (observed).
Observed referred materials. MCZ 2148, MCZ 2149, MCZ 4204, MCZ 4416, and NMNH 392180.
Main bibliography. Price (1937); Huene (1944b); Carroll (1969a); Clark & Carroll (1973).

Protocaptorhinus pricei Clark & Carroll, 1973
Age. Late Artinskian, Cisuralian, Lower Permian (Clark & Carroll 1973; Lucas 2006).
Horizon/Locality. Uppermost Admiral Formation, Wichita Group—Rattlesnake Canyon, Archer County, Texas, USA (Clark & Carroll 1973).
Holotype. MCZ 1478 (observed).
Main bibliography. Clark & Carroll (1973); Gaffney & McKenna (1979); Olson (1984); Heaton & Reisz (1986).

Captorhinus aguti (Cope, 1882)
Age. Early to late Cisuralian, Lower Permian (Fox & Bowman 1966; Cisneros *et al.* 2015).
Horizon/Locality. Admiral, Belle Plains and Clyde formations, Wichita group—Texas, USA; Arroyo, Vale (?) and Choza formations, Clear Fork Group—Texas, USA; Abo Formation—New Mexico, USA; Arroyo (?) Formation, Clear Fork Group—Oklahoma, USA; Lower Pedra de Fogo Formation, Parnaíba Basin— Nazária Municipality, Piauí State, Brazil (Fox & Bowman 1966; Cisneros *et al.* 2015).
Holotype. AMNH 4333 (observed).

Observed referred materials. AMNH 4332, AMNH 4338**,** AMNH 4339, AMNH 4340, AMNH 4434, KU 9978, KU 106458**,** FMNH UC 383, FMNH 386, FMNH UC 491, FMNH UC 1699, FMNH PR 913.
Main bibliography. Cope (1882); Cope (1895); Case (1911); Price (1935); Price (1940); Romer (1946); Peabody (1951); Romer (1956); Fox & Bowman (1966); Bolt & DeMar (1975); Holmes (1977); de Ricqlès & Bolt (1983); Heaton & Reisz (1986); Modesto (1998); Holmes (2003); Cisneros *et al.* (2015).

Labidosaurus hamatus (Cope, 1895)
Age. Kungurian, Cisuralian, Lower Permian (Lucas 2006).
Horizon/Locality. Lowermost Arroyo Formation, Clear Folk Group—Baylor County, Texas, USA (Modesto *et al.* 2007).
Holotype. AMNH 4341.
Observed referred materials. FMNH P 12758 FMNH UC 634, FMNH UR 161, FMNH UR 273, FMNH UR 634, FMNH UR 643, FMNH UR 696, FMNH UR 727, FMNH UR1198, FMNH UC 1543.
Main bibliography. Cope (1895); Cope (1896); Case (1911); Williston (1910b); Williston (1917); Olson (1937); Parrington (1937); Olson (1984); Sumida (1987); Sumida (1989); Sumida (1991); Modesto *et al.* (2007).
Remarks. Modesto *et al.* (2007) indicated the age of *L. hamatus* as being "Leonardian (= Artinskian)". However, the Leonardian has been indicated to correspond to the Kugurian by Lucas (2006). Data on the morphology of the autopodium in *Labidosaurus* has been obtained from Sumida (1989).

Eunotosaurus africanus Seeley, 1892
Age. middle Capitanian to Capitanian/Wuchiapingian boundary, Middle Permian (Day *et al.* 2013).
Horizon/Locality. *Tapinocephalus* and *Pristerognathus* zones of the Abrahamskaal Formation, upper part of the Koonap Formation, and lowermost Middleton Formation, Beaufort Group, Karoo Supergroup—multiple localities in the Western Cape, Northern Cape, Free State and Eastern Cape provinces, South Africa [for details see Day *et al.* (2013)].
Holotype. NHMUK R1968 (observed).
Observed referred materials. NHMUK R4949, NHMUK R49424, SAM-PK-K7909.
Main bibliography. Seeley (1892); Cox (1969); Gow (1997); Gow & de Klerk (1997); Lyson *et al.* (2010); Lyson & Joyce (2012); Carroll (2013); Day *et al.* (2013); Lee (2013a); Lee (2013b); Lyson *et al.* (2013a); Lyson *et al.* (2014); Bever *et al.* (2015b); Joyce (2015); Nagashima *et al.* (2015); Lyson *et al.* (2016).
Remarks. Additional and well informative data on the skull of *Eunotosaurus* was obtained from published 3D CT scans of the adult skull of CM 777 (Bever *et al.* 2015b; a), and additional details on the pedal morphology from Gow & de Klerk (1997).

Eunotosaurus is a key taxon towards understanding diapsid relationships that has also called more recent attention towards understanding the early evolution of turtles (Lee 2013a; Lyson *et al.* 2013a; Bever *et al.* 2015b; Joyce 2015; Lyson *et al.* 2016). Similarity between *Eunotosaurus* and turtles is best represented by the postcranial morphology, especially the anteroposteriorly expanded presacral ribs, which might have contributed to form the turtle shell (Lyson *et al.* 2013a; Lyson *et al.* 2016). Important similarities in the cranial morphology also occur between *Eunotosaurus* and *Proganochelys*, such as the presence of teeth on the pterygoids, palatines and vomers, the presence of a lateral process of the ectopterygoid, the supratemporal expanded anteriorly—covering the upper temporal fenestra in adults of *Eunotosaurus* (Bever *et al.* 2015a; b). The relatively expanded temporal bones in adults *Eunotosaurus*, such as the postorbital and squamosal, also confer a more similar shape to the same elements in turtles, especially *Proganochelys* among the observed taxa herein, with the consequent reduction of the processes in these bones and the closure of the temporal fenestrae. The quadrate in *Eunotosaurus* differs from most turtles in not having a well-developed posterior emargination and tympanic conch, such as in *Odontochelys*, *Kayentachelys*, and in later forms. However, *Proganochelys* has a posterior emargination while lacking a tympanic conch, indicating the latter feature was acquired later in turtle evolution, and thus explaining the condition in *Eunotosaurus*. A laterosphenoid has also been suggested for *Eunotosaurus* (Bever *et al.* 2015b), but its homology to the one in *Proganochelys* (Bhullar & Bever 2009) is uncertain.

Proganochelys queensdedti Baur, 1887
Age. Late Norian, Late Triassic (Gaffney 1990).
Horizon/Locality. Upper Stubensandstein, Keuper Group, Germanic Basin—Halberstadt, Tübingen and Trossingen, Germany [(Gaffney 1990) and SMNS specimen labels].
Holotype. uncatalogued material in Tubingen [see Gaffney (1990)].
Observed referred materials. SMNS 16980, SMNS 15759.
Main bibliography. Baur (1887); Quenstedt (1888); Fraas (1899); Jaekel (1914); Jaekel (1918); Parsons & Williams (1961); Gaffney & Meeker (1983); Gaffney (1985); Gaffney (1990); Müller (2004); Bhullar & Bever (2009); Lyson *et al.* (2010); Carroll (2013); Lyson *et al.* (2013a); Lyson *et al.* (2013b); Nagashima *et al.* (2015); Joyce (2015); Lyson *et al.* (2016).
Remarks. A relevant difference in our interpretation of the anatomy of *Proganochelys* to that of Gaffney (1990) is the presence of a postfrontal that is not fused to the postorbital. A similar characterization of *Pappochelys* (Schoch & Sues 2015) and *Eunotosaurus* (Bever *et al.* 2015b), both inferred to lie more rootward relative to *Proganochelys*, indicates both elements were separate during early turtle evolution, thus becoming fully fused in later evolving forms, such as *Kayentachelys.*

Odontochelys semitestacea Li et al. 2008
Age. Lower Carnian, Late Triassic (Li *et al.* 2008b).

Horizon/Locality. Wayao Member, Falang Formation—Guanling, Guizhou Province, southwestern China (Li *et al.* 2008b).
Holotype. IVPP V 15639.
Paratype. IVPP V 13240 (observed).
Observed referred materials. IVPP V 15653.
Main bibliography. Li *et al.* (2008b); Lyson *et al.* (2010); Lyson & Joyce (2012) ;Carroll (2013); Lyson *et al.* (2013a); Lyson *et al.* (2014); Hirasawa *et al.* (2015); Nagashima *et al.* (2015); Joyce (2015); Lyson *et al.* (2016).

Kayentachelys aprix Gaffney et al., 1987
Age. Sinemurian-Pliensbachian, Lower Jurassic (Padian 1989).
Horizon/Locality. Silty facies of the Kayenta Formation—Gold Springs and Willow Springs, Adeii Eechii Cliffs, Coconino County, Arizona, USA (Gaffney *et al.* 1987).
Holotype. MNA V1558 (also catalogued as MCZ 8913).
Observed referred materials. MCZ 8914, MCZ 8915, MCZ 8916, MCZ 8917, MCZ 8983, MCZ 8999, TMM 43647−1, TMM 43669−2, TMM 43670−2.
Main bibliography. Gaffney *et al.* (1987); Sterli & Joyce (2007); Gaffney & Jenkins (2010); Lyson *et al.* (2013b).

Petrolacosaurus kansensis Lane, 1945
Age. Stephanian of Europe [equivalent to the Kasimovian (Ogg *et al.* 2008)], Late Pennsylvanian, Carboniferous.
Horizon/Locality. Stanton Formation, Lansing Group—Garnett, Kansas, USA (Peabody 1952; Reisz 1977).
Holotype. KUVP 1424 (observed).
Observed referred materials. KUVP 1423, KUVP 1426, KUVP 1427**,** KUVP 8351, KUVP 9940, KUVP 9951 A, B & C, KUVP 9952, KUVP 9955, ROM 29900, ROM 29907, ROM 55098, ROM uncatalogued.
Main bibliography. Lane (1945); Peabody (1952); Kuhn (1969); Reisz (1975); Reisz (1977); Reisz (1981); Benton (1985); Müller (2004).
Remarks. The presence and configuration of the supratemporal and tabular are preserved only on the left side of KUVP 9952 (Reisz 1981). However, the left side of this specimen is now covered in resin, and our scorings on these elements follows Reisz (1981). Contrary to the interpretation provided by Reisz (1981), the ankle of the holotype (KUVP 1424) includes both the medial and lateral centralia.

Araeoscelis gracilis Williston, 1910a
Age. Late Kungurian, Cisuralian, Lower Permian (Vaughn 1955; Lucas 2006).
Horizon/Locality. Arroyo Formation, Clear Fork Group— Craddock bonebed, near Seymour, Baylor County, Texas, USA [(Vaughn 1955) and FMNH specimen labels].

Holotype. FMNH UR 341 (observed).
Lectotype series. FMNH UC 659, FMNH UC 660, FMNH UC 661, FMNH UC 662 (all observed).
Observed referred materials. FMNH UC 1708, FMNH UC 2415, FMNH UC 2416, FMNH UC 2417, FMNH UC 2418, FMNH UC 2419.
Main bibliography. Williston (1910a); Williston (1913); Williston (1914); Broom (1931); Parrington (1937); Huene (1944a); Huene (1944b); Romer (1946); Romer (1947); Vaughn (1955); Kuhn (1969).

Araeoscelis casei (Broom, 1913c)
Age. Artinskian and lower Kungurian, Cisuralian, Lower Permian (Vaughn 1955; Lucas 2006).
Horizon/Locality. Admiral Formation, Wichita Group—Godwin Creek, Archer County, Texas, USA; Belle Plains Formation, Wichita Group—Turbeville Pasture, Baylor County, Texas [(Vaughn 1955) and MCZ specimen labels].
Holotype. AMNH 4685 (observed).
Observed referred materials. MCZ 4380, MCZ 8828.
Main bibliography. Case (1907); Broom (1913c); Williston (1914); Broom (1931); Romer (1946); Romer (1947); Vaughn (1955); Kuhn (1969); Reisz *et al.* (1984).

Hupehsuchus nanchangensis Young & Dong, 1972
Age. Spathian, late Olenekian, Lower Triassic (Li *et al.* 2008a; Chen *et al.* 2014).
Horizon/Locality. Upper Jialingjian Formation— Mingfeng Town, Yuanan County and Xunjian Commune, Nanzhang County, both in Hubei Province, China (Carroll & Zhi-Ming 1991; Li *et al.* 2008a; Chen *et al.* 2014).
Holotype. IVPP V3232 (observed).
Paratype. IVPP V4608.
Main bibliography. Young & Dong (1972); Carroll & Zhi-Ming (1991); Li *et al.* (2008a); Wu *et al.* (2016).
Remarks. Additional information from *Hupehsuchus nanchangensis* concerning the temporal region and parts of the pectoral girdle have been obtained by new specimens and good quality pictures published by Wu *et al.* (2016).

Utatsusaurus hataii Shikama, Kamei, and Murata, 1978
Age. Spathian, late Olenekian, Lower Triassic (Motani *et al.* 1998).
Horizon/Locality. Middle-Upper Osawa Formation, Inai Group—Utatsu and Miyagi, Japan (Shikama *et al.* 1978; Motani *et al.* 1998).
Holotype. IGPS 95941.
Observed referred materials. NSM-VP-20028, UHR 30691.
Main bibliography. Shikama *et al.* (1978); Mazin (1986); Nicholls & Brinkman (1993); Minoura (1994); Motani (1997); Motani *et al.* (1998); Motani (1999b); Maisch & Matzke

(2000); Sander (2000); McGowan & Motani (2003); Müller (2004); Cuthbertson *et al.* (2013b); Cuthbertson *et al.* (2014).

Parvinatator wapitiensis Nicholls & Brinkman, 1995
Age. Spathian, late Olenekian, Lower Triassic-latest Ladinian, Middle Triassic (McGowan & Motani 2003).
Horizon/Locality. Unknown specific horizon, Sulphur Mountain Formation—Wapiti Lake, east-central British Columbia, Canada (Maisch & Matzke 2000; McGowan & Motani 2003).
Holotype. TMP 1989.127.0008 (observed).
Main bibliography. Nicholls & Brinkman (1995); Motani (1999b); Maisch & Matzke (2000); Sander (2000); McGowan & Motani (2003).

Gulosaurus helmi Cuthbertson, Russell & Anderson, 2013
Age. Spathian, late Olenekian, Lower Triassic-latest Ladinian, Middle Triassic (Brinkman *et al.* 1992; McGowan & Motani 2003).
Horizon/Locality. Vega-Phroso Siltstone Member, Sulphur Mountain Formation—south-east of Wapiti Lake, east-central British Columbia, Canada (Brinkman *et al.* 1992).
Holotype. TMP 1989.127.0003 (observed).
Main bibliography. Brinkman *et al.* (1992); Cuthbertson *et al.* (2013a); Kelley *et al.* (2016); Ji *et al.* (2016).

Mixosaurus panxianensis Jiang et al., 2006
Age. Late Pelsonian, Anisian, Middle Triassic (Jiang *et al.* 2006; Sun *et al.* 2006; Benton *et al.* 2013).
Horizon/Locality. Upper Member, Guanling Formation—Yangjuan Village, Xinmin District, Panxian County, Guizhou Province, China (Jiang *et al.* 2006).
Holotype. GMPKU-P-1033 (observed).
Observed referred materials. GMPKU-P-1031, GMPKU-P-1038, GMPKU-P-1039, IVPP uncatalogued.
Main bibliography. Jiang *et al.* (2006); Li *et al.* (2008a); Benton *et al.* (2013); Ji *et al.* (2016).

Youngina capensis Broom, 1914
Age. Lopingian, Late Permian (Smith *et al.* 2012; Rubidge *et al.* 2013).
Horizon/Locality. *Daptocephalus* zone [= late Cistecephalus and Dicynodon Zones], Beaufort Group, Karoo Supergroup—New Bethesda, Eastern Cape Province and Doornplaat, North-West Province, South Africa [(Gow 1974), SAM and BPI databases].
Holotype. AMNH 5561 (observed).
Observed referred materials. BPI/1/70, BPI/1/2459, BPI/1/2871, BPI/1/3859, NHMUK 5481, SAM-PK-K7578, SAM-PK-K8565.

Main bibliography. Broom (1914); Kuhn (1969); Broom (1937); Parrington (1937); Huene (1944b); Romer (1946); Young (1948); Wild (1973); Kuhn-Schnyder (1974); Gow (1974); Currie (1981b); Estes (1983); Evans (1984); Benton (1985); Evans (1987); Gardner *et al.* (2010).
Remarks. Information from the braincase of *Y. capensis* was complemented using the CT scan data published by Gardner *et al.* (2010). Specimen TM 3603, used by Gow (1974) in his description of *Y. capensis* is damaged and broken into separate pieces. TM 3603, along with TM 200 and TM 4095 are regarded herein as cf. *Youngina* due to their fragmentary condition. The same applies to TM 1490, initially described as *Younginopsis*, but synonymized with *Y. capensis* by Gow (1974). SAM-PK-K8565 can be assigned to *Y. capensis* on the basis skull morphology, and it is represented by a juvenile. However this specimen is not used in order to avoid biases due to ontogeny. Specimens SAM-PK-K5836, SAM-PK-K10651, SAM-PK-K10681, SAM-PK-K10777 and SAM-PK-K10818 are very poorly preserved and are only referred herein as cf. *Youngina*. Specimen SAM-PK-K7710, which consists of at least four juvenile individuals in a single block, differs from *Y. capensis* by having ventral midline crests on its cervical and dorsal vertebrae, and by its dorsal neural spines lacking the lateral expansion seen in *Y. capensis*. Additionally, the pubis seems to lack an obturator foramen, although the degree of preservation may affect this assessment. This specimen may represent a separate species o the genus *Youngina*.

Hovasaurus boulei Pivetau, 1926
Age. Lower Lopingian, Late Permian (Lucas 2006; Smith *et al.* 2012; Rubidge *et al.* 2013) to Induan, Early Triassic (Wescott & Diggens 1998; Ketchum & Barrett 2004b).
Horizon/Locality. Lower Sakamena Formation, Sakamena Group, Karoo Supergroup— near Mount Eliva, Sakamena River Valley, southwestern Magadascar (Currie 1981a; Lucas 2006); "Couches à Claraia et Poissons" or the overlying "Couches à Poissons et Ammonites" [equivalent to the Middle Sakamena Formation], Diego Basin—northwestern Madagascar (Wescott & Diggens 1998; Ketchum & Barrett 2004b).
Lectotype series. MNHN 1908-21-2 and MNHN 1908-21-7 (observed).
Observed referred materials. MNHN 1925-5-34, MNHN 1925-5-30, MNHN 1908-21-14b.
Main bibliography. Piveteau (1926); Haughton (1929); Kuhn (1969); Currie (1981a); Benton (1985); Carroll (1985a); Carroll (1988); Carroll & Currie (1991); Caldwell (1995); Caldwell (2002); Ketchum & Barrett (2004a).

Acerosodontosaurus piveteaui Currie, 1980
Age. Lower Lopingian, Late Permian (Lucas 2006; Smith *et al.* 2012; Rubidge *et al.* 2013).
Horizon/Locality. Lower Sakamena Formation, Sakamena Group, Karoo Supergroup —exact locality unknown, Sakamena River Valley, southwestern Magadascar (Currie 1980; Lucas 2006).
Holotype. MNHN 1908-32-57a,b (observed).
Observed referred materials. UALVP 45621 (cast of holotype).
Main bibliography. Currie (1980); Carroll (1988); Bickelmann *et al.* (2009).

Remarks. Currie (1980) indicated the presence of a quadratojugal in *A. piveteaui*, which was later contested by Bickelmann *et al.* (2009). The latter authors suggested the element identified as the quadratojugal is, in fact, a rib head. It is agreed herein that the element in question is most likely to represent a rib head, as suggested by Bickelmann *et al.* (2009). However, an additional element distinct from the quadrate and articulating laterally to it in the skull of the holotype (and not mentioned by previous authors) is suggested herein to represent the quadratojugal. It bears an anterior process, but its anteriormost end is broken, and the total extension of it is unknown.

Claudiosaurus germaini Carroll, 1981
Age. Lopingian, Late Permian (Lucas 2006; Smith *et al.* 2012; Rubidge *et al.* 2013).
Horizon/Locality. Upper portion of the Lower Sakamena Formation, Sakamena Group, Karoo Supergroup —near the village of Leoposa, southwestern Magadascar (Carroll 1981).
Holotype. MNHN 1978-6-1 (observed).
Observed referred materials. MNHN 1978-6-2, MNHN 1910-33-1a, MNHN 1925-5-90, SAM-PK-K8265, SAM-PK-K8580.
Main bibliography. Carroll (1981); de Buffrénil & Mazin (1989); Caldwell (1995); Müller (2004).
Remarks. Many of the specimens used by Carroll (1981) in the description of *Claudiosaurus* were in a private collection that could not be located. Additionally, some of the specimens housed at the MNHN could not be found (MNHN 1911-18, MNHN 1909-3-21, MNHN 1909-3-22, MNHN 1909-3-25, MNHN 1909-3-26, MNHN 1909-3-37, MNHN 1909-34-3). This limitation prevented a better assessment of the skull morphology of *Claudiosaurus.* Nevertheless, new specimens at the SAM provided some additional details on the postcranial morphology of *Claudiosaurus.*

Coelurosauravus jaekeli (Weigelt, 1930)
Age. Middle Wuchiapingian, lower Lopingian, Late Permian (Menning *et al.* 2011).
Horizon/Locality. Kupferschiefer Formation, Zechstein Group—Ellrich (Thuringia), Richelsdorf (Hesse), Mansfeld, (Sachsen/Anhalt), Germany; and Marl Slate— Eppleton Quarry, Tyne and Wear, United Kingdom (Schaumberg 1976; Evans & Haubold 1987; Frey *et al.* 1997; Schaumberg *et al.* 2007).
Holotype. SSWG 113/7 (observed).
Main bibliography. Weigelt (1930a); Weigelt (1930b); Kuhn (1939); Kuhn (1969); Schaumberg (1976); Evans (1982); Evans & Haubold (1987); Frey *et al.* (1997); Schaumberg *et al.* (2007); Bulanov & Sennikov (2010)**.**
Remarks. Here we follow the assignment of *Gracilisaurus* Weigelt, 1930a and *Weigeltisaurus* Wigelt, 1930b as a junior synonyms of *Coelurosauravus* by Evans & Haubold (1987).

Coelurosauravus elivensis Piveteau, 1926

Age. Wuchiapingian, lower Lopingian, Late Permian (Lucas 2006; Smith *et al.* 2012; Rubidge *et al.* 2013).
Horizon/Locality. Upper portion of the Lower Sakamena Formation, Sakamena Group, Karoo Supergroup—near Mount Eliva, Sakamena River Valley, southewstern Magadascar (Carroll 1978).
Holotype. MNHN IP 1908-11-21a (observed).
Observed referred materials. MNHN IP 1908-11-22a, MNHN IP 1908-11-23a, MNHN IP 1908-5-2 (previous holotype of *Daedalosaurus madagascariensis*).
Main bibliography. Piveteau (1926); Kuhn (1969); Carroll (1978); Evans (1982); Evans & Haubold (1987); Bulanov & Sennikov (2015b).
Remarks. Here we follow the assignment of *Daedalosaurus* Carroll, 1981 as a junior synonyms of *Coelurosauravus* by Evans & Haubold (1987).

Protorosaurus speneri Meyer, 1832
Age. Middle Wuchiapingian, lower Lopingian, Late Permian (Menning *et al.* 2011).
Horizon/Locality. Kupferschiefer Formation, Zechstein Group—Heilderberg, Suhl, Gliicksbrunn, Kupfersuhl, Rothenburg (Thuringia), Richelsdorf (Hesse), Near Ibbenbiihren (North Rhine-Westphalia), and mining pits in Richelsdorfer Gebirge, Germany (Gottmann-Quesada & Sander 2009); Marl Slate—Quarrington Quarry, near Durham, England, United Kindom (Evans & King 1993).
Lectotype. NHMW 194314.
Observed referred materials. NMOK S 180, NMOK SSch 185, NMOK SSch 186 a-b-c, NMOK SSch 187, NMOK cast (SIMON-BARTHOLOMAUS specimen), SMNS 59790 (cast), WMsN 47361.
Main bibliography. Meyer (1832); Fitzinger (1843); Hancock & Howse (1870); Seeley (1887); Huene (1944a); Romer (1947); Kuhn (1969); Benton (1985); Haubold & Schaumberg (1985); Carroll (1988); Carroll & Currie (1991); Evans & King (1993); Gottmann-Quesada & Sander (2009). For a more comprehensive bibliographic list on *P. speneri* see Gottmann-Quesada & Sander (2009), p. 135.

Prolacerta broomi Parrington, 1935
Age. Induan-Olenekian, Early Triassic (Smith *et al.* 2012).
Horizon/Locality. *Lystrosaurus* zone, Beaufort Group, Karoo Supergroup—Harrismith District (Free State Province), Hueningkrans (Burgersdorp District, Eastern Cape Province), Fairydale and Tweefontein (Bethulie District, Free State Province), Rietport (Dewetsdorp District, Free State Province), Big Bank, Queen's Hill and Old Brickfield's Donga (Harrismith District, Free State Province), Barendskraal (Middleburg District, Eastern Cape Province) South Africa [(Gow 1974; Modesto & Sues 2004) and individual specimen labels]; possibly from Fremow Formation—Transantarctic Mountains, Antarctica (Colbert 1987).
Holotype. UMZC 2003.40 (high resolution pictures provided by F. Costa).

Observed referred materials. BPI/1/471, BPI/1/2675, BPI/1/2676, BPI/1/4504a &b, BP/1/5066, BPI/1/5375, BPI/1/5880.
Main bibliography. Parrington (1935); Huene (1944b); Camp (1945); Broom & Robinson (1948); Young (1948); Robinson (1967a); Kuhn (1969); Wild (1973); Kuhn-Schnyder (1974); Gow (1974); Wild (1980a); Evans (1984); Evans (1986); Colbert (1987); Modesto & Sues (2004); Müller (2004); Botha-Brink & Smith (2011).
Remarks. We follow here the designation of *Pricea longipes* Broom & Robinson, 1948 as a junior synonym of *Prolacerta broomi* (Gow 1974; Modesto & Sues 2004).

Macrocnemus bassanii (Nopcsa, 1930)
Age. Late Anisian to early Ladinian, Middle Triassic (Kuhn-Schnyder 1962; Rieppel 1993a; Furrer 1995).
Horizon/Locality. *Grenzbitumen* Horizon (Besano Formation)—Monte San Giorgio, Switzerland-Italy, and Besano, Italy (Kuhn-Schnyder 1962; Rieppel 1989a).
Holotype. Destroyed during World War II (Rieppel 1989a).
Observed referred materials. PIMUZ T2472, PIMUZ T2477, PIMUZ T4355, PIMUZ T5753, MSNM 15863 V457, MSNM BES SC 111.
Main bibliography. Nopcsa (1930); Peyer (1931c); Peyer (1937); Huene (1944a); Huene (1944b); Kuhn-Schnyder (1962); Kuhn-Schnyder (1964); Kuhn (1969); Wild (1973); Kuhn-Schnyder (1974); Wild (1980a); Rieppel & Gronowski (1981); Benton (1985); Rieppel (1989a); Renesto & Avanzini (2002); Müller (2004); Fraser & Furrer (2013).

Macrocnemus fuyuanensis Li et al., 2007
Age. Longobardian, late Ladinian, Middle Triassic (Benton *et al.* 2013).
Horizon/Locality. Zhuganpo Formation—Huabi of Fuyuan, Yunnan Province, southwestern China (Li *et al.* 2007; Benton *et al.* 2013).
Holotype. IVPP V15001.
Observed referred materials. GMPKU-P-3001.
Main bibliography. Li *et al.* (2007); Jiang *et al.* (2011).

Langobardisaurus pandolfii Renesto, 1994
Age. Late Alaunian-early Sevatian, late Norian, Late Triassic (Saller *et al.* 2013).
Horizon/Locality. Dolomia di Forni Formation—Seazza Creek, near the village of Preone, Udine, Friuli, Italy, and Rovadia Creek, Venezia, Italy; Zorzino Limestone Formation—Cene, Lombardy, Italy; Seefeld Formation—Seefeld, Tyrol, Austria (Renesto & Dalla Vecchia 2000; Saller *et al.* 2013).
Holotype. MBSN 2883.
Observed referred materials. MFSN 1921.
Main bibliography. Renesto (1994b); Muscio (1996); Renesto & Dalla Vecchia (2000); Renesto *et al.* (2002); Saller *et al.* (2013).

Remarks. Saller *et al.* (2013) revised the genus *Langobardisaurus*, re-assigning the specimen studied herein (MFSN 1921, previously, the holotype of *L. tonelloi*) to *L. pandolfii*.

Tanystropheus longobardicus (Bassani, 1886)
Age. Late Anisian to early Ladinian, Middle Triassic (Kuhn-Schnyder 1962; Rieppel 1993a; Furrer 1995).
Horizon/Locality. *Grenzbitumen* Horizon (Besano Formation) and Meride Formation—northern Italy and Monte San Giorgio, Switzerland-Italy (Nosotti 2007).
Neotype. PIMUZ T2791.
Observed referred materials. PIMUZ T2817, PIMUZ T2818, PIMUZ T2819, PIMUZ T2793, MSNM BES SC 1018, MSNM BES SC 265.
Main bibliography. Bassani (1886); Nopcsa (1923b); Wild (1973); Kuhn-Schnyder (1959); Kuhn (1969); Kuhn-Schnyder (1974); Wild (1980a); Wild (1980b); Benton (1985); Tschanz (1985); Wild (1987); Tschanz (1988); Renesto (2005a); Nosotti (2007); Rieppel *et al.* (2010).
Remarks. Among the studied specimens, some considerable morphological variation was observed. Therefore, only specimens MSNM BES SC 1018, MSNM BES SC 265 and PIMUZ T2818 (some of the most complete specimens that seem to constitute a single morphospecies) have been used for scoring this taxon.

Megalancosaurus preonensis Calzavara, Muscio & Wild, 1980
Age. Middle Norian, Late Triassic (Renesto 2000).
Horizon/Locality. Dolomia di forni (Friuli) and Zorzino Limestone (Bergamo), Italy (Renesto 2000; Renesto *et al.* 2010).
Holotype. MFSN 1769 a&b (observed).
Observed referred materials. MFSN 1801, MFSN 18443 a&b, MBSN 25, MBSN 26.
Main bibliography. Calzavara *et al.* (1980); Feduccia & Wild (1993); Renesto (1994a); Renesto (2000); Renesto & Dalla Vecchia (2005); Spielmann *et al.* (2006); Renesto *et al.* (2010); Castiello *et al.* (2015).
Remarks. The structure of the fibula and the pedal unguals differ between specimens MBSN 25 and MPUM 8437. In MBSN 25 the fibula is curved and the unguals have a deeper basis for articulation with the penultimate phalanx, whereas MPUM 8437 has a straight fibula and shallower bases of the pedal unguals (Renesto *et al.* 2010). Renesto *et al.* (2010) and Castiello *et al.* (2015) further indicated a difference in the first pedal digit, mentioning the presence of a modified pedal digit 1, with an opposable, clawless hallux. These differences were first attributed to sexual dimorphism (Renesto 2000), but later were re-interpreted as a taxonomical difference, and a new species was named, *Megalancosaurus endennae* (holotype: MBSN 25; referred specimen: MBSN 26). However, personal observations indicate the presence of an ungual element in MBSN 25, lying ventral to the penultimate phalanx and oriented on the same direction of the other pedal phalanges, thus differing from the interpretation by Renesto *et al.* (2010). This observation is also consistent with the morphology of other scansorial reptiles, in

which the deep unguals are an important adaptation towards climbing (Zani 2000; Tulli *et al.* 2009). Therefore, the supposed absence of an ungual on pedal digit one (especially if that was an opposed hallux) would also prevent an efficient grasping capacity for the feet in *M. endennae*. Finally, the holotype of *M. preonensis* (MFSN 1769 a&b) lacks its hindlimbs, thus preventing a direct comparisons between the type materials of these two putative species—this limitation was also mentioned by Renesto *et al.* (2010). Therefore, it is considered herein that even if the two remaining differences between MBSN 25 and MPUM 8437 mentioned by Renesto *et al.* (2010); (shape of fibula, and height of the pedal unguals) are indeed taxonomically significant (and not intraspecific variation), it cannot be assessed with enough precision which of these correspond to the condition in the holotype of *M. preonensis*. For the above reasons, the validity of *M. endennae* is questioned herein. Additionally, for the purposes of the present analysis, scoring either MBSN 25, or MPUM 8437, or both as belonging to *M. preonensis*, would also not affect any of the scorings performed, as none of the characters herein relate to any of the only two differences observed between these specimens. Therefore, we score all the specimens of *Megalancosaurus* under the OTU *M. preonensis*.

Askeptosaurus italicus Nopcsa, 1925
Age. Late Anisian to early Ladinian, Middle Triassic (Kuhn-Schnyder 1962; Rieppel 1993a; Furrer 1995).
Horizon/Locality. *Grenzbitumen* Horizon (Besano Formation)—Monte San Giorgio, Switzerland-Italy (Müller 2005).
Holotype. MSNM V3550.
Observed referred materials. MSNM V456, PIMUZ T 4831, PIMUZ T 4832, PIMUZ T 4846.
Main bibliography. Nopcsa (1925); Kuhn (1952); Kuhn-Schnyder (1960); Kuhn-Schnyder (1964); Kuhn (1969); Kuhn-Schnyder (1971); Kuhn-Schnyder (1974); Carroll (1985a); Kuhn-Schnyder (1988); Carroll & Currie (1991); Müller (2004); Müller (2005).

Endennasaurus acutirostris Renesto, 1984
Age. Middle-late Norian, Late Triassic (Tintori 1995; Gaetani *et al.* 1998).
Horizon/Locality. Upper levels of the Zorzino Limestone Formation—Endenna quarry, Zogno region of the Lombardian pre-alps, Italy (Müller *et al.* 2005).
Holotype. MBSN 5170 (observed).
Observed referred materials. MBSN 27.
Main bibliography. Renesto (1984); Renesto (1991); Müller *et al.* (2005); Renesto (2005b).

Xinpusaurus kohi Jiang et al., 2004
Age. Carnian, Late Triassic (Jiang *et al.* 2005).
Horizon/Locality. Wayao Member, Falang Formation— Xinpu village, Guizhou Province, China (Jiang *et al.* 2004).
Holotype. GMPKU- 2000/005 (observed).

Main bibliography. Jiang *et al.* (2004); Jiang *et al.* (2005); Rieppel & Jun (2006); Liu (2013); Maisch (2014); Li *et al.* (2016).
Remarks. There is an existing debate on the validity of *X. kohi*, regarded as a junior synonym of *X. bamaolinensis* by Rieppel & Jun (2006), as a junior synonym of *X. suni* (Liu 2013), and once again as a valid taxon by Maisch (2014). The latter author considered, however, that a re-description of *X. bamaolinensis* is necessary before decisive conclusions regarding the status of *X. kohi*. Therefore, only data personally collected from the holotype of *X. kohi* has been utilized herein (pending revision to determine whether this also represents *X. bamaolinensis*).

Champsosaurus lindoei Gao & Fox, 1998
Age. Mid-Campanian, Late Cretaceous (Gao & Brinkman 2005).
Horizon/Locality. Dinosaur Park Formation—Dinosaur Provincial Park, Alberta, Canada (Gao & Brinkman 2005).
Holotype. UALVP 931 (observed).
Observed referred materials. UALVP 33928; TMP 1987.036.0041; TMP 1994.163.0001.
Main bibliography. Fox (1968); Gao & Fox (1998); Gao & Brinkman (2005); Matsumoto & Evans (2016).

Philydrosaurus proseilus Gao & Fox, 2005
Age. Albian, Early Cretaceous (Gao & Fox 2005).
Horizon/Locality. Jiufotang Formation, Jehol Group - near the city of Chaoyang, Liaoning Province, China (Gao & Fox 2005).
Holotype. PKU V2001 (observed).
Main bibliography. Gao & Fox (2005); Gao *et al.* (2007); Gao *et al.* (2013).
Remarks. Additional information on the braincase and palate obtained from pictures in Gao *et al.* (2007).

Trilophosaurus buettneri Case, 1928a
Age. Middle Otischalkian, lower Carnian, Late Triassic to late Adamanian, latest Carnian, Late Triassic (Spielmann *et al.* 2008).
Horizon/Locality. Colorado City Formation, Chinle Group and Tecovas Formation, Dockum Group—Texas, USA; Blue Mesa Member, Petrified Forest Formation, Chinle Group—Arizona, USA; Bluewater Creek Formation, Chinle Group—New Mexico, USA (Lucas 1998; Spielmann *et al.* 2008).
Holotype. MNA V3192.
Observed referred materials. TMM 31025-4, TMM 31025-5, TMM 31025-68, TMM 31025-73, TMM 31025-74, TMM 31025-80, TMM 31025-116, TMM 31025-125, TMM 31025-140, TMM 31025-142, TMM 31025-143, TMM 31025-144, TMM 31025-154-164, TMM 31025-207, TMM 31025-208, TMM 31025-210, TMM 31025-225, TMM 31025-233, TMM 31025-239, TMM 31025-248, TMM 31025-357, TMM 31025-366, TMM 31025-394.

Main bibliography. Case (1928a); Case (1928b); Gregory (1945); Robinson (1957); Kuhn (1969); Parks (1969); Demar & Bolt (1981); Murry (1986); Elder (1987); Murry (1987);Carroll & Currie (1991); Spielmann *et al.* (2005); Heckert *et al.* (2006); Spielmann *et al.* (2008); Nesbitt *et al.* (2015). Additional literature on the genus *Trilophosaurus* has been discussed in detail by (Spielmann *et al.* 2008).

Mesosuchus browni Watson, 1912
Age. Earliest to middle/late Anisian, Middle Triassic (Dilkes 1998; Smith *et al.* 2012).
Horizon/Locality. *Cynognathus* Zone B, Bugersdrop Formation, Tarkastad Sub-group, Beaufort Group, Karoo Supergroup—near Aliwal North, Eastern Cape Province, South Africa [SAM database and Dilkes (1998)].
Holotype. SAM-PK-5882 (observed).
Observed referred materials. SAM-PK-6046, SAM-PK-6536, SAM-PK-7416.
Main bibliography. Watson (1912); Broom (1913a); Broom (1913b); Haughton (1922); Haughton (1924); Broom (1925); Romer (1946); Hoffstetter (1955a); Romer (1956); Malan (1963); Robinson (1967a); Kuhn (1969); Carroll (1976); Dilkes (1998); Müller (2004); Ezcurra *et al.* (2016); Ezcurra (2016).
Remarks. Two additional specimens, SAM-PK-6546 and SAM-PK-7701 are morphological similar to *M. browni*, but because of the limited amount of information preserved they are only tentatively assigned to that species (cf. *Mesosuchus browni*). Important similarities were observed between *Mesosuchus* and protorosaurs, such as the squamosal having distinct anteroventral and posterior processes; the squamosal anterior process forked to receive the postorbital (also observed in later rhynchosaurs); the quadratojugal without an anterior extension contacting the jugal, the shape of the scapula, coracoid, and the presence of a hooked fifth metatarsal (also present in later rhynchosaurs). It is also remarkable the presence in intercentra between the dorsal vertebrae (also occurring in *Howesia* and *Trilophosaurus*) and teeth on the vomers, palatines and pterygoids, common features of early diapsids such as *Youngina* and non-diapsid reptiles. Importantly, postparietals are present in SAM-PK-6535, contrary to previous observations—e.g. Dilkes (1998) and Nesbitt (2011). Both elements of the postparietals are clearly distinct from the parietals at their anterior margin, and their sutures quite symmetrical on both lateral sides, but the suture becomes obliterated posteriorly on the left side, which may have induced previous authors to consider it as absent in this taxon. The presence of postparietals further indicates the similarity between this taxon with earlier diapsids and with early archosauriforms such as *Proterosuchus* and *Euparkeria.*

Howesia browni Broom, 1905
Age. Earliest to middle/late Anisian, Middle Triassic (Dilkes 1995; Smith *et al.* 2012).
Horizon/Locality. *Cynognathus* Zone B, Bugersdrop Formation, Tarkastad Sub-group, Beaufort Group, Karoo Supergroup—near Aliwal North, Eastern Cape Province, South Africa (SAM database).

Holotype: SAM 5884 (observed).
Observed referred materials. SAM 5885, SAM 5886.
Main bibliography. Broom (1905b); Broom (1906b); Haughton (1924); Hoffstetter (1955a); Malan (1963); Kuhn (1969); Carroll (1976); Benton (1985); Dilkes (1995); Ezcurra *et al.* (2016); Ezcurra (2016).
Remarks. The only difference suggested by Dilkes (1998) between *Mesosuchus* and *Howesia* is the depth of the pockets on the neural arches above the transverse processes of the posterior dorsals, the orientation of the caudal neural spines, and the presence of a groove on the ventral side of the second sacral and first two anterior caudals. The neural spines are slightly inclined posteriorly in *Mesosuchus* and steeply inclined in *Howesia*, however, the degree in depth of the pockets on the lateral sides of the neural arches on the posteriormost dorsal vertebrae is quite similar between *Mesosuchus* (SAM-PK-6046) and *Howesia* (SAM-PK-5886). One of the few significant difference between both taxa is that mentioned by Ezcurra (2016), which relates to the number of maxillary tooth rows. Details of the supratemporal, squamosal and postorbital of SAM-PK-5885 are not visible as the specimen is now placed on a gypsum bed, thus concealing the dorsal view of the skull bones. Information on those elements was obtained from Dilkes (1995).

Teyumbaita sulcognathus Azevedo & Schultz, 1987
Age. Early Norian, Late Triassic (Langer *et al.* 2007; Montefeltro *et al.* 2010).
Horizon/Locality. Lower part of the Caturrita Formation, Paraná Basin—outcrops between the cities of Santa Maria and Candelária, Central areas of Rio Grande do Sul, Brazil (Montefeltro *et al.* 2010).
Holotype. UFRGS-PV-0232T (observed).
Main bibliography. Azevedo & Schultz (1987); Montefeltro *et al.* (2010); Montefeltro *et al.* (2013); Ezcurra *et al.* (2016).

Hyperodapedon huenei Langer & Schutlz, 2000
Age. Latest Carnian-earliest Norian, Late Triassic (Langer *et al.* 2007).
Horizon/Locality. Santa Maria Formation, Paraná Basin—Inhamandá outcrop, east of São Pedro do Sul, Rio Grande do Sul, BrazilRio Grande do Sul, Brazil (Langer & Schultz 2000).
Holotype. UFRGS-PV-0132T.
Observed referred materials. UFRGS-PV-0309T, UFRGS-PV-0408T.
Main bibliography. Langer & Schultz (2000); Langer *et al.* (2000); Ezcurra *et al.* (2016).

Proterosuchus fergusi Broom, 1903
Age. Induan-Olenekian, Early Triassic (Smith *et al.* 2012).
Horizon/Locality. *Lystrosaurus* Zone, Katberg Formation, Beaufort Group, Karoo Supergroup—Farm Wheatlands, Tarkastad, Chris Hani District, Eastern Cape Province, South Africa (Broom 1903a; Ezcurra 2016).

Holotype. SAM-PK-591 (observed).
Neotype. RC 846 (Ezcurra & Butler 2015b).
Observed referred materials. BPI/1/3993, BPI/1/4016, TM 201, SAM-PK-11208.
Main bibliography. Broom (1903a); Hughes (1963); Charig & Reig (1970); Cruickshank (1972); Charig & Sues (1976); Benton & Clark (1988);Carroll (1988); Carroll & Currie (1991); Clark *et al.* (1993); Welman (1998); Klembara & Welman (2009); Botha-Brink & Smith (2011); Ezcurra & Butler (2015a); Ezcurra & Butler (2015b); Ezcurra (2016).
Remarks. All South African proterosuchids have been synonymized by Welman (1998) under *P. fergusi*, namely: *Chasmatosaurus vanhoepeni*, *C. alexanderi*, and *Elaphrosuchus rubidgei*. However, Ezcurra & Butler (2015b) split the specimens that had been attributed by Welman (1998) as a single species into distinct taxa, thus resurrecting *Proterosuchus* (=*Chasmatosaurus*) *alexanderi* based on NMQR 1484/C.3016, and erecting a new taxon, *Proterosuchus goweri* based on a complete skull (NMQR 880/C.500). We follow the taxonomy of Ezcurra & Butler (2015b) herein. Regarding the morphology of *P. fergusi*, Cruickshank (1972) misinterpreted the partially broken anteroventral process of the squamosal in BPI/1/4016 as being a suture between the squamosal and the quadratojugal. Instead, the quadratojugal is a very reduced element, with its dorsal margin being located more ventrally relative to the point illustrated by Cruickshank (1972). Additionally, the quadratojugal does not have an anterior extension as observed in later archosaurs, thus having the lower temporal bar formed entirely by the jugal posterior process. This condition is similar to the one seen in *Prolacerta*, in which the jugal has an elongate posterior process (although not reaching the quadratojugal), and the quadratojugal does not have an anterior extension. The observed specimens all have the retroarticular process directed posteriorly (BPI/1/3993, BPI/1/4016). This is also illustrated by Welman (1998) in his fig. 3. The interpretation of a dorsally oriented retroarticular process is usually based on the specimen RC 96 (not observed herein). Whether this is an artefact or intraspecific variation cannot be determined by us, and may be addressed in further detail the future.

Proterosuchus alexanderi (Hoffman, 1965)
Age. Induan-Olenekian, Early Triassic (Smith *et al.* 2012).
Horizon/Locality. *Lystrosaurus* Zone, Balfour Formation or Katberg Formation, Beaufort Group, Karoo Supergroup— Farm Zeekoegat, four miles from Venterstad, Joe Gqabi District, Eastern Cape Province, South Africa (Hoffman 1965; Ezcurra 2016).
Holotype. NMQR 1484/C.3016 (observed).
Main bibliography. Hoffman (1965)**;** Charig & Reig (1970); Cruickshank (1972)**;** Charig & Sues (1976); Clark *et al.* (1993);**;**Welman (1998); Ezcurra & Butler (2015b); Ezcurra (2016).

Erythrosuchus africanus Broom, 1905
Age. Earliest to middle/late Anisian, Middle Triassic (Dilkes 1995; Smith *et al.* 2012).
Horizon/Locality. *Cynognathus* Zone B, Bugersdrop Formation, Tarkastad Sub-group, Beaufort Group, Karoo Supergroup—Oorlogsfontein (type locality), Lemoenfontein, and other sites near

Aliwal North, Eastern Cape Province, South Africa; Burgersdorp and Rouxville, Free State Province, South Africa (Gower 2003; Botha-Brink & Smith 2011; Smith *et al.* 2012).
Holotype. SAM-PK-905 (observed).
Observed referred materials. BPI/1/5207, BPI/1/4680, BPI/13893, SAM 905, NM QS1473, NHMUK R3592, NHMUK R2790, NHMUK 3762a.
Main bibliography. Broom (1905a); Broom (1906a); Huene (1911);Williston (1911); Brink (1955); Hughes (1963); Cruickshank (1978); Benton (1985); Benton & Clark (1988); Parrish (1992); Gower (1996); Gower (1997); Gower (2001); Gower (2003); O'Connor (2006); Botha-Brink & Smith (2011).

Euparkeria capensis Broom, 1913a
Age. Earliest to middle/late Anisian, Middle Triassic (Dilkes 1995; Smith *et al.* 2012).
Horizon/Locality. *Cynognathus* Zone B, Bugersdrop Formation, Tarkastad Sub-group, Beaufort Group, Karoo Supergroup—different quarries near Aliwal North, Eastern Cape Province, South Africa [SAM database; Smith *et al.* (2012); Sookias & Butler (2013)].
Holotype. SAM-PK-5867 (observed).
Observed referred materials. AMNH 2239, AMNH 5548, SAM-PK-6047A&B, SAM-PK-6050, SAM-PK-7699-7710, SAM-PK-7696, SAM-PK-13665, SAM-PK-13666.
Main bibliography. Broom (1913a); Broom (1913b); Haughton (1922); Romer (1946); Ewer (1965); Gow (1970); Benton (1985); Benton & Clark (1988); Sereno & Arcucci (1990); Carroll & Currie (1991); Sereno (1991); Welman (1995); Gower & Weber (1998); Senter (2003); Müller (2004); Botha-Brink & Smith (2011); Sookias & Butler (2013); Sobral *et al.* (2016).
Remarks. The atlas intercentrum described by Ewer (1965) in SAM-PK-6047A could not be located. Intercentra are presented between cervicals and dorsals, a feature also observed in *Mesosuchus*, and earlier diapsids (e.g. *Youngina*). This feature could not be assessed with confidence either species of *Proterosuchus*, but it suggests intercentra between dorsals may be a plesiomorphic feature among archosauriforms, and shared with early rhynchosaurs. No cleithra are preserved, but a facet on the posterodorsal margin of the scapular blade in SAM-PK-13665 suggests it could have been present.

Largocephalosaurus qianensis Li et al., 2014
Age. Late Pelsonian, Anisian, Middle Triassic (Benton *et al.* 2013).
Horizon/Locality. Member 2, Guanling Formation—Xinmin District, Panxian County, southwest-most Guizhou Province, China (Benton *et al.* 2013; Li *et al.* 2014).
Holotype. IVPP V 15638.
Observed referred materials. GMPKU-P-1532-A, GMPKU-P-1532-B.
Main bibliography. Benton *et al.* (2013); Li *et al.* (2014)**.**
Remarks. Information from the palate of the holotype was obtained from Li *et al.* (2014)**.**

Sinosaurosphargis yunguiensis Li et al., 2011
Age. Late Pelsonian, Anisian, Middle Triassic (Benton *et al.* 2013).

Horizon/Locality. Member 2, Guanling Formation—Xinmin District, Panxian County, southwest-most Guizhou Province, China (Li *et al.* 2011; Benton *et al.* 2013).
Holotype. IVPP V 17040 (observed).
Main bibliography. Li *et al.* (2011)**;** Benton *et al.* (2013)**.**
Remarks. Information on the ventral aspect of the axial skeleton was obtained from Li *et al.* (2011).

Placodus gigas Agassiz, 1833
Age. Early Anisian to early Ladinian, Middle Triassic (Rieppel 2000; Menning *et al.* 2011).
Horizon/Locality. Jena Formation to Warburg Formation, Muschelkalk Group, Germanic Basin—central and southern Europe (Rieppel 2000; Neenan & Scheyer 2012).
Holotype. BSPG AS VII 1208 (observed).
Observed referred materials. BSPG I 76, BSPG 1968 I 75, UMO BT 13, UMO BT uncatalogued, SMNS 54437, SMNS 54558, SMNS 54567, SMNS 54571, SMNS 59824, SMF R 1035.
Main bibliography. A thorough review of the literature concerning *Placodus gigas* has been provided by Rieppel (2000). Subsequent literature includes: Rieppel (2001); Nosotti & Rieppel (2002); Scheyer (2007); Diedrich (2010); Diedrich (2011a); Neenan & Scheyer (2012); Diedrich (2013c); Neenan *et al.* (2014).

Cyamodus hildegardis Peyer, 1931
Age. Late Anisian to early Ladinian, Middle Triassic (Kuhn-Schnyder 1962; Rieppel 1993a; Furrer 1995).
Horizon/Locality. *Grenzbitumen* Horizon (Besano Formation)— Monte San Giorgio, Southern Alps, Europe (Rieppel 2000; Scheyer 2010).
Holotype. PIMUZ T 4763 (observed).
Observed referred materials. PIMUZ T58, PIMUZ T 4768, PIMUZ T 4771, PIMUZ T 2796, PIMUZ T A/III 729 (cast of MSNM V458).
Main bibliography. A thorough review of the literature concerning *Cyamodus hildegardis* has been provided by Rieppel (2000). Subsequent literature includes: Scheyer (2010); Diedrich (2011b); Scheyer *et al.* (2012); Klein *et al.* (2015).

Serpianosaurus mirigioliensis Rieppel, 1989
Age. Late Anisian to early Ladinian, Middle Triassic (Kuhn-Schnyder 1962; Rieppel 1993a; Furrer 1995).
Horizon/Locality. *Grenzbitumen* Horizon (Besano Formation)—Monte San Giorgio, Southern Alps, Europe (Rieppel 1989b).
Holotype. PIMUZ T3931 (observed).
Observed referred materials. PIMUZ T132, PIMUZ T951, PIMUZ T3678, PIMUZ T3681, PIMUZ T3685, PIMUZ T3709, PIMUZ T3771, MSNM MSC SC1280.

Main bibliography. A thorough review of the literature concerning *Serpianosaurus mirigioliensis* has been provided by Rieppel (2000). Subsequent literature includes: Caldwell (2002); Hugi *et al.* (2011); Beardmore *et al.* (2012); Diedrich (2013a); Renesto *et al.* (2014).

Wumengosaurus delicatomandibularis Jiang et al., 2008
Age. Late Pelsonian, Anisian, Middle Triassic (Benton *et al.* 2013).
Horizon/Locality. Upper Member, Guanling Formation—Yangjuan Village, Xinmin District, Panxian County, Guizhou Province, China (Jiang *et al.* 2008).
Holotype. GMPKU-P-1210 (observed).
Observed referred materials. GMPKU-P-1209.
Main bibliography. Jiang *et al.* (2008); Wu *et al.* (2011); Benton *et al.* (2013).

Lariosaurus calcagnii (Peyer, 1931b)
Age. Lower Ladinian, Middle Triassic (Furrer 1995).
Horizon/Locality. Cava Inferiore beds, lower Meride Limestones—Near Serpiano, Monte San Giorgio, Southern Alps, Europe (Rieppel 2000).
Holotype. PIMUZ T 2460 (observed).
Observed referred materials. PIMUZ T 2461, PIMUZ T 2435, PIMUZ T 4914.
Main bibliography. A thorough review of the literature concerning *Cyamodus hildegardis* has been provided by Rieppel (2000). Subsequent literature includes: Caldwell (2002); Hugi (2011); Araújo & Correia (2015).
Remarks. Originally classified under the genus *Ceresiosaurus* by Peyer (1931b), but reassigned to *Lariosaurus* by Rieppel (1998).

Pistosaurus longaevus Meyer, 1839
Age. Illyrium, late Anisian, Middle Triassic (Menning *et al.* 2011).
Horizon/Locality. Trochitenkalk or lower Meissner Formation, Upper Muschelkalk Group, Germanic Basin—Bavaria, Southern Germany (Rieppel 2000).
Holotype. UMO BT, uncatalogued (observed).
Observed referred materials. SMF 4041, SMF R 870, SMF R 75.
Main bibliography. A thorough review of the literature concerning *Cyamodus hildegardis* has been provided by Rieppel (2000). Subsequent literature includes: Rieppel *et al.* (2002); Diedrich (2013b); Krahl *et al.* (2013).
Remarks. Sues (1987) and Rieppel (2000) have considered *P. grandaevus*, *P. strunzi*, and *P. typus* as junior synonyms of *P. longaevus*, with which we concur and follow herein.

Palaegama vielhaueri Broom, 1926
Age. Middle Lopingian, Late Permian-middle Olenekian, Early Triassic (Smith *et al.* 2012).
Horizon/Locality. Top of *Daptocephalus* zone [= late *Cistecephalus* and *Dicynodon* Zones], or *Lystrosaurus* Zone, Beaufort Group, Karoo Supergroup—Kinira, Mount Frere District, Eastern Cape Province, South Africa (Broom 1926; Carroll 1975).

Holotype. MGM 3707 (observed).
Main bibliography. Broom (1926); Haughton (1929); Kuhn (1969); Carroll (1975); Carroll (1977); Estes (1983); Evans (1984); Carroll (1988); Carroll & Currie (1991).
Remarks. The identification of the squamosal and quadrate by Carroll (1975) are dubious, and thus considered to be only tentative. Additionally, the suture between the lacrimal and prefrontal is difficult to distinguish and could be merely a crack. Nevertheless, the shape of the postfrontal, postorbital and jugal are considered to be just as provided by Carroll (1975).

Paliguana whitei Broom, 1903
Age. Middle Lopingian, Late Permian-middle Olenekian, Early Triassic (Smith *et al.* 2012).
Horizon/Locality. *Daptocephalus* zone [= late *Cistecephalus* and *Dicynodon* Zones], or *Lystrosaurus* Zone, Beaufort Group, Karoo Supergroup —Donnybrook, KwaZulu-Natal Province, South Africa (Carroll 1975; Estes 1983).
Holotype. AM 3585 (observed).
Main bibliography. Broom (1903b); Nopcsa (1908); Broom (1925); Huene (1944b); Kuhn (1969); Carroll (1975); Carroll (1977); Estes (1983); Evans (1984); Benton (1985); Carroll (1988); Carroll & Currie (1991).
Remarks. The shape of the lacrimal is different from that suggested by Carroll (1975; 1977). The lacrimal is much deeper than in his reconstruction, and is limited anteriorly by the nasal process of the maxilla, as in nearly all other diapsid reptiles. Additionally, Carroll (1975) indicated the opening between the quadrate and the quadratojugal to be an artefact. However, the internal margins of the opening are smoothly rounded and do not indicate breakage. The shape of the entire structure is very similar to the condition see in *Sphenodon*, in which a large quadratojugal foramen separates the quadrate and the quadratojugal. Therefore, this opening is considered to be a quadratojugal foramen, as also indicated by Broom (1925). Nevertheless, there is no evidence for an anterior extension of the quadratojugal contacting the jugal, as proposed by Broom. The shape of the squamosal, postorbital, postfrontal and jugal are interpreted here in agreement with the description provided by Carroll (1975; 1977).

Saurosternon bainii Huxley, 1868
Age. Middle Wuchiapigian-latest Changhsingian, Lapingian, Late Permian (Smith *et al.* 2012)
Horizon/Locality. *Daptocephalus* zone [= late *Cistecephalus* and *Dicynodon* Zones], Beaufort Group, Karoo Supergroup—Krantz, Sneeuwberg, Eastern Cape Province, South Africa (Carroll 1975; Estes 1983).
Holotype. NHMUK R1234 (observed).
Observed referred materials. SAM-PK-919.
Main bibliography. Huxley (1868); Haughton (1929)**;** Kuhn (1969); Carroll (1975); Carroll (1977); Evans (1984); Benton (1985); Carroll (1988); Carroll & Currie (1991).

Pamelina polonica Evans, 2009
Age. Early late Olenekian, Early Triassic (Shishkin & Sulej 2009).
Horizon/Locality. Czatkowice 1 Quarry, Kraków Region, Poland (Evans 2009).

Holotype. ZPAL RV/1036 (observed).

Observed referred materials. ZPAL RV/142, ZPAL RV/143, ZPAL RV/144, ZPAL RV/149, ZPAL RV/151, ZPAL RV/153, ZPAL RV/154, ZPAL RV/155, ZPAL RV/ 384, ZPAL RV/537, ZPAL RV/555, ZPAL RV/975, ZPAL RV/977, ZPAL RV/978, ZPAL RV/979, ZPAL RV/1003, ZPAL RV/1004, ZPAL RV/1005, ZPAL RV/1008, ZPAL RV/1009, ZPAL RV/1011, ZPAL RV/1012, ZPAL RV/1029, ZPAL RV/1036, ZPAL RV/1046, ZPAL RV/1047, ZPAL RV/1048, ZPAL RV/1049 ZPAL RV/1050, 1066, ZPAL RV/1067, ZPAL RV/1073, ZPAL RV/1074, ZPAL RV/1077, ZPAL RV/1094, ZPAL RV/1097, ZPAL RV/1098, ZPAL RV/1202, ZPAL RV/1205, ZPAL RV/1206, ZPAL RV/1209, ZPAL RV/1210, ZPAL RV/1211, ZPAL RV/1212, ZPAL RV/1214.

Main bibliography. Evans (2009).

Remarks. The remains of this taxon are composed of isolated bones only. Upon personal observation, it could be detected that most of the skull elements fit into each other, thus demonstrating an anatomical connectivity between the referred specimens. The dental morphology also matches between the lower and upper jaws. However, the absence of anatomical connections between the preserved skull elements and the postcranium make the attribution of the postcranial material previously assigned to *P. polonica* only tentative. For this reason, we chose to be conservative and only include data from the skull remains of this taxon.

Sophineta cracoviensis Evans & Borsuk-Białynicka, 2009

Age. Early late Olenekian, Early Triassic (Shishkin & Sulej 2009).

Horizon/Locality. Czatkowice 1 Quarry, Kraków Region, Poland (Evans & Borsuk-Białynicka 2009).

Holotype. ZPAL RV/175 (observed).

Observed referred materials. ZPAL RV/10, ZPAL RV/13, ZPAL RV/226, ZPAL RV/227, ZPAL RV/228, ZPAL RV/232, ZPAL RV/233, ZPAL RV/234, ZPAL RV/431, ZPAL RV/236, ZPAL RV/246-247, ZPAL RV/248-249, ZPAL RV/506, ZPAL RV/746, ZPAL RV/747, ZPAL RV/748, ZPAL RV/749, ZPAL RV/974, ZPAL RV/1053, ZPAL RV/1054, ZPAL RV/1061, ZPAL RV/1089, ZPAL RV/1094, ZPAL RV/1101, ZPAL RV/1142, ZPAL RV/1145, ZPAL, ZPAL RV/1584, ZPAL RV/1121.

Main bibliography. Evans & Borsuk-Białynicka (2009).

Remarks. Remarks. The remains of this taxon are composed of isolated bones only. Upon personal observation, it could be detected that most of the skull elements fit into each other, thus demonstrating an anatomical connectivity between the referred specimens. The dental morphology also matches between the lower and upper jaws. However, the absence of anatomical connections between the preserved skull elements and the postcranium make the attribution of the postcranial material previously assigned to *S. cracoviensis* only tentative. For this reason, we chose to be conservative and only include data from the skull remains of this taxon.

Megachirella wachtleri Renesto & Posenato, 2003

Age. Pelsonian, Anisian, Middle Triassic (Renesto & Bernardi 2014).
Horizon/Locality. Dont Formation, Braies Group—Monte Prà della Vacca, Braies/Prags Dolomites, Bolzano, Italy (Renesto & Posenato 2003).
Holotype. bolza628 (observed).
Main bibliography. Renesto & Posenato (2003); Renesto & Bernardi (2014).

Kuehneosaurus latus Robinson, 1962
Age. Carnian-Rhaetian, Late Triassic (Fraser 1994; Evans & Jones 2010).
Horizon/Locality. Emborough, Cromhall and Pant quarries, southwest England and Wales, United Kindgom (Evans & Kermack 1994).
Holotype. NHMUK R8172 (observed).
Observed referred materials. NHMUK R5968- NHMUK R5985, NHMUK R5987-NHMUK R5994, NHMUK R5998, NHMUK R5999, NHMUK R6006-NHMUK R6037, NHMUK R6050, NHMUK R6059-NHMUK R6061, NHMUK R6063-NHMUK R6066, NHMUK R6068-NHMUK R6090, NHMUK R6092, NHMUK R6096-NHMUK R6098, NHMUK R6116-NHMUK R6124, NHMUK R6126-NHMUK R6215.
Main bibliography. Robinson (1962); Robinson (1967a); Robinson (1967b); Wild (1973); Estes (1983); Evans (1984); Benton (1985); Evans & Kermack (1994); Fraser (1994); Müller (2004); Stein *et al.* (2008); Evans & Jones (2010).

Icarosaurus siefkeri Colbert, 1966
Age. Tuvalian, Carnian, Late Triassic (Lucas 1998).
Horizon/Locality. Lockatong Formation, Newark Group [Conewagian assemblage, a correlate of the Adamanian assemblage from the Chinle Group (Lucas 1998)]—Granton Quarry, New Jersey, USA (Colbert 1966).
Holotype. AMNH 2101 (observed).
Main bibliography. Colbert (1966); Colbert (1970); Wild (1973); Estes (1983); Benton (1985); Fraser *et al.* (2007).

Marmoretta oxoniensis Evans, 1991
Age. Late Bathonian, Middle Jurassic to Kimmeridgian, Late Jurassic (Evans & Kermack 1994).
Horizon/Locality. Kirtlington Mammal Bed, near the base of Forest Mable Formation (late Bathonian)—Old Cement Works Quarry, Kirtlington, Oxfordshire, United Kingdom; Kilmaluag Formation (Bathonian)—north side of Glen Scaladel (Cladach a'Ghlinne), Isle of Skye, Scotland, United Kingdom; Guimarota lignite mine, Leira, Portugal (Kimmeridgian) (Evans 1991; Evans & Kermack 1994; Waldman & Evans 1994).
Holotype. NHMUK R.12020.
Paratypes. NHMUK R.12025, NHMUK R.12026, NHMUK R.12027, NHMUK R.12028.
Observed referred materials. NHMUK 12400-12406, NMS G 1992.47.1, NMS G 1992.47.4, NMS G 1992.47.5.

Main bibliography. Evans (1991); Evans & Milner (1994); Waldman & Evans (1994); Benton & Spencer (1995); Evans & Waldman (1996).
Remarks. Semi-articulated and associated cranial and postcranial remains of *Marmoretta* from the Bathonian of the Isle of Skye, Scotland, have been used as means of anatomical comparison and attribution of some isolated remains to this taxon.

Gephyrosaurus bridensis Evans, 1980
Age. Haettagian or Sinemurian, Lower Jurassic (Evans & Kermack 1994; Evans & Jones 2010).
Horizon/Locality. Pontalun and Pant quarries, and St. Bride's Island, South Glamorgan, Wales, United Kingdom (Evans 1980; Evans & Kermack 1994).
Holotype. NHMUK T.1503 (observed).
Observed referred materials. NHMUK T.722, NHMUK T.748, NHMUK T.752, NHMUK T.753, NHMUK T.755, NHMUK T.766, NHMUK T.769, NHMUK T.772, NHMUK T.782, NHMUK T.791, NHMUK T.856, NHMUK T.860, NHMUK T.865, NHMUK T.901, NHMUK T.907-910, NHMUK T.913-917, NHMUK T.937, NHMUK T.938, NHMUK T.940, NHMUK T.945-948, NHMUK T.950, NHMUK T.955-959, NHMUK T.1001, NHMUK T.1015, NHMUK T.1055, NHMUK T.1177, NHMUK T.1238-1264, NHMUK T.1428, NHMUK T.1450, NHMUK T.1454, NHMUK T.1481, NHMUK T.1509, NHMUK T.1512, NHMUK T.1515, NHMUK T.1522, NHMUK T.1528, NHMUK T.1543, NHMUK T.1553, NHMUK T.1554, NHMUK T.1618, NHMUK T.1633, NHMUK T.1693, NHMUK T.1751, NHMUK T.1814, NHMUK T.1815, NHMUK T.1818-1833, NHMUK T.1845, NHMUK T.1847, NHMUK T.1849, NHMUK T.1853, NHMUK T.1855, NHMUK T.1863-1866, NHMUK T.1874, NHMUK T.1875, NHMUK T.1880, NHMUK T.1881, NHMUK T.1942, NHMUK T.1951, NHMUK T.1993, NHMUK T.1994, NHMUK T.2044, NHMUK T.2046, NHMUK T.2047, NHMUK T.2054, NHMUK T.2055, NHMUK T.2065, NHMUK T.2066, NHMUK T.2070, NHMUK T.2086, NHMUK T.2093, NHMUK T.2098, NHMUK T.2111, NHMUK T.2135, NHMUK T.2143, NHMUK T.2154, NHMUK T.2175, NHMUK T.2196, NHMUK T.2216, NHMUK T.2225, NHMUK T.2227, NHMUK T.2231, NHMUK T.2301, NHMUK T.2311, NHMUK T.2313, NHMUK T.2319, NHMUK T.2320, NHMUK T.2323, NHMUK T.2325, NHMUK T.2335, NHMUK T.2336, NHMUK T.2337, NHMUK T.2346-2352, NHMUK T.2357-2361, NHMUK T.232, NHMUK T.2639-2642, NHMUK T.3017-3022, NHMUK T.3113-3117, NHMUK T.3223.
Main bibliography. Evans (1980); Evans (1981); Estes (1983); Evans (1984); Benton (1985); Evans (1985); Fraser & Benton (1989); Evans & Kermack (1994); Borsuk-Białynicka (1996); Wu (2003); Jones (2008); Evans & Jones (2010); Simões *et al.* (2016 [Suppl. Mat.]).
Remarks. Although no articulated specimens of *G. bridensis* are known, personal observation of the referred specimens indicates that most of the skull elements fit into each other, thus demonstrating an anatomical connectivity between the referred specimens. The dental morphology also matches between the lower and upper jaws. Furthermore, all cranial material studied herein from Pontalun and Pant quarries could be assigned to *G. bridensis*, and thus the associated postcranial material (Evans 1981) was also treated as part of this same taxon.

Diphyodontosaurus avonis Whiteside, 1986
Age. Carnian-Rhaetian, Late Triassic (Fraser 1994; Evans & Jones 2010).
Horizon/Locality. Tytherington and Cromhall quarries, South Gloucestershire, United Kingdom (Whiteside 1986).
Holotype. BU 23760 (observed).
Paratypes. BU 23763, BU 23764, BU 23842, BU 23787, BU 23789, BU 23785, BU 23781, BU 23790, BU 23780, BU 23782, BU 23783, BU 23784, BU 23772, 23776, BU 23768 BU 23774, BU 23986, BU 23778, BU 23777, BU 23761, BU 23762 (all observed).
Main bibliography. Whiteside (1986); Fraser & Benton (1989); Evans & Kermack (1994); Fraser (1994)**;** Borsuk-Białynicka (1996); Wu (2003); Jones (2008); Evans & Jones (2010); Simões *et al.* (2016 [Suppl. Mat.]).
Remarks. The remains of this taxon are composed of isolated bones only. Upon personal observation, it could be detected that most of the skull elements fit into each other, thus demonstrating an anatomical connectivity between the referred specimens. The dental morphology also matches between the lower and upper jaws. However, the absence of anatomical connections between the preserved skull elements and the postcranium make the attribution of the postcranial material previously assigned to *D. avonis* only tentative. For this reason, we chose to be conservative and only include data from the skull remains of this taxon.

Planocephalosaurus robinsonae Fraser, 1982
Age. Carnian-Rhaetian, Late Triassic (Fraser 1994; Evans & Jones 2010).
Horizon/Locality. Cromhall (old Slickstones) and Tytherington quarries, South Gloucestershire, United Kingdom (Fraser 1982; Evans & Kermack 1994).
Holotype. AUP 11061 (observed).
Observed referred materials AUP 11062-AUP 11081, AUP 11170-AUP 11185, NHMUK R9953-NHMUK R9976.
Main bibliography. Fraser (1982); Fraser & Walkden (1984); Fraser & Benton (1989); Evans & Kermack (1994); Fraser (1994)**;** Wu (2003); Jones (2008); Evans & Jones (2010); Simões *et al.* (2016 [Suppl. Mat.]).
Remarks. The remains of this taxon are composed of isolated bones only. Upon personal observation, it could be detected that most of the skull elements fit into each other, thus demonstrating an anatomical connectivity between the referred specimens. The dental morphology also matches between the lower and upper jaws. However, the absence of anatomical connections between the preserved skull elements and the postcranium make the attribution of the postcranial material previously assigned to *P. robinsonae* only tentative. For this reason, we chose to be conservative and only include data from the skull remains of this taxon.

Clevosaurus hudsoni (Swinton, 1939)
Age. Carnian-Rhaetian, Late Triassic (Fraser 1994; Evans & Jones 2010).

Horizon/Locality. Cromhall (old Slickstones) Quarry, South Gloucestershire, United Kingdom (Fraser 1988); same genus (possibly the same speies) from Tytherington, Emborough, and Pant quarries, southwest England and Wales, United Kingdom (Fraser 1988; Evans & Kermack 1994).
Holotype. NHMUK R5939 (syntypes).
Observed referred materials. NHMUK R604, NHMUK R605 (a,b,c), NHMUK R9249, UMZC T1264, UMZC T1265, UMZC T1266, UMZC T1267, UMZC T1268, UMZC T1269, UMZC T1270, UMZC T1271, UMCZ T 1272, UMCZ T 1273, UMCZ T 1274, UMCZ T 1275, UMCZ T 1276, UMCZ T 1277, UMCZ T 1279.
Main bibliography. Swinton (1939); Robinson (1973); Fraser (1988); Fraser & Benton (1989); Evans & Kermack (1994); Fraser (1994); Wu (2003); Jones (2008); Evans & Jones (2010); Simões *et al.* (2016 [Suppl. Mat.]).
Remarks. The articulated material that includes cranium and postcranium (UMZC T1271) as well as the articulated skulls (NHMUK R604, NHMUK R605, and UMZC T1269) was used as the main basis of comparison to establish which of the isolated bones can be confidentially associated to *Clevosaurus hudsoni*. See also comments for the Late Triassic-Early Jurassic British faunas in the taxonomic sampling criteria above.

Palaeopleurosaurus posidoniae Carroll, 1985b
Age. Toarcian, Early Jurassic (Carroll 1985b).
Horizon/Locality. Posidonienschiefer, Schwarzjura, Lias Epsilon II1and2—P. Kirchmann Quarry, in Staatswald Ohmden, near Holzmaden, Germany (Carroll 1985b).
Holotype. SMN 50722 (observed).
Paratype. SMN 50721.
Main bibliography. Carroll (1985b)**;** Carroll & Wild (1994); Dupret (2004)**;** Jones (2008); Evans & Jones (2010).

Homeosaurus maximiliani Meyer, 1847
Age. Latest Kimmeridgian-early Tithonian, Late Jurassic (Schweigert 2007).
Horizon/Locality. Solnhofen Plattenkalk—Kelheim and Wintershof, Bavaria, Germany [specimen identification labels and Cocude-Michel (1963)].
Holotype. lost in 1944 in Munich—see Cocude-Michel (1963).
Neotype: BSPG 1887 VI 502 (observed).
Observed referred materials. BSPG 1937-1-40.
Main bibliography. Meyer (1847); Wagner (1852); Meyer (1860); Meyer (1866); Boulenger (1891); Broili (1925); Barbour & Stetson (1929); Cocude-Michel (1963); Kuhn (1969).
Remarks. The genus *Homeosaurus* is in need of revision, therefore only the neotype of *H. maximiliani* and another specimen housed at the BSPG collection (BSPG 1937-1-40.) that could be attributed to the same species are included herein as *H. maximialiani*. The localities provided herein are the ones where the specimens referred above come from.

Kallimodon pulchellus Zittel, 1887

Age. Latest Kimmeridgian-early Tithonian, Late Jurassic (Schweigert 2007).
Horizon/Locality. Solnhofen Plattenkalk—Kelheim and Kupferberg, Bavaria, Germany [specimen identification labels and Cocude-Michel (1963)].
Holotype. BSPG 1887 VI 1 (observed).
Observed referred materials. MB.R. 1008.1 (previously Berlin Rhy 2), MB.R. 1009.1-2 (previously Berlin Rhy 3), BSPG 1887 VI 2, BSPG 1922 I 15.
Main bibliography. Zittel (1887); Broili (1925); Cocude-Michel (1959); Cocude-Michel (1963); Kuhn (1969); Fabre *et al.* (1982); Fraser & Benton (1989).
Remarks. As with *Homeosaurus*, the genus *Kallimodon* also needs revision as numerous specimens attributed to *K. pulchellus* display significant differences to the holotype, mostly based on the postcranium morphology. Additionally, specimens labeled as belonging to other taxa show no significant differences to the holotype of *K. pulchellus.* Only studied specimens that show no observable differences to the holotype are included herein as *K. pulchellus*, but a revision and re-characterization of the genus might reveal additional specimens of *K. pulchellus* that were not studied herein. The localities provided herein are the ones where the specimens referred above come from.

Priosphenodon avelasi Apesteguia & Novas, 2003
Age. Cenomanian-Turonian, Late Cretaceous (Apesteguia & Novas 2003).
Horizon/Locality. Candeleros Formation, Neuquén Group—La Buitreta Quarry, Río Negro Province, Argentina (Leanza & Hugo 2001; Apesteguia & Novas 2003).
Holotype. MPCA 300 (observed).
Observed referred materials. MPCA 275, MPCA 293, MPCA 303, MPCA 304, MPCA 305, MPCA 316, MPCA 374.
Main bibliography. Apesteguia & Novas (2003); Simón & Kellner (2003); Jones (2008); Evans & Jones (2010); Apesteguia & Carballido (2014).
Remarks. *P. avelasi* and *Kaikaifilusaurus calvoi* are synonynoum taxa considering the published accounts on both taxa. Although *K. calvoi* has priority due to an earlier publication, this taxon has been considered as a nomen dubium by Apesteguia & Carballido (2014). For an account in the taxonomic dispute between *Kaikaifilusaurus calvoi* and *Priosphenodon avelasi*, see Apesteguia & Carballido (2014).

Eichstaettisaurus schroederi (Broili, 1938)
Age. Latest Kimmeridgian-early Tithonian, Late Jurassic (Schweigert 2007).
Horizon/Locality. Solnhofen Plattenkalk— Wintershof (near Eichstätt), Bavaria, Germany (Broili 1938).
Holotype. BSPG 1937 I 1 (observed).
Main bibliography. Broili (1938); Young (1948); Hoffstetter (1953); Kuhn (1958); Cocude-Michel (1961); Cocude-Michel (1963); Hoffstetter (1964); Hoffstetter (1966); Estes (1983); Evans (1993); Rieppel (1994a); Evans *et al.* (2000); Evans *et al.* (2004); Daza *et al.* (2014); Simões *et al.* (2017a).

Remarks. For a detailed recent account on the taxonomy, systematics, and re-assessment of the osteology of *E. schroederi* see Simões *et al.* (2017a).

Ardeosaurus brevipes (Meyer, 1855)
Age. Latest Kimmeridgian-early Tithonian, Late Jurassic (Schweigert 2007).
Horizon/Locality. Solnhofen Plattenkalk—Eichstätt, Bavaria, Germany (Mateer 1982).
Holotype. Collection Hetzell, now lost (Mateer 1982; Estes 1983). Cast of holotype: NHMUK 38006 (observed).
Observed referred materials. BSPG 1923. I. 501.
Main bibliography. Meyer (1855); Meyer (1860); Zittel (1887); Nopcsa (1908); Camp (1923); Broili (1925); Hoffstetter (1953); Hoffstetter (1955b); Cocude-Michel (1963); Hoffstetter (1964); Hoffstetter (1966); Estes (1983); Evans (1993); Rieppel (1994a); Simões *et al.* (2017a)
Remarks. After the loss of the holotype of *A. brevipes*, a new specimen (PMU.R58) was discovered an described by Mateer (1982). However, PMU.R58 is currently lost as well (B. Kear, personal communication). Another specimen, previously assigned as *Ardeosaurus* cf. *digitatellus* (BSPG 1923. I. 501), displays several features that allow its assignment to *A. brevipes*. These include: impressions of skull roof osteoderms, a wider posterior margin of the parietals between the supratemporal processes (compared to the holotype of *A. digitatellus*), separate postorbital and posfrontal, and only three phalanges on the fifth pedal digit. Although preserved mostly as impressions, the level of detail preserved in the soft matrix allows the identification of individual bones and sutures, which highly contribute to increase the amount of information to be scored for this taxon in the present dataset.

Paramacellodus oweni Hoffstetter, 1967
Age. Bathonian, Middle Jurassic (?); Berriasian, Early Cretaceous (Evans 2003).
Horizon/Locality. Purbeck Limestone Formation (Berriasian)—Durdlestone Bay, Swanage, Isle of Purbeck, Dorset, United Kingdom; possibly from Kilmaluag Formation (Bathonian)—north side of Glen Scaladel (Cladach a'Ghlinne), Isle of Skye, Scotland, United Kingdom (Hoffstetter 1967; Estes 1983).
Holotype. NHMUK R8131-8132 (observed).
Observed referred materials. NHMUK R8082, NHMUK R8085, NHMUK R8104, NHMUK R8115, NHMUK R8117a, NHMUK R8118, NHMUK R8130, NHMUK R8208, NHMUK R8209, NHMUK R8210.
Main bibliography. Hoffstetter (1967); Estes (1983); Waldman & Evans (1994); Rieppel (1994a); Evans & Chure (1998); Evans & Searle (2002).

Huehuecuetzpalli mixtecus Reynoso, 1998
Age. Late Albian, Early Cretaceous (Benammi *et al.* 2006).
Horizon/Locality. Middle portion of the Tlayúa Formation—south of Tepexi de Rodríguez, State of Puebla, Mexico (Reynoso & Cruz 2014).
Holotype. IGM 7389 (observed).
Paratype. IGM 4185**.**

Main bibliography. Reynoso (1998); Reynoso & Cruz (2014).
Remarks. Personal observation of the holotype and paratype indicate a few differences to the description provided by Reynoso (1998). Among these, vertebrae on the pelvic region of the holotype are somewhat disarticulated and the anteriormost portion of their neural arches exposed with no clear indication of a zygosphene-zygantra system. On the skull, the left side of the parietal includes an elongate supratemporal process contacting the left squamosal, which is slightly displaced anteriorly. Between the squamosal and the supratemporal process of the parietal, a third distinct element is present, sutured to the parietal and elongate in shape. This corresponds to the supratemporal, which also occupies this same position and has this same overall shape in most squamates bearing those three elements. The supratemporal is less distinct on right side of the skull, but under UV light a partial suture is observed between it and the parietal. This suggests a partial fusion of the right element took place. Additionally, the presence of dorsal intercentra could not be confirmed. The holotype is preserved in dorsal view, preventing an assessment of the later condition, whereas the paratype shows the posterior dorsals in lateral view. Reynoso (1998) mentioned the presence of intercentra in the last presacrals (an inference that might have been made based on the paratype), but no clear structures between the dorsal centra could be established as intercentra. Therefore, this particular feature is treated herein as missing data.

Tepexisaurus tepexii Reynoso & Callison, 2000
Age. Late Albian, Early Cretaceous (Benammi *et al.* 2006).
Horizon/Locality. Middle portion of the Tlayúa Formation—south of Tepexi de Rodríguez, State of Puebla, Mexico (Reynoso & Cruz 2014).
Holotype. IGM 7466 (observed).
Main bibliography. Reynoso & Callison (2000); Reynoso & Cruz (2014).

Priscagama gobiensis Borsuk-Białynicka & Moody, 1984
Age. Campanian-earliest Maastrichtian (Jerzykiewicz *et al.* 1993; Dashzeveg *et al.* 2005; Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot (Khermeen Tsav and Khulsan) and Djadochta Formation (Bayn Dzak and Ukhaa Tolgod), Nemegt Basin—Gobi Desert, Mongolia; Djadokhta Formation, Nemegt Basin—Bayan Mandahu redbeds, Inner Mongolia, China (Gao & Norell 2000).
Holotype. ZPAL MgR/III-32 (observed).
Observed referred materials. ZPAL MgR/III-31, ZPAL MgR/III-72, ZPAL MgR/III-33, ZPAL MgR/III-83, ZPAL MgR/lI-77, ZPAL MgR/II-101, IVPP V 10038.
Main bibliography. Borsuk-Białynicka & Moody (1984); Alifanov (1989); Rieppel (1994a); Dashzeveg *et al.* (1995); Alifanov (1996); Borsuk-Białynicka (1996); Gao & Hou (1996); Alifanov (2000a); Gao & Norell (2000); Conrad & Norell (2007); Wang & Li (2008).
Remarks. The age of the Djadokhta Formation is usually restricted to the latest Campanian-early Maastrichtian (between 75 and 71 MYA) such as inferred from more recent datings for the Bayn Dzak Member (Dashzeveg *et al.* 2005). The age of the overlying Tugrugeen Shireh (or Tugrugyin Shireh) is therefore supposed to be earliest Maastrichtian. However, a more precise dating for other localities is lacking, and these are often referred to only as Campanian, such a

Ukhaa Tolgod and the Bayan Mandahu redbeds in Inner Mongolia (China) (Eberth 1993; Jerzykiewicz *et al.* 1993; Dingus *et al.* 2008). Therefore, *Priscagama* and other taxa that occur in Bayn Dzak and Tugrugeen Shireh certainly occur in the late Campanian and earliest Maastrichtian. However, when such taxa also occur in other localities (e.g. Barun Goyot) then their stratigraphic range may be higher, and thus a less restrictive age range is provided herein (e.g. Campanian or Campanian-earliest Maastrichtian).

Pleurodontagama aenigmatoides Borsuk-Białynicka & Moody, 1984
Age. Campanian (Jerzykiewicz *et al.* 1993; Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot (Khermeen Tsav) Formation—Gobi Desert, Mongolia; Djadokhta Formation, Nemegt Basin—Bayan Mandahu redbeds, Inner Mongolia, China (Borsuk-Białynicka 1996).
Holotype. ZPAL MgR-III/35 (observed).
Main bibliography. Borsuk-Białynicka & Moody (1984); Rieppel (1994a); Alifanov (1996); Borsuk-Białynicka (1996); Gao & Hou (1996); Gao & Norell (2000); Wang & Li (2008).

Igua minuta Borsuk-Białynicka & Alifanov, 1991
Age. Campanian, Late Cretaceous (Jerzykiewicz *et al.* 1993; Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot Formation (Khulsan)—Gobi Desert, Mongolia (Gao & Norell 2000).
Holotype. ZPAL MgR-I/60 (observed).
Main bibliography. Borsuk-Białynicka & Alifanov (1991).
Remarks. The holotype constitutes a juvenile [already noticed by Borsuk-Białynicka & Alifanov (1991)], lacking fusion between the exoccipitals and opisthotics (and among any other braincase elements), and bearing a squared parietal with an enlarged parietal foramen, forming a parietal fontanelle. A squared parietal in many lizards, including iguanians such as *Stenocercus* and *Iguana*, is common among juveniles (Barahona & Barbadillo 1998; Bell *et al.* 2003; Torres-Carvajal 2003; Simões *et al.* 2016). Additionally, a parietal fontanelle is observed in the early development of the pineal foramen (Torres-Carvajal 2003). For those reasons, the juvenile condition of the holotype of *Igua minuta* is confirmed herein. Therefore, characters prone to ontogenetic variation in squamates are treated as uninformative herein (with "?") herein. This is the case of characters related to the parietal table shape and ornamentation, and fusion of braincase elements.

Polrussia mongoliensis Borsuk-Białynicka & Alifanov, 1991
Age. Campanian, Late Cretaceous (Jerzykiewicz *et al.* 1993; Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot Formation (Khulsan)—Gobi Desert, Mongolia (Gao & Norell 2000).
Holotype. ZPAL MgR-I/119 (observed).

Main bibliography. Borsuk-Białynicka & Alifanov (1991); Alifanov (2000a); Gao & Norell (2000).
Remarks. Gao & Norell (2000) stated the squared shape of the parietal in *Polrussia* as a feature that the latter has in common with *Igua minuta*. However, as noted above, this particular feature is a result of ontogeny in *Igua*, and possibly also the case of the two known specimens of *Polrussia*. Although the dentition of *Polrussia* has been described as unicuspid, most tooth apices are broken or not observable. On the right maxilla, although some teeth seem unicuspid, the fourth (front to back) tooth in situ has incicipient mesiodistally places cusps. It is possible that *Polrussia* has at least some unicuspid teeth, but the state of preservation combined with potential tooth wear creates an apparent unicuspidity in the holotype. The second reported specimen of *Polrussia* [IGM3/73—Gao & Norell (2000)] has been reported to bear unicuspid teeth, but given some differences between it and the holotype (e.g. presence of pterygoid teeth, which are absent in the holotype) it may actually not belong to *Polrussia*.

Gilmoreteius chulsanensis (Sulimski, 1975)
Age. Campanian, Late Cretaceous (Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot Formation (Khulsan and Monadnocks), Nemegt Basin—Gobi Desert, Mongolia (Gao & Norell 2000).
Holotype. ZPAL MgR-I/14 (observed).
Observed referred materials. ZPAL MgR-I/18, ZPAL MgR-I/20, ZPAL MgR-I/21, ZPAL MgR-I/22, ZPAL MgR-I/23, ZPAL MgR-I/24, ZPAL MgR-I/5.
Main bibliography. Gilmore (1943); Sulimski (1975); Langer (1998); Alifanov (2000b); Gao & Norell (2000).

Gobinatus arenosus Alifanov, 1993
Age. Campanian, Late Cretaceous (Jerzykiewicz *et al.* 1993; Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot (Khermeen Tsav and Khulsan) and Djadokhta Formation (Ukhaa Tolgod)—Gobi Desert, Mongolia (Gao & Norell 2000).
Holotype. PIN No. 3142/308.
Observed referred materials. ZPAL MgR-I/77, ZPAL MgR-II/1 (duplicated No), ZPAL MgR-II/8, ZPAL MgR-II/56, ZPAL MgR-III/44.
Main bibliography. Alifanov (1993a); Alifanov (2000b); Gao & Norell (2000).

Gobekko cretacicus Borsuk-Białynicka, 1990
Age. Late Campanian-earliest Maastrichtian, Late Cretaceous (Dashzeveg *et al.* 2005).
Horizon/Locality. Djadokhta Formation (Bayn Dzak), Nemegt Basin—Gobi Desert, Mongolia (Borsuk-Białynicka 1990).
Holotype. ZPAL MgR-II/4 (observed).
Observed referred materials. ZPAL MgR-II/43, ZPAL MgR-II/47.

Main bibliography. Borsuk-Białynicka (1990); Conrad & Norell (2006); Daza *et al.* (2013); Daza *et al.* (2014); Conrad & Daza (2015).

Meyasaurus diazromerali Evans & Barbadillo, 1997
Age. Barremian, Early Cretaceous (Buscalioni & Fregenal-Martínez 2010).
Horizon/Locality. La Huérguina Limestone Formation—Las Hoyas fossil site, Serranía de Cuenca, Cuenca Province, Castilla-La Mancha, Spain (Evans & Barbadillo 1997).
Holotype. LH 370 (observed).
Observed referred materials. LH 33, LH 372, LH 13510, LH 6026, LH 143175.
Main bibliography. Evans & Barbadillo (1997); Bolet & Evans (2010); Bolet & Evans (2012); Venczel & Codrea (2016).

Globaura venusta Borsuk-Białynicka, 1988
Age. Campanian-earliest Maastrichtian, Late Cretaceous (Dashzeveg *et al.* 2005; Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot (Khermeen Tsav and Khulsan) and Djadochta Formation (Bayn Dzak and Ukhaa Tolgod), Nemegt Basin—Gobi Desert, Mongolia (Gao & Norell 2000).
Holotype. ZPAL MgR-III/40 (observed).
Observed referred materials. ZPAL MgR-I/45, ZPAL MgR-I/46, ZPAL MgR-I/47, ZPAL MgR-I/48, ZPAL MgR-I/49, ZPAL MgR-I/50, ZPAL MgR-I/51, ZPAL MgR-I/53, ZPAL MgR-I/71, ZPAL MgR-I/118, ZPAL MgR-II/26, ZPAL MgR-II/42, ZPAL MgR-II/53, ZPAL MgR-II/55, ZPAL MgR-III/36, ZPAL MgR-III/41, ZPAL MgR-III/43.
Main bibliography. Borsuk-Białynicka (1988); Alifanov (2000a); Gao & Norell (2000).

Slavoia darevskii Sulimski, 1984
Age. Campanian, Late Cretaceous (Dashzeveg *et al.* 2005; Dingus *et al.* 2008).
Horizon/Locality. Barun Goyot (Khermeen Tsav and Khulsan) and Djadochta Formation (Ukhaa Tolgod), Nemegt Basin—Gobi Desert, Mongolia (Gao & Norell 2000).
Holotype. ZPAL MgR-I/8 (observed).
Observed referred materials. ZPAL MgR-I/2, ZPAL MgR-I/9, ZPAL MgR-I/77, ZPAL MgR-I/85, ZPAL MgR-I/93, ZPAL MgR-I/94, ZPAL MgR-I/95, ZPAL MgR-I/96, ZPAL MgR-I/97, ZPAL MgR-I/98, ZPAL MgR-I/99, ZPAL MgR-I/100, ZPAL MgR-I/101, ZPAL MgR-I/102, ZPAL MgR-I/103, ZPAL MgR-I/104, ZPAL MgR-I/105, ZPAL MgR-I/106, ZPAL MgR-I/107, ZPAL MgR-I/108, ZPAL MgR-I/112, ZPAL MgR-III/76, ZPAL MgR-III/81.
Main bibliography. Sulimski (1984); Rieppel (1994a); Alifanov (2000a); Gao & Norell (2000); Tałanda (2016); Tałanda (2017).
Remarks. The genus *Slavoia* has been suggested to occur in the Late Cretaceous of Kazakhstan (Kordikova *et al.* 2001), but the referred material has been recently re-assigned as Scincomorpha indet. (Averianov *et al.* 2016). Alifanov (1993b) and Alifanov (2000a) also lists *Slavoia* in the

Early Cretaceous, but does not provide further details on this potential occurrence. Therefore, the stratigraphic distribution of the genus is here restricted to the Late Cretaceous.

Dalinghosaurus longidigitus Ji, 1998
Age. Earliest Hautuverian-Barremian/Aptian, Early Cretaceous (Sha 2007).
Horizon/Locality. Lujiatun, Jianshangou and Dawangzhangzi beds, Yixian Formation, Jehol Group—Beipiao and Lingyuan, Liaoning Province, China (Evans & Wang 2005; Wang & Li 2008).
Holotype. GMV2127.
Observed referred materials. IVPP V12345 A&B, IVPP V12586, IVPP V13282, IVPP V14342.
Main bibliography. Ji (1998); Ji (2004); Ji & Ji (2004); Evans & Wang (2005); Evans & Wang (2007); Evans *et al.* (2007); Wang *et al.* (2010).

Dinilysia patagonica Woodward, 1901
Age. Santonian to early/middle Campanian, Late Cretaceous (Leanza & Hugo 2001; Scanferla & Canale 2007; Filippi & Garrido 2012).
Horizon/Locality. Bajo de la Carpa Formation, Rio Colorado Subgroup, Neuquén Group—City of Neuquén, Boca del Sapo, Aca Mahuida, Barreales Norte and Tripailao Farm localities (Neuquén Province), Paso Córdova (Rio Negro Province), Argentina; Anacleto Formation, Rio Colorado Subgroup, Neuquén Group— Aguada Toledo, south of Mari Menuco Lake and Puesto La Rinconada (Neuquén Province), Argentina (Caldwell & Albino 2002; Scanferla & Canale 2007; Filippi & Garrido 2012; Triviño & Albino 2015).
Holotype. MLP 26-410 (observed).
Observed referred materials. MACN-N 26, MACN-N 27, MACN-N 115, MACN-RN 976, MACN-RN 1013, MACN-RN 1014, MACN-RN 1015, MACN-RN 1016, MACN-RN 1017, MLP 79-11-27-2, MLP 79-11-27-8.
Main bibliography. Woodward (1901); Estes *et al.* (1970); Frazzetta (1970); Rage (1977); Hecht (1982); Rage & Albino (1989); Caldwell & Albino (2001); Caldwell & Albino (2002); Albino & Caldwell (2003); Budney *et al.* (2006); Caldwell & Calvo (2008); Filippi & Garrido (2012); Zaher & Scanferla (2012); Palci & Caldwell (2014); Scanferla & Bhullar (2014); Triviño & Albino (2015).

Najash rionegrina Apesteguía & Zaher, 2006
Age. Cenomanian-Turonian, Late Cretaceous (Corbella *et al.* 2004; Zaher *et al.* 2009).
Horizon/Locality. mid to upper levels of the Candeleros Formation, Neuquén Group—La Buitrera Quarry, Río Negro, Argentina (Apesteguía & Zaher 2006; Zaher *et al.* 2009).
Holotype. MPCA 390-398, 400 (observed).
Observed referred materials. MPCA 380, MPCA 381, MPCA 382, MPCA 383, MPCA 385, MPCA 386, MPCA 388, MPCA 417, MPCA 418, MPCA 419, MPCA 480, MPCA 500.
Main bibliography. Apesteguía & Zaher (2006); Zaher *et al.* (2009); Palci *et al.* (2013a).

Remarks. Due to the possible presence of more than one taxa among the type specimens of *Najash rionegrina* [Palci *et al.* (2013a), TRS personal observations] only the specimens from the holotype were utilized herein for the scorings of *Najash*. The latter includes the holotype lower jaw, which was found in close association to the postcranial elements of the holotype (F. Garberoglio, personal communication).

Pachyrhachis problematicus Haas, 1979
Age. lower Cenomanian, Late Cretaceous (Lee & Caldwell 1998).
Horizon/Locality. Bed-Meir Formation—Ein Jabrud, near Ramallah, Israel (Caldwell & Lee 1997; Lee & Caldwell 1998).
Holotype. HUJ-PAL 3659 (observed).
Observed referred materials. HUJ-PAL 3775.
Main bibliography. Haas (1979); Caldwell & Lee (1997); Lee & Caldwell (1998); Zaher (1998); Scanlon *et al.* (1999); Zaher & Rieppel (1999); Caldwell (2000); Coates & Ruta (2000); Rieppel & Zaher (2000); Caldwell & Albino (2001); Rieppel & Zaher (2001); Zaher & Rieppel (2002); Rage & Escuillié (2003); Polcyn *et al.* (2005); Palci & Caldwell (2013); Palci *et al.* (2013b).

Spathorhynchus fossorium Berman, 1973
Age. Early to Middle Eocene, Paleogene (Berman 1977).
Horizon/Locality. Bridger and Wind River formations—Sweetwater County, Wyoming, USA (Berman 1973; 1977).
Holotype. NMNH 26317.
Paratype. NMNH26318.
Observed referred materials. AMNH 25556.
Main bibliography. Berman (1973); Berman (1977); Müller *et al.* (2016).

Aigialosaurus Kramberger, 1892
Age. Late Cenomanian-Early Turonian, Late Cretaceous (Gušić & Jelaska 1993).
Horizon/Locality. Island of Hvar, Croatia (Caldwell & Dutchak 2006).
Holotype. BSPG 1902II501 (observed).
Main bibliography. Kramberger (1892); Williston (1904); Nopcsa (1903); Nopcsa (1908); Carroll (1985a); Carroll & de Braga (1992); de Braga & Carroll (1993); Dutchak (2005); Caldwell & Dutchak (2006).

Adriosaurus suessi Seeley, 1881
Age. late Cenomanian- late Turonian, Late Cretaceous (Gušić & Jelaska 1993; Lee & Caldwell 2000).
Horizon/Locality. Komen Platey Limestone—Near Komen, Slovenia; Island of Hvar, Croatia (Lee & Caldwell 2000).
Holotype. NHMW unnumbered.

Observed referred materials. NHMUK R2867.
Main bibliography. Seeley (1881); Nopcsa (1908); Nopcsa (1923a); Lee & Caldwell (2000).

Pontosaurus Kramberger, 1892
Age. Early-middle Cenomanian (*P. kornhuberi*) to Late Cenomanian-Early Turonian (*P. lesinensis*), Late Cretaceous (Gušić & Jelaska 1993; Dal Sasso & Pinna 1997).
Horizon/Locality. Quarry in the Valley of Al Gabour near Al Nammoura, 10 km southeast of Hadjula, Lebanon (Caldwell 2006); Island of Hvar, Croatia.
Holotype. MSNM V3662 (observed).
Main bibliography. Kornhuber (1873); Kramberger (1892); Caldwell & Sasso (2004); Pierce & Caldwell (2004); Caldwell (2006).

Extant taxa

Rhynchocephalia

Sphenodon punctatus: MCZ R4702, FMNH 11113, FMNH 197942, FMNH 207433.

Squamata

Iguania

Trioceros jacksonii*:** AMNH R-84559, AMNH R-99984, AMNH R-141099, FMNH 206753, ***Uromastyx aegyptia*:** AMNH R-73160, FMNH 63961, FMNH 31030, ***Hoplocercus spinosus*:** AMNH R-89398, AMNH R-90384, AMNH R-90658, ***Iguana iguana*:** AMNH R-43302, AMNH R-81871, AMNH R-82125, ***Polychrus marmoratus*:** AMNH R-141084, AMNH R-148543, AMNH R-148544, AMNH R-141130, ***Pristidactylus scapulatus*:** AMNH R-148535, AMNH R-148534, AMNH R-148536, ***Crotaphytus collaris*:** AMNH R-75090, AMNH R-82297, AMNH R-84489, AMNH R-85381, ***Liolaemus signifer: AMNH R-80140, AMNH R-81801, AMNH R-80139, AMNH R-154846, ***Leiocephalus carinatus*:** AMNH R-70575, AMNH R-59988, AMNH R-57461, ***Oplurus cyclurus*:** FMNH 75620, FMNH 72640, ***Stenocercus scapularis*:** FMNH 40612, ***Phrynosoma modestum*:** TMP1997.030.0318, TMP1997.030.0321, TMP1997.030.0324, TMP1990.007.0161.

Gekkota
Coleonyx variegatus*:** AMNH R-74613, AMNH R-89271, AMNH R-73763, AMNH R-73762, ***Dactylocnemis pacificus: MCZ R-141790, MCZ R-141791, MCZ R-141793, MCZ R-141794, MCZ R-141796, ***Gecko gekko***: TMP 1990.007.0021, 1997.030.0333, TMP 1997.030.0327.

“Scincomorpha”

Xantusia vigilis*:** AMNH R-150167, AMNH R-150164, R-150165, FMNH 22329; ***Cordylus niger*:** AMNH R-81809, AMNH R-82396, AMNH R-81885, ***Broadleysaurus major*:** AMNH R-173621, MCZ R-147438, ***Timon lepidus*:** FMNH 22267, FMNH 22098, FMNH 229612, ***Lacerta viridis: UAMZ uncatalogued; ***Plestiodon fasciatus*:** AMNH R-92742, AMNH R-155177, AMNH R-155179, AMNH R-155181, ***Mabuya mabouya*:** AMNH R-141128, ***Teius teyou*:** FMNH 170853, FMNH 10407**;** ***Petracola ventrimaculatus*:** CJB 571.

Anguimorpha
***Xenosaurus grandis*:** AMNH R-103212, AMNH R-98122, AMNH R-91487, AMNH R-19380, FMNH 117105, ***Elgaria multicarinata*:** AMNH R-154694, AMNH R-154693, AMNH R-154692, ***Pseudopus apodus*:** AMNH R-57958, AMNH R-75481, AMNH R-73228, ***Heloderma suspectum*:** AMNH R-72646, AMNH R-71864, AMNH R-73771, ***Lanthanotus borneensis*:** FMNH 134771, FMNH 130981, ***Varanus salvator*:** TMP 1990.007.0036, TMP 1990.007.0037, TMP 1990.007.0270.

Amphisbaenia
***Rhineura floridana*:** AMNH R-92989, AMNH R-147916, FMNH 263913, ***Bipes biporus*:** AMNH R-92758, AMNH R-154703, FMNH 266420, ***Blanus cinereus*:** AMNH 95942, FMNH 265151.

Serpentes
Anilius scytale: MCZ R-19537, MCZ R-17645, MCZ R-2984, ***Xenopeltis unicolor*:** MCZ-R5483, MCZ-R188759, MCZ-R188760, MCZ-R3114, FMNH 287277, ***Cylindrophis ruffus*** FMNH 297456.

Dibamidae
***Dibamus novaeguineae*:** NMNH 305914; NMNH 305916.

Institutional abbreviations:

AM – Grahamstown, South Africa.
AMNH – American Museum of Natural History, New York-NY, USA.
AUP – University of Aberdeen Paleontology collection.
BPI – Evolutionary Studies (former Bernard Price) Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg.
BSPG - Bayerische Staatssammlung für Paläontologie und historische Geologie, Munich, Germany.
BU – University of Bristol, Bristol, UK.
CJB – Chris J. Bell personal collection.
CM – Carnegie Museum of Natural History, Pittsburgh, PA, USA.
FMNH – Field Museum of Natural History, Chicago, IL, USA.
GMPKU - Geological Museum of Peking University, Beijing, China.

GMV - Geological Museum of China, Beijing, China.
HUJ-PAL - Hebrew University of Jerusalem, Palaeontology Collections, Jerusalem, Israel.
IGM - Instituto de Geología, Universidad Nacional Autónoma de México.
IVPP – Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China.
KUVP – Museum of Natural History, University of Kansas, Lawrence, KA, USA.
LH - Museo de Cuenca (Las Hoyas material), Cuenca, Spain.
MACN - Museo Argentino de Ccurators iencias Naturales "Bernardino Rivadavia," Buenos Aires, Argentina.
MB – Museum fur Naturkunde, Berlin, Germany.
MBSN – Museo Brembano di Scienzi Naturali, San Pelegrino, Bergamo, Italy.
MCZ – Museum of Comparative Zoology, Harvard University, Cambridge, MA, USA.
MFSN – Museo Friulano di Storia Naturale, Udine, Italy.
MGM - McGregor Museum, Kimberely, South Africa.
MLP – Museu de La Plata, La Plata, Argentina.
MNHN – Muséum National d'Histoire Naturelle, Paris, France.
MPCA - Museo Carlos Ameghino, Cipolletti, Río Negro Province, Argentina.
MSNM – Museo Civico di Storia Naturale di Milano, Milano, Italy.
NHMUK – Natural History Museum, London, UK.
NHMW – Naturhistorisches Museum Wien.
NMNH – National Museum of Natural History, Washington, D.C., USA.
NMOK - Naturkundemuseum im Ottoneum Kassel, Kassel, Germany.
NMQR – National Museum, Bloemfontein, South Africa.
NMS – National Museum of Scotland, Edinburgh, United Kingdom.
NSM - National Science Museum, Tokyo, Japan.
PIN - Paleontological Institute, Academia Nauk, Moscow, Russia.
PIMUZ - Paläontologisches Institut und Museum der Universität Zürich, Switzerland.
PKU – Peking University, Beijing, China.
PMU – Paleontological Museum, Uppsala.
PZO – Museo Archeologico dell'Alto Adige, Bolzano (Bozen), Italy.
SAM – South Africa Museum (Iziko Museums), Cape Town, South Africa.
SMF - Senckenberg Museum, Frankfurt, Germany.
SMNS – Staatliches Museum fur Naturkunde, Stuttgart, Germany.
SSWG - Sektion Geologie, Ernst-Moritz-Arndt Universitat, Greifswald, Germany.
TM – Ditsong (former Transvaal) Museum, Pretoria, South Africa.
TMM – Texas Memorial Museum, Austin, Texas, USA.
TMP – Royal Tyrrell Museum, Drumheller, Alberta, Canada.
UALVP – University of Alberta Laboratory for Vertebrate Paleontology (Department of Biological Sciences), Edmonton, Canada.
UAMZ – University of Alberta Museum of Zoology, Edmonton, Alberta, Canada.
UFRGS – Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.
UHR - Hokkaido University, Sapporo, Japan.
UMO BT – Urwelt-Museum Oberfranken, Bayreuth, Germany.
UMZC –Cambridge University Museum of Zoology, Cambridge, UK.
WMsN – Westfalisches Museum fur Naturkunde, Munster, Germany.

YPM – Yale Peabody Museum, Yale University, New Haven, CO, USA.
ZPAL - Institute of Paleobiology Polish Academy of Sciences, Warsaw, Poland.

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Characters list

Character references indicate the first usage of such characters in any of the data matrices compiled by us. They do not refer to when the character was first mentioned in the literature, only to its actual first usage for a cladistic purpose.

AN03 (Apesteguia & Novas 2003); B85 (Benton 1985); C99 (Caldwell 1999); Ch14 (Chen *et al.* 2014); CoN06 (Conrad & Norell 2006); Co08 (Conrad 2008); D98 (Dilkes 1998); DBC93 (de Braga & Carroll 1993); DBR96 (de Braga & Reisz 1996); DBR97 (de Braga & Rieppel 1997); E88 (Estes *et al.* 1988); Ev88 (Evans 1988); Ev90 (Evans 1990); G88a (Gauthier *et al.* 1988a); G88b (Gauthier *et al.* 1988b); G12 (Gauthier *et al.* 2012); GN98 (Gao & Norell 1998); GS96 (Gower & Sennikov 1996); J94 (Juul 1994); K03 (Kearney 2003); LC00 (Lee & Caldwell 2000); LS02 (Lee & Scanlon 2002); Lee 93 (Lee 1993); Lee97 (Lee 1997b); Lee98 (Lee 1998); Lee01 (Lee 2001); Lo12 (Longrich *et al.* 2012); LR95 (Laurin & Reisz 1995); Ly13 (Lyson *et al.* 2013a); M80 (Moody 1980); Mo99 (Motani 1999b); MS04 (Modesto & Sues 2004); N11 (Nesbitt 2011); P86 (Pregill *et al.* 1986); PR88 (Presch 1988); R94 (Rieppel 1994b); R99 (Rieppel *et al.* 1999); RZ00 (Rieppel & Zaher 2000); RD03 (Reisz & Dilkes 2003); S09 (Smith 2009).

Cranium

Premaxillae

1. Premaxillae, fusion: unfused (0)/ fused (1) (B85, Ch. Y1).

2. Premaxillae, nasal process: present (0)/ absent (1) (B85, Ch. C2).
Remarks: The nasal (or dorsal) process of the premaxilla occurs in most reptiles, contributing to the division of the external nares. It is absent in taxa such as kuehneosaurids, *Pamelina*, *Palaegama*, and rhynchosaurs. When the nasal process is absent, there is usually a single aperture of the external naris.

3. Premaxillae, posterodorsal process: absent (0)/ present (1) (Ev88, Ch. G1—modified).
Remarks: Posterodorsal process extending on top of the dorsal surface of the premaxillary process of the maxilla. It is observed in many diapsids, including sphenodontians, rhynchosaurs, *Euparkeria* and other archosauriforms.

4. Premaxillae, dentition: present (0)/ absent medially only (1)/ entirely absent (2) (DBR97, Ch. 3—modified).

Remarks: In some snakes (e.g. *Anilius*) and dolichosaurids (e.g. *Pontosaurus*) the premaxillary teeth are present, but they are absent medially (state "1"), thus splitting the dentigerous region of the premaxilla in two. However, other reptile groups lose their premaxillary dentition entirely, such as some snakes (e.g. *Cylindrophis* and scolecophidians), and most turtles.

5. Premaxillae, dentigerous beak: absent (0) / present (1) (NEW).
Remarks: A dentigerous beak is present in *Sphenodon* and other sphenodontians. It is formed by enlarged premaxillary teeth with secondarily grown bony tissue in between them (Carroll 1985b; Fraser 1988). In some sphenodontians, the secondary bone growth is extensive (e.g. *Kallimodon pulchellus*). This differs from the condition seen in rhynchosaurs, in which the premaxillae form a beak-like structure but the dentition is not an integral part of it, even when teeth are present on the premaxillae (as in *Mesosuchus browni*). Therefore, the ventral projection (beak-like structure) of rhynchosaurs is treated here as a non-primary homolog to the ventral projection observed in sphenodontians. When premaxillary teeth are absent, the present character must be treated as inapplicable.

6. Premaxillae, ventral bony beak: absent (0)/ present (1) (D98, Ch. 6 – modified).
Remarks: Beak-like structure in which the dentition is not an integral part of its composition, such as observed in rhynchosaurs (see further explanation above for character 5), captorhinids, proterosuchids, and later evolving thalattosaurs such as *Thalattosaurus* (Nicholls 1999).

7. Premaxillae, incisive process: absent (0)/ present (1) (Co08, Ch. 14—modified).

8. Premaxillae, ventral surface, premaxillary foramina: absent (0)/ present (1) (G12m Ch. 8—modified).
Remarks: The locator or part under consideration here are the openings for the exit of the terminal branches of the maxillary artery that pierces the premaxillae ventrally (Bahl 1937; Oelrich 1956).

9. Premaxillae, vomerine medial flange: absent (0)/ present (1) (Pr88, Ch. 40—modified).
Remarks: The vomerine medial flange is a process located on the ventral surface of the premaxilla, which is located posteriorly to the incisive process (when the latter is present), and extends in the direction of the vomers, occasionally contacting them.

Septomaxillae

10. Septomaxillae: present (0)/ absent (1) (D98, Ch. 14).

11. Septomaxillae, position: on narial margin (0)/ within nasal capsule (1) (G88b, Ch.3).

Remarks: In the vast majority of reptiles, the septomaxillae is within the nasal capsule. However, in a few reptiles the septomaxillae is on the surface of the snout. In *Captorhinus aguti*, for instance, each septomaxilla contacts the external surface of the maxilla, nasal and lacrimal.

12. Septomaxillae, shape, anteriorly: flat (0)/ convex dorsally (1)/ convex ventrally (2)/ laterally compressed (3) (E88, Ch. 41 – modified).
Remarks: When convex dorsally (e.g. *Xenopeltis*), the septomaxilla roofs the vomeronasal organ.

13. Septomaxillae, midline crest, dorsal projection: absent (0)/ present (1) (E88, Ch. 40; Fig. in G12, Ch. 205).
Remarks: A midline crest formed by both septomaxillae is observed within certain clades of squamates, including some scincids, teiids, amphisbaenians and scolecophidian snakes. This crest may extend ventrally to the point of contact between both septomaxillae (see G12, Fig. 202), or dorsally to where both septomaxilla meet. We scored only for the midline crest that forms a dorsal projection because it is considered herein that the ventral and dorsal projections are non-primary homologs, deserving to be coded as separate characters. In this character list, we coded only for the dorsal projection because it can be scored for numerous extant and fossil taxa without the aid of CT scan data.

Maxillae

14. Maxillae, contact, with premaxilla: syndesmotic (0)/ sutural (1) (Lee97, Ch. 7; Fig. in G12, Ch. 9).
Remarks: When there is a syndesmotic contact between the maxilla and the premaxilla, the maxilla has a premaxillary process that is convex and smoothly blunt surface anteriorly, such as observed mostly among snakes, but also in *Pontosaurus kornhuberi* and *Eichstaettisaurus schroederi*. This character is based on osteology, so we score state “0” based on the absence of sutural articulation between the maxilla and the premaxilla.

15. Maxilla-premaxilla fenestra, ventrally: absent (0)/ present (1) (G12, Ch. 5, Fig. Ch. 5 therein).
Remarks: This fenestra may occur on the ventral side of the skull in specimens in which it is not visible dorsally, such as when this fenestra is covered dorsally by the premaxillary process of the maxilla (e.g. some amphisbaenians). Therefore, this character has been scored based only on skulls in which the ventral side of the maxilla can be observed.

16. Maxillae, anterior superior alveolar foramen: absent (0)/ present (1) (LR95, Ch. 21).

Remarks: This foramen serves for the passage of the anterior superior alveolar nerve and the terminal branch of the maxillary artery in lizards (Oelrich 1956). A similarly located foramen for the passage of the same soft tissues occurs in rhynchosaurs (Benton 1983) and turtles (Gaffney 1972). The maxillary anterior narial foramen of procolophonids and pareiasaurs (Laurin & Reisz 1995) lies in the same position, likely giving passage to the same nerve and artery. The location of the ASAF can be quite variable, such as on the external surface of the maxilla, the internal border of the external nares (as in many lepidosaurs), or well posteriorly on the internal surface of the maxilla (e.g. *Trilophosaurus*).

17. Maxillae, nasal process: absent (0)/ present (1) (LR95, Ch. 19).
Remarks: Diapsid reptiles almost invariably have a nasal (or facial) process of the maxilla, which establishes a contact with the nasals and isolates the lacrimals posteriorly from the external naris. This process is reduced in many snakes, dolichosaurids and mosasauroids.

18. Maxillae, posterior emargination, between nasal and orbital processes: absent (0)/ present (1) (NEW).

Remarks: The antorbital fenestra in archosauriform reptiles is characterized by an emargination of the maxilla posteriorly that is usually seen in conjunction with an anteriorly curved lacrimal—e.g. *Euparkeria, Proterosuchus, Erythrosuchus*, and most of the later evolving archosaurian lineages (Romer 1956; Ewer 1965; Witmer 1997; Gower 2003). The observed modifications in the maxillae and lacrimals, however, vary differently in each lineage. For instance, in the crocodylomorph *Pelagosaurus typus*, the maxilla emargination is regressed, but the lacrimal still curves forward (Witmer 1997), producing a reduced antorbital fenestra. In later evolving crocodylomorphs and many hadrosaurs, regression of both the maxillary emargination and lacrimal curvature reduces or entirely closes the antorbital fenestra. Finally, in some birds (*e.g. Aquila chrysaetos*) and in some other archosaurs, including *Lesothosaurus diagnosticus* and *Scleromochlus taylori* (Witmer 1997; Benton 1999) the fenestra is fully open due to the maxillary posterior emargination, but the lacrimal is not curved. These differences are illustrative of the many distinct morphological transformations leading up to superficially similar "absences" and "presences" of the antorbital fenestra. Nevertheless, upon a more detailed consideration of the morphological changes leading up to the development or loss of the antorbital fenestra, it is clear that these "absent" and "present" conditions fail the criteria of similarity. Different morphological changes in the history of archosauriforms have led to multiple independent acquisitions and loss of the antorbital fenestra, and only detecting the individual changes in the anatomical parts composing the fenestra those changes can be appropriately assessed phylogenetically. Therefore, the maxillary emargination and lacrimal curvature are treated separately in here, allowing the detection of different "kinds" of antorbital fenestra that would, otherwise, be mistakenly coded as primary homologs. This approach follows the discussions on "complex characters" (Nesbitt 2011), or "composite locator coding" (Wilkinson 1995; Simões *et al.* 2017b) that affects most characters associated with skull fenestration.

19. Maxillae, antorbital fossa: absent (0)/ present (1) (G88b, Ch.32).

20. Maxillae, premaxillary process: present (0)/ absent (1) (NEW).
Remarks: the premaxillary process of the maxilla projects medially from the anterior margin of the maxilla and ventrally to the external naris, and it is seen in most squamates and other lepidosaurs.

21. Maxillae, premaxillary process, groove, on dorsal surface: absent (0)/ present (1) (S09, Ch. 7; Fig. in G12, Ch. 112).
Remarks: A groove for the passage of the internal ramus of the subnarial artery (Gauthier *et al.* 2012) is observed in some squamates, most specially among iguanians, and it occurs on the premaxillary process of the maxilla.

Nasals

22. Nasals, fusion: paired (0)/ fused (1) (P86, Ch. 1).

23. Nasals, ventrolateral process: absent (0)/ present (1) (G12, Ch. 22, Fig. Ch. 22 therein).

24. Nasals, ventrolateral process, position, relative to maxillary nasal process: posteriorly (0)/ anteriorly (1)/ dorsally (2) (NEW).
Remarks: When a ventrolateral process of the nasal occurs in reptiles it is almost always in contact with the nasal process of the maxilla (especially among diapsids). Exceptions occur in a few instances in which the nasal process of the maxilla is absent in diapsids (e.g. some dolichosaurids and snakes, among squamates), and among non-diapsid forms (e.g. captorhinids). When a ventrolateral process of the nasals is present, but the maxillary nasal process is absent, this character is inapplicable. However, the conservative relationship of the contact between nasals and maxilla in the vast majority of diapsids allows the position of the ventrolateral process of the nasal relative to the maxillary nasal process to be comparable across a broad range of reptiles.

25. Nasals, foramina: absent (0)/ present (1) (NEW).

26. Nasals, ventromedial crest: absent (0)/ present (1) (G12, Ch. 21, Fig. Ch. 21 therein).
Remarks: Present as a small crest in taxa such as in *Xantusia vigilis* and *Elgaria multicarinata*, becoming much deeper in amphisbaenians and dividing the olfactory tract anteriorly. In some snakes (e.g. scolecophidians), a deep single medial pillar is present as a result of the fusion of the nasals (and their medial crests).

Lacrimals

27. Lacrimals: present (0)/ absent (1) (E88, Ch. 28)

28. Lacrimals, position, relative to prefrontal lateral margin: ventral (0)/ anterior (1)/ posterior (2) (B85, Ch. B1).
Remarks: In most reptiles, the prefrontals extend ventrally contacting the palatines and the medial margin of the maxilla, but the lateral margin of the prefrontals remains restricted dorsally to the lacrimals not contacting the maxilla in lateral view. In *Kuehneosaurus* and *Icarosaurus*, however, the lateral margin of the prefrontal extends ventrally contacting the maxilla, and the lacrimal is positioned anterior to this extension. The conservative relationship of contact between the lacrimals and prefrontals across a wide range of reptiles and sampled taxa herein justifies the codification of the position of the lacrimal using the prefrontal as a referential landmark.

The lacrimals are not visible in many rhynchocephalians, being detectable externally only in *Gephyrosaurus* (Evans 1980). Additionally, there is no sign of fusion between the lacrimal and the prefrontal during ontogeny nor phylogeny (Howes & Swinnerton 1901; Whiteside 1986), thus current evidence indicates the element is lost in sphenodontians. Wu *et al.* (1996) considered the position of the lacrimal duct (posteriorly or laterally on the skull) as a proxy to evaluate whether the lacrimal bone was present, but fused to the prefrontal (when the lacrimal duct was facing posteriorly), or if it is absent altogether (when the lacrimal duct facing laterally). However, this conflicts with the observational and literature evidence gathered herein regarding the fusion of the lacrimal to the prefrontal. Additionally, even if fusion indeed occurs in some specimens, expanding the assumption of fusion to all sphenodontians in a dataset would be a major overreach in taxon scoring practise. Therefore, we keep the absence/presence of the lacrimal as a separate character in relation to the position of the lacrimal duct.

29. Lacrimal duct, foramen, division: single (0)/ double (1) (P86, Ch. 22—modified).
Remarks: The lacrimal duct can be single, or divided in two, passing through two distinct foramina, such as in *Varanus* (Bellairs 1949) and in some rhynchosaurs.

30. Lacrimal duct, posterior opening on skull surface, position: posteriorly (0)/ laterally (1) (RD03, Ch. 19 - modified).
Remarks: When the lacrimal duct passes to the snout region through an opening that lies between the prefrontal and the maxilla, the lacrimal foramen is located laterally on the skull.

31. Lacrimals, shape, curved anteriorly: absent (0)/ present (1) (NEW).
Remarks: See above (character 18). This anterior curvature usually occurs in taxa with an antorbital fenestra, in which the lacrimal has a "Γ" shape in lateral view.

Prefrontals

32. Prefrontals, ornamentation on external surface: absent (0)/ rugosities (1)/ tubercles (2)/ pits (3) (L98, Ch. 17 - modified).
Remarks: The different types of ornamentation are seen as distinct from each other as they are from absence of ornamentation (not hierarchically nested and being mutually exclusive). Therefore, these conditions are all included as part of the same character instead of being split into contingent characters.

33. Prefrontal crest: absent (0)/ present (1) (G12, Ch. 130, Fig. Ch. 130 therein).
Remarks: Thickening of the dorsal margin of the prefrontal, just above the anterodorsal margin of the orbit, forming a crest.

Supraorbital (palpebral) bones

34. Supraorbital bones: absent (0)/ present (1) (E88, Ch. 36).

Jugals

35. Jugals: present (0)/ absent (1) (Lee98, Ch. 12).

36. Jugals, posteroventral process: absent (0)/ present (1) (Ev88, Ch. O5).
Remarks: Most diapsids have a posteroventral process of the jugal forming a lower temporal bar that delimits the lower temporal fenestra. In most squamates, however, a posteroventral process of the jugal is entirely absent, and the jugal smoothly curves posterodorsally. The development of the posteroventral process of the jugal and a complete lower temporal bar seem to be evolutionary constrained in squamates, but has been -de-canalized and evolved at least twice independently in borioteiioids (Simões *et al.* 2016). The length of the posteroventral process of the jugal exhibits ontogenetic variation in stem rhynchocephalians, sometimes forming a complete lower temporal bar in old individuals of some taxa, such as: *Planocephalosaurus*, *Clevosaurus*, and *Diphyodontosaurus* (Fraser 1982; Whiteside 1986; Fraser 1988). Ontogenetic variation in this feature was also present in *Polyglyphanodon sternbergi*, a squamate from the Late Cretaceous of North America (Simões *et al.* 2016). Among early reptiles a similar ontogenetic variation also seems to be present, such as in the development of a third posterior process that forms the tetraradiate jugal of the parareptile *Delorhynchus* (Haridy *et al.* 2016). Due to intraindividual variation and the continuous nature of this feature, we do not consider the presence or absence of a complete lower temporal bar as a valid discrete character. Therefore, only the overall presence or absence of the jugal posteroventral process is considered.

37. Jugals, posteroventral process, shape: separate from dorsal process (0)/ connected to dorsal process by bony flange (1) (NEW).
Remarks: In early reptiles, such as *Protorothyris archeri* and *Protocaptorhinus pricei*, the jugal bears a posterior process contacting the quadratojugal that is connected via a bony flange to the dorsal (= orbital) process of the jugal (which, in turn, contacts the postorbital bone). In many diapsids, the jugal has a posteroventral process that is separated from the dorsal process (lacking a bony flange connection), acquiring a forked aspect posteriorly.

Quadratojugals

38. Quadratojugals: present (0)/ absent (1)/ (G88a, Ch. 12).

39. Quadratojugals, anterior extension: present (0)/ absent (1) (G88a, Ch. 9).

Remarks: In lepidosaurs, when the quadratojugal is present, the main body of the quadratojugal contacts the quadrate, but its anterior extension (such as the one observed in many archosauriforms) is absent.

40. Quadratojugals, ventral margin, medially inflected flange: absent (0)/ present (1) (NEW).
Remarks: In choristoderes, the quadratojugal has a medially inflected flange that is visible on the ventral side of the skull.

41. Quadratojugals, ornamentation, on external surface: absent (0)/ pits (1)/ rugosities (2)/ striations (3)/ tubercles (4) (DBR97, Ch. 43 - modified).
Remarks: The different types of ornamentation are seen as distinct from each other as they are from absence of ornamentation (not hierarchically nested and being mutually exclusive). Therefore, these conditions are all included as part of the same character instead of being split into contingent characters.

42. Quadratojugal foramen: absent (0)/ present (1) (Re-conceptualized).
Remarks: The quadratojugal foramen of many reptiles is a space in between the quadrate and the quadratojugal through which the mandibular and internal mandibular veins pass, such as in *Sphenodon* (O'Donoghue 1920, plate 7, fig. 2). In some previous publications (e.g., Gauthier *et al.* 1988a) this opening was homologized to the quadrate foramen of squamates. However, in extant squamates (where a quadratojugal is absent), the quadrate foramen carries the anterior tympanic vein, and a branch of the posterior condylar artery (Oelrich 1956). Furthermore, the quadratojugal foramen and the quadrate foramen may occur in conjunction, such as observed in *Sphenodon punctatus* (MCZ R4702, TRS pers. obs.). These observations preclude the treatment of both structures as homologs, and they are treated as separate characters in the present dataset.

Postorbitals

43. Postorbitals: present (0)/ absent (1) (G88b, Ch. 12).

44. Postorbitals, fusion to postfrontal: unfused (0)/ fused (1) (E88, Ch. 14).
Remarks: The postfrontal is fused to the postorbital in some lizards, such as in some teiids (although this can vary intraspecifically), some scincids, *Xantusia*, some anguimorphs, and mosasauroids. The fusion between both elements is also observed in other diapsids, such as within turtles and thalattosaurs.

45. Postorbitals, dorsal margin, position relative to postfrontal: laterally (0)/ posteriorly (1)/ anteriorly (2) (NEW).

Remarks: The contact between the postorbital and the postfrontal occurs in most, if not all, reptiles [including snakes in which both elements are present—see Palci & Caldwell (2013) for a recent review on the topic]. Therefore, the conservative relationship of the contact between the postorbital and postfrontal across a wide range of clades and sampled taxa allows the codification of the position of the postorbital using the postfrontal as a referential landmark. In most reptiles, the postorbital contacts the postfrontal posteriorly. However, in some instances the postorbital is positioned anteriorly to the postfrontal (e.g. *Eichstaettisaurus schroederi*), or laterally to the lateral margin of the postfrontal (e.g. *Sphenodon punctatus*, and borioteiioid squamates).

46. Postorbitals, dorsal process: absent (0)/ present (1) (NEW).
Remarks: The main body of the postorbital contacts the squamosal posteriorly in most reptiles by means of a posterior process. We use this conservative landmark as a reference point to detect if a distinct dorsal process (usually contacting the postfrontal) is absent or present. This character is inapplicable when the postorbital is completely fused with the postfrontal, as its dorsal process is undistinguishable from the distal process of the postfrontal. In non-diapsids, as well as a few modified diapsids with a reduced upper temporal fenestra, a distinct dorsal process is absent. In most diapsids this process contributes to the formation of the upper temporal fenestra. However, in most ichthyosaurs and hupehsuchids this process is absent, and the upper temporal fenestra is bordered anteriorly by an elongate distal (or postorbital) process of the postfrontal. In some instances, where the parietals acquire a lateral extension (see more details below), the upper temporal fenestra becomes reduced or entirely closed despite the presence of the dorsal process of the postorbital, such as in the saurosphargid *Sinosaurophargis yunguiensis* (and also in cordyloid squamates). The present character, as well as others linked to the bones that frame the temporal fenestrae (see below), is useful to identify subsequent non-homologous modifications in the structure of temporal fenestration in reptiles. See also discussion for character 18, above, and (Simões *et al.* 2017b).

47. Postorbitals, ventral process: absent (0)/ present (1) (NEW).

Remarks: Using the contact between the main body of the postorbital with the squamosal as a reference landmark (see above), a distinct ventral process of the postorbital (usually contacting the jugal) can be distinguished in most diapsids. This process is defined as a process extending ventrally towards the jugal (usually contacting it when the latter is present), and distinct from the posterior contact of the postorbital with the squamosal This process contributes to the formation of a lower temporal fenestra of most reptiles when the latter is present, but not in most choristoderes, such as *Phylidrosaurus* and *Champsosaurus*. This character is useful to distinguish between the different kinds of lower temporal fenestration in reptiles, and to track putative independent developments of that structure in phylogenetic reconstructions. In some squamates, such as *Globaura venusta*, this process becomes highly reduced, but it is still present ventral to the jugal. In taxa with fused postorbitals and postfrontals, the process is still distinct projecting towards the jugal anteroventrally, as in *Aigialosaurus dalmaticus* and *Pontosaurus kornhuberi*. In xenosaurids, this process is reduced and projects anteriorly.

48. Postorbitals, dorsal concavity: absent (0)/ present (1) (AN03, Ch. 13).
Remarks: Observed within sphenodontians.

Squamosals

49. Squamosals: present (0)/ absent (1) (E88, Ch. 33)
Remarks: Absent in snakes, most amphisbaenians, *Dibamus*, *Anniella* and some geckos (Estes *et al.* 1988).

50. Squamosals, anteroventral process: absent (0)/ present (1) (Ev88, Ch. L4 - modified).
Remarks: The squamosal of diapsids can be tetraradiate in many early diapsids and rhynchocephalians (Benton 1985). One of the processes creating the tetraradiate condition is the anteroventrally directed process, which braces the quadrate (and the quadratojugal, when present) anteriorly, as seen in most rhynchocephalians.

51. Squamosals, posterior process: absent (0)/ present (1) (NEW).
Remarks: The posterior process is distinct from the main body of the squamosal that contacts the postorbital bone, and it usually extends posteroventrally to contact the quadrate. It inserts into a squamosal notch on the cephalic condyle of the quadrate in most squamates, or it covers the quadrate in lateral aspect as in saurosphargids. Many rhynchocephalians (e.g. *Gephyrosaurus, Homeosaurus,* and *Palaeopleurosaurus*) have a posterior process that, along with the anterovetral process, make the ventral margin of the squamosal to become U-shaped, into which the quadrate-quadratojugal complex attach to in lateral view.

52. Squamosals, dorsal process: absent (0)/ present (1) (E88, Ch. 34 - modified).

Remarks: Occurs in a variety of diapsid reptiles, but is absent in many squamates (although present in stem squamates, many iguanians, teiioids, borioteiioids and mosasauroids).

53. Squamosals, occipital flange: present (0)/ absent (1) (LR95, Ch. 27).
Remarks: The absence of the occipital flange exposes the quadrate laterally and posterolaterally in many reptiles (e.g. *Claudiosaurus* compared to *Youngina*). The lateral exposure of the quadrate is thus biologically dependent on the absence or presence of the occipital flange, and it this feature is not treated separately from the present character.

54. Squamosals, ventral margin, medial inflection: absent (0)/ present (1) (NEW).
Remarks: The squamosal in choristoderes has a medial flange that forms the internal aspect of the posterolateral margin of the upper temporal fenestra. Within the upper temporal fenestra, this flange also projects medially, forming a temporal terrace.

55. Squamosals, anterior margin, bifid facet for postorbital: absent (0)/ present (1) (NEW).
Remarks: This facet occurs on the region where the squamosal articulates with the postorbital, and it is observed in rhynchocephalians, as well as in many protorosaurians and rhynchosaurs (e.g. *Mesosuchus* and *Howesia*).

Postfrontals

56. Postfrontals: present (0)/ absent (1) (B85, Ch. Y2—modified).

57. Postfrontals, distal process: present (0)/ absent (1) (NEW).

58. Postfrontals, distal process, division: single (0)/ double (1) (G12, Ch. 64).

59. Postfrontals, medial margin, position, relative to parietal: ventral (0)/ dorsal (1)/ lateral (2)/ anterior (3) (G12, Ch. 65 – modified).
Remarks: The conservative relationship of contact between the parietal and postfrontal across a wide range of clades and sampled taxa justifies the codification of the position of the postfrontal using the parietal as a referential landmark.

60. Postfrontals, parietal process: absent (0)/ present (1) (E88, Ch. 13—modified).
Remarks: When the postfrontal parietal process is absent, the postfrontal acquires a lunate-like appearance, such as in kuehneosaurids, protorosaurs, *Prolacerta. Palaegama, Pamelina*, and iguanians.

61. Postfrontals, medial forking: absent (0)/ present (1) (E88, Ch. 13).

Remarks: When the parietal process of the postfrontal is absent (character 60), the present character is inapplicable.

Supratemporals

62. Supratemporals: absent (0)/ present (1) (B85, Ch. J3).

63. Supratemporals, temporal process: absent (0)/ present (1) (NEW).
Remarks: A temporal process of the supratemporal, extending laterally on the temporal region, is observed in most ichthyosaurs.

Tabulars

64. Tabulars: present (0)/ absent (1) (B85, Ch. C4).

Postparietals

65. Postparietals: present (0)/ absent (1) (G88a, Ch. 5).

66. Postparietals, number: single (0)/ paired (1) (Ev88, Ch. D3).

Frontals

67. Frontals, fusion to each other: unfused (0)/ fused (1) (B85, Ch. Y1).

68. Frontals, parietal tabs: absent (0)/ present (1) (E88, Ch. 10).
Remarks: Among some early diapsids and rhynchocephalians, each frontal possesses a process overlying the parietal laterally.

69. Frontals, subolfactory processes: absent (0)/ present (1) (G12, Ch. 38—modified, Fig. Ch. 38 therein).

70. Frontals, subolfactory processes, fusion to each other: absent (0)/ present (1) (P86, Ch. 7 – modified). L*.

71. Frontals, orbitonasal projection: absent (0)/ present (1) (NEW).

Remarks: This projection is absent in most reptiles and iguanian squamates, but it occurs among most other squamates. These constitute anterior projections of the frontals that border the orbitonasal fenestra laterally and adjacent to the main body of the prefrontal medially. This structure is not part of the transformation series related to the ventral expansion of the subolfactory process, because some taxa (e.g. *Coleonyx*) have strongly developed suborbital processes (forming a tube), but lack the orbitonasal projection. Furthermore, among taxa with weakly developed subolfactory processes, there are species with (*Lacerta viridis*) and without (*Sphenodon punctatus*) orbitonasal projections. Such variation indicates the subolfactory process and the orbitonasal projection are better treated as separate characters.

Parietals

72. Parietals, fusion: unfused (0)/ fused (1) (B85, Ch. Y1).

73. Pineal foramen: present (0)/ absent (1) (B85, Ch. K2).

74. Parietals, supratemporal process: absent (0)/ present (1) (LC00, Ch. 46—modified).

75. Parietals, supratemporal process, distal end, division: single (0)/ bifid (1) (NEW).
Remarks: Early reptiles have the supratemporal process of the parietal bifid distally to receive the supratemporal, such as in *Hovasaurus* and *Araeoscelis.*

76. Parietals, ornamentation: absent (0)/ rugosities (1)/ tubercles (2)/ pits (3) (LR95, Ch. 38—modified).
Remarks: It is rather difficult to determine if the sculpturing in all dermal ossifications are primarily homologous or not. Nevertheless, because the parietal is usually one of the most common bones to present sculpturing, the parietal sculpturing is used here as a character to represent skull roof ornamentation. A single bone (parietal) is chosen for this character to make sure the skull roof ornamentations are comparable across taxa. The different types of ornamentation are seen as distinct from each other as they are from absence of ornamentation (not hierarchically nested and being mutually exclusive). Therefore, these conditions are all included as part of the same character instead of being split into contingent characters.

77. Parietals, lateral frill: absent (0)/ present (1) (NEW).
Remarks: In weigeltisaurids, the parietals possess laterally projecting frills (depressed spikes). This condition is seen in *Coelurosauravus* [(Evans 1982; Evans & Haubold 1987) and TRS pers. obs.], and also in *Rautiana* (Bulanov & Sennikov 2006), but are somewhat reduced in *Glaurung* (Bulanov & Sennikov 2015a) .

78. Parietals, frontal tabs of parietal: absent (0)/ present (1) (E88, Ch. 22).

Remarks: Parietal projection inserting ventrally on the frontals of some lepidosaurs, such as *Marmoretta*, *Gephyrosaurus*, *Planocephalosaurus*, and also within squamates (Lee 1998).

79. Parietals, nuchal fossa: absent (0)/ present (1) (G12, Ch. 94—modified, Fig. Ch. 94 therein).
Remarks: The parietal nuchal fossa is a thin bony plate projecting posteriorly from the parietal posterior margin, and which is distinct from the main body of the parietal.

80. Parietals, nuchal fossa, roofing by parietal posterior flange: unroofed (0)/ roofed (1) (CoN06, Ch. 47; Fig. in G12, Ch. 94(1 and 2)). L*.
Remarks: When present, the nuchal fossa may be covered by a posterior growth of the parietal main table (the parietal flange), as seen in *Gekko gecko* for instance.

81. Parietals, ventral side, parietal fossa: present (0)/ absent (1) (CoN06, Ch. 46; Fig. 33 in Co08).

82. Parietals, ventral side, parietal fossa, posterior margin: open (crests extend posterolaterally) (0)/ closed (crests meet at midline) (1) (CoN06, Ch. 46—modified).

83. Parietals, posteromedial (= postparietal) process: absent (0)/ present (1) (G12, Ch. 95, Fig. Ch. 95 therein).

84. Parietals, posteromedial (= postparietal) process, division: single (0)/ bifid (1) (G12, Ch. 97-modified, Fig. Ch. 97 therein). L*.

85. Parietals, parietal table, shape: margins ventrally directed, sagittal crest present (0)/ margins ventrally directed, without sagittal crest (1)/ margins laterally directed (2) (Lee98, Ch. 35 and G88b, Ch.19).

Remarks: Many reptiles, including numerous squamates, have ventrally directed lateral margins of the parietal(s), to which the epipterygoid attaches to. In such instances, some adductor muscles (*M. adductor mandibulae externus medialis* and the *M. adductor mandibulae internus pseudotemporalis superficialis* in squamates) attach to the dorsal side of the parietal. In many rhynchocephalians, among other reptilian groups, this condition is further developed by the formation of a sagittal crest dorsally on the parietal. The sagittal crest only occurs in ventrally directed lateral margins, and due to this conservative relationship among the studied taxa, the sagittal crest is considered herein to be part of the transformation series of the parietal table shape and not an independent variable. In other reptiles, the lateral margin of the parietal extends laterally, partially closing the supratemporal fossa (e.g. *Cordylus*). In the latter case, the epipterygoid attaches to the crista cranii parietalis [or ventrolateral crest of Evans (2008)] on the ventral side of the parietal (e.g. *Xantusia*) and the aforementioned adductor muscles also attach to the ventral side of the parietal. This suggests that the origin of the temporal muscles [character #54 of Estes *et al.* (1988)] and the orientation of the parietal(s) lateral margins are dependent features—the adductors cannot attach dorsally when the supratemporal fenestra is reduced or closed. Because the actual site of attachment of the adductors cannot be always determined for most fossil taxa, this transformation series is scored based on the orientation of the lateral margin of the parietal.

86. Parietals, dorsal surface, parasagittal crests: absent (0)/ present (1) (NEW).
Remarks: In some reptiles, parasagittal crests occur on the lateral margins of the parietal(s), such as in choristoderes and *Placodus*. The development of these crests might reflect a greater development of the adductor musculature rather than the position of the adductor musculature and the overall shape of the parietal lateral margins (accounted for in the previous character).

87. Parietals, crista cranii parietalis, epipterygoid process: absent (0)/ present (1) (E88, Ch. 23 – modified; Fig. in G12, Ch. 108).

Palate

Vomers

88. Vomers, fusion: unfused (0)/ fused (1) (G88b, Ch.43 – modified).

89. Vomers, teeth: absent (0)/ present (1) (G88b, Ch. 120).

90. Vomers, anterior premaxillary process: absent (0)/ present (1) (NEW).
Remarks: When present, the vomerine premaxillary process partially divides the incisive foramen between the vomer and the premaxilla.

91. Vomers, lateral expansion: absent (0)/ present (1) (Ev90, Ch. 8; Fig. in G12, Ch. 214).
Remarks: When present, the lateral processes may contribute to a neochoanate condition separating the vomeronasal fenestra from the fenestra exochoanalis.

92. Vomers, ventral surface, midline crest (=longitudinal ridge): absent (0)/ present (1) (G12, Ch. 222 – modified; Fig. in Ch. 222 therein).
Remarks: Among squamates, this is observed in some teiids, for instance. These crests lie adjacent and butt against each other on the midline, sometimes diverging anteriorly.

93. Vomers, ventral surface, lateral crest (=longitudinal ridge): absent (0)/ present (1) (G12, Ch. 222 – modified; Fig. in Ch. 222 therein).
Remarks: Observed in many squamates, this crest is generally observed on the anterior half of the vomers. They are parallel and curve inwards anteriorly, occasionally touching each other. Both a lateral and medial crest are observed in *Varanus*, and due to the criterion of conjunction they are treated as separate characters.

94. Vomers, ventral foramina, in each vomerine element: present (0)/ absent (1) (G12, Ch. 229—modified, Fig. in Ch. 229 therein).

95. Vomers, shape in cross-section: flat (0)/ convex ventrally (1) (NEW).

96. Vomers, posteroventral process (=descending tubercle): absent (0)/ present (1) (G12, Ch. 228—modified, Fig. in Ch. 228 therein).
Remarks: A posteroventrally directed process from the vomer that overlaps with the anterior margin of the palatine, as observed in *Acontias plumbeus* and other scincids, anguids, pygopodids, *Xantusia vigilis*, among others.

Palatines

97. Palatines, teeth: absent (0)/ present (1) (E88, Ch. 82).

98. Palatines, ascending process: absent (0)/ present (1) (G88b, Ch. 45).

99. Palatines, dorsomedially directed process: absent (0)/ present (1) (Lee97, Ch. 59).

100. Palatines, ventral surface, sulcus choanalis: absent (0)/ present (1) (G88a, Ch. 60 – modified).

101. Palatines, infraorbital foramen: present (0)/ absent (1) (NEW).

102. Palatine foramen: absent (0)/ present (1) (G12, Ch. 246, Fig. in Ch. 246 therein).
Remarks: Present dorsomedially to the infraorbital foramen, occurring in most iguanins.

103. Palatines, maxillary process, ventral aspect: absent (0)/ present (1) (G12, Ch. 239, Fig. in Ch. 239 therein).

104. Palatines, subchoanal shelf: absent (0)/ present (1) (G12, Ch. 251—modified, Fig. in Ch. 251 therein).

Pterygoids

105. Pterygoids, teeth: absent (0)/ present (1) (E88, Ch. 83).

106. Pterygoids, anteromedial processes, anterior end division: single (0)/ bifurcate (1) (Wu96, Ch. 93—modified).
Remarks: Present in some squamates (e.g. borioteiioids, *Varanus*). Wu *et al.* (1996) originally designated this character as another process of the pterygoid (a lateral process of the palatine ramus). However, no difference is observed between the condition described by the authors and the anterior bifurcation of the palatine ramus as proposed by Gao & Norell (1998).

107. Pterygoids, transverse processes: absent (0)/ present (1) (NEW).

108. Pterygoids, transverse processes, flange: absent (0)/ present (1) (G12, Ch. 266, Fig. in Ch. 266 therein).
Remarks: The acquisition of the pterygoid flange on its transverse process has been considered as one of the distinguishing feature of reptiles (Carroll 1969b).

109. Pterygoids, transverse process, teeth: absent (0)/ present (1) (G88b, Ch. 123).

110. Pterygoids, main body, concave in ventral aspect: absent (0)/ present (1) (NEW).
Remarks: The main body is considered the portion of the pterygoid from which the transverse process and the anteromedial process originate. This area is usually flat in reptiles, but in many squamates this area is concave in ventral view and it is bordered by the lateral margins of the pterygoid.

111. Pterygoids, arcuate flange: absent (0)/ present (1) (LR95, Ch. 42).

Remarks: A large number of reptiles, such as captorhinids, early turtles, early diapsids, rhynchosaurs, and some sphenodontians developed a posteromedially directed flange at the level of the transverse process of the pterygoid, and close to the point of contact with the basipterygoid process of the basisphenoid.

112. Pterygoids, quadrate rami, posterolateral excavation: absent (0)/ present (1) (DBR96, Ch. 29).

Ectopterygoids

113. Ectopterygoids: absent (0)/ present (1) (G88b, Ch. 55).

114. Ectopterygoids, lateral process: absent (0)/ present (1) (G12, Ch. 283—modified, Fig. in Ch. 283 therein).

Palatoquadrate

Epipterygoid (= alisphenoid): processus ascedens of the palatoquadrate that gives origin to the ala temporalis. This process ossifies endochondrally into the epipterygoid bone in lepidosaurs and turtles and the alisphenoid bone in mammals (Gauthier et al. 1988b).

115. Epipterygoid: present (0)/ absent (1) (E88, Ch. 47).
Remarks: The epipterygoid is absent in most snakes, amphisbaenians [except *Blanus* (Montero & Gans 2008) and *Trogonophis* (Kearney 2003)], and also absent *Dibamus*, but present in *Anelytropsis* (Rieppel 1984a; Greer 1985).

116. Epipterygoid, base shape: base flared out (0)/ base columnar (1) (G88a, Ch. 28; Fig. in G12, Ch. 295).
Remarks: Most reptiles have a flared base of the epipterygoid attaching to the pterygoid dorsally. However, most squamates that bear an epipterygoid have a straight shaft of the latter element without any flaring or widening of its base, thus having a continuous width throughout its entire extension. Although some variation may exist on the degrees of width of the flared bases of the epipterygoid in non-squamatan reptiles, here we assess only the qualitative difference on the absence or presence of this structure.

Quadrates

117. Quadrates, articulating surface: flat (0)/ with condyles (1) (LR95, Ch. 65—modified).

118. Quadrate foramen: present (0)/ absent (1) (G88a, Ch. 21).
Remarks: The quadrate foramen is considered to be solely the small foramen piercing the quadrate bone itself, usually near the base of the quadrate posterior pillar. This is not to be confounded with the opening between the quadrate and the quadratojugal—see also character 42 (quadratojugal foramen).

119. Quadrates, pterygoid process: present (0)/ absent (1) (G88a, Ch. 27—modified).

120. Quadrates, posterior emargination: absent (0)/ present (1) (B85, Ch. B6).

121. Quadrates, quadrate conch: absent (0)/ present (1) (B85, Ch. Y11).
Remarks: The tympanic membrane attachment to the quadratojugal (or the quadrate when the quadratojugal is lost) creates a reinforced attachment site (the tympanic crest) that always occurs in conjunction with thinner and medially projecting bony flange that forms by the quadrate conch. Therefore, the absence/presence of a quadrate conch, and the absence/presence of a tympanic crest are dependent characters among the studied taxa herein, and the quadrate conch is scored in this dataset to avoid redundancy. Another important consideration is that the tympanic crest of most squamates is positioned on the lateral margin of the quadrate, whereas in most rhynchocephalians this crest actually belongs to the fused quadratojugal. This topological difference seems to be a consequence of the loss of the quadratojugal in squamates, transferring the attachment site of the tympanum from the qudratojugal to the quadrate. Therefore, this topological difference on the composition of the tympanic crest is dependent upon the loss of the quadratojugal itself (already considered under character 38), and thus, it is not a separate and independent character. Accordingly, we do not treat the composition of the tympanic crest as a distinct character herein to avoid redundancy.

122. Quadrates, suprastapedial process: absent (0)/ present (1) (DBC93, Ch. 40).
Remarks: A posteroventral extension of the cephalic condyle of the quadrate, which is most commonly present in mosasauroids and dolichosaurids, but also occurs in some teiids (e.g. *Dracaena*) and some early snakes (*Dinilysia patagonica*). This process is only considered to be present if it is ventrally directed. This ventral deflection of the expanded cephalic condyle provides a better assessment on the absent/present state of the suprastapedial process than a more subjective assessment of the degree of expansion of the cephalic condyle. The vast majority of mosasauroids and other lizards that are considered to possess a suprastapedial process have this ventral deflection of the process [e.g. Bell (1997), fig. 7].

123. Quadrates, cephalic condyle, notch for the squamosal: absent (0)/ present (1) (Ev88, Ch. L9 – modified).

Braincase

The fusion of braincase elements is especially important in the evolution of many groups of squamates that have special adaptations for burrowing, such as amphisbaenians and burrowing snakes. Despite the fact many distinct groups of squamates present “braincase fusion”, burrowing squamates show great variation in their degrees and particular modes of braincase fusion. Individual braincase components are fused differently across these taxa, and assessing these differences should provide a better indication of their phylogenetic histories than an overall assessment of “braincase fusion”. For instance, the fusion of the basioccipital to the basisphenoid occurs in some taxa (e.g. *Bipes*, *Blanus*, and *Priscagama*) regardless of the fusion of the basioccipital to other elements, such as the exoccipitals. Also, fusion of the basioccipital to the exoccipitals (but not to the basisphenoid) occurs in xantusiids. The opposite is also true, as some taxa (e.g. *Slavoia darevskii*) have fused the basioccipital to the basisphenoid, but there is no detectable fusion to the exoccipitals. Therefore, fusion of distinct braincase elements are coded under separate characters. It is expected that this more detailed analysis of braincase fusion may provide better ways to detect homoplasies in this set of processes that are so widely distributed among squamates and that may affect inferences of their phylogenetic relationships.

Nerves and vessels

124. Carotid foramina, entrance in braincase, position: lateral wall of braincase (0)/ ventral surface of braincase (1) (D98, Ch. 45).
Remarks: The entrance of the canal or groove for the internal carotid artery in the braincase can be either laterally, as in *Captorhinus aguti* and squamates, or ventrally, as in *Gephyrosaurus* and *Mesosuchus*.

Supraoccipital

125. Supraoccipital, lateral ascending processes: absent (0)/ present (1) (NEW).
Remarks: This character refers to dorsolateral processes on the supraoocipital that extend onto the dorsal surface of the braincase. In early reptiles, this process may be enlarged and partially cover the post-temporal fenestra, such as in captorhinids. We use this character to replace Gauthier *et al.* (1988b) character on the closure of the post-temporal fenestra, since that character did not make specific reference to an anatomical part that could be referenced as the homolog under consideration. Also, the presence of this processs does not necessarily close the post-temporal fenestra.

126. Supraoccipital, medial ascending process: absent (0)/ present (1) (RZ00, Ch. 232; Fig. in G12, Ch. 297).
Remarks: Usually referred to as the processus ascendens of the synotic tectum in squamates (Oelrich 1956), this character reflects the ossification of this medially placed and dorsally ascending process that, in many squamates, contacts the parietal ventrally.

127. Supraoccipital, fusion to exoccipitals: unfused (0)/ fused (1) (NEW).
Remarks: The fusion between the supraoccipital to the adjacent exoccipitals may occur later during the ontogeny (e.g. *Coleonyx variegatus*). In such cases, the medial contact between the exoccipitals (see below) can be determined from individuals that still have partially separate supraoccipital and exoccipitals. The fusion of the supraoccipitals to the exoccipitals (or otoccipitals) may vary during post-embryonic ontogeny in many squamates (Maisano 2002), which may also occur in other reptiles, and thus only adults specimens are scored for his character.

128. Supraoccipital, sagittal crest: absent (0)/ present (1) (LR95, Ch. 55).

129. Supraoccipital, lateral nuchal crest: absent (0)/ present (1) (G12, Ch. 300, Fig. in Ch. 300 therein).
Remarks: Posteroventrally directed crests that are more commonly observed in snakes. In *Hoplodactylus* and other squamates with diminutive size and reduced degree of ossification of the skull, the posterior semi-circular canals pathways become visible externally, and thus form a "crest" on the supraoccipital (Simões *et al.* 2017a). This feature might also be the case of other small-sized reptiles. This is not homologous to the external crests referred to in this character.

Basioccipital

130. Basioccipital/basisphenoid, sphenoid tubercles: absent (0)/ present (1) (LR95, Ch. 63).
Remarks: In amphisbaenians, despite the presence of the sphenooccipital epiphyses (element "X") in many species, a distinct sphenoid tubercle is commonly absent. Considering the sphenooccipital epiphyses may occur in taxa with (e.g. *Uromastyx*) or without (amphisbaenians) sphenoid tubercles, we treat both atributes under separate characters.

131. Sphenooccipital epiphyses: absent (0)/ present (1) (K03, Ch. 102; Fig. in G12, Ch. 340).
Remarks: The "element X" of amphisbaenians has been widely regarded to represent the sphenooccipital epiphyses observed in many other squamates (e.g. *Uromastyx* and *Oplurus*, *Heloderma, Elgaria, Xenosaurus* and *Scincus*) [(Rieppel 1981; Montero *et al.* 1999; Kearney 2003) and TRS personal observation].

132. Basioccipital, fusion, to exoccipital: unfused (0)/ fused (1) (NEW).
Remarks: See comments and examples above in the introduction of the "Braincase" section. The fusion of the basioccipital to the exoccipitals (or otoccipitals) may vary during post-embryonic ontogeny in many squamates (Maisano 2002), which may also occur in other reptiles. Therefore, only adults specimens are scored for this character.

133. Basioccipital, fusion to basisphenoid: unfused (0)/ fused (1) (Lee93, Ch. A5).

Remarks: See comments and examples above in the introduction of the "Braincase" section. The fusion of the basioccipital to the exoccipitals (or otoccipitals) may vary during post-embryonic ontogeny in many squamates (Maisano 2002), which may also occur in other reptiles, and thus only adults specimens are scored for his character.

134. Basioccipital, ventral aspect, shape, concavity: single (0)/ divided (1)/ absent (2) (NEW).
Remarks: This concavity the for axial musculature can be either single or divided. Since both conditions are seen as distinct from each other as they are from the absent condition (not hierarchically nested and being mutually exclusive) they are all included as part of the same character instead of being split into contingent characters.

Basisphenoid

135. Basisphenoid, Vidian canal: open (0)/ fully enclosed (1) (B85, Ch. Y14).
Remarks: The palatine ramus of the facial nerve (VII) and carotid artery pass laterally to the braincase (in a groove) in most reptiles, but they are enclosed by the basisphenoid in the form of a canal in most squamates. In some scolecophidian snakes and early deriving alethinophidian snakes the Vidian canal is open, but in other snakes and dibamids the Vidian canal is partially or entirely closed by the parabasisphenoid. Additionally, polymorphisms may occur, with some individuals presenting both an open or partially closed canal, such as in *Liotyphlops albirostris* (Rieppel *et al.* 2009). Here, we consider the closure of the canal only when it is closed by the basisphenoid itself (or parabasisphenoid, when fusion between the basisphenoid and parasphenoid occurs). We do not consider this closure primarily homologous (by the criterion of similarity) to the one caused by an extreme ventral projection of the parietal, which may occasionally contribute to the closure of the Vidian canal, as observed in *Anilius*.

136. Basisphenoid, basipterygoid processes: present (0)/ absent (1) (G12, Ch. 332—modified, Fig. in Ch. 332 therein).
Remarks: The basispterygoid processes are absent in some snakes, such as *Xenopeltis unicolor*.

137. Basisphenoid, dorsum sellae: absent (0)/ present (1) (Ev88, Ch. J14).
Remarks: The dorsum sellae is absent in dibamids and in some snakes [e.g. *Liotypholps albirsotris* (Rieppel *et al.* 2009)].

138. Basisphenoid (or fused parabasisphenoid), ventral aspect, shape, concavity: single (0)/ divided (1)/ absent (2) (LR95, Ch. 50).
Remarks: In a variety of reptiles the basisphenoid possesses a ventral concavity—or pocket Laurin & Reisz (1995)—that is delimited laterally by the cristae ventrolaterales.

139. Basisphenoid, lateral depression: absent (0)/ present (1) (NEW).

Remarks: Small depression located ventrolaterally on the basisphenoid, and usually lying dorsal or posterodorsal to the level of the basipterygoid process within archosauriforms. This recess has been recently considered to be homologous to the anterior tympanic recess observed in later archosauriforms, such as *Silesaurus* and dinosaurs (Sobral et al. 2016).

Prootics

140. Prootics, prootic crest: absent (0)/ present (1) (LC00, Ch. 78—modified).
Remarks: A prootic crest is common among squamates, although absent in *Dibamus* (Evans 2008).

141. Prootics, prootic crest, shape: crest (0)/ curved flange (1) (LC00, Ch. 78—modified; Fig. in G12, Ch. 310). L*.
Remarks: Expansion of the prootic crest into a posteriorly curved bony flange (state "1") occurs in macrostomatan snakes (e.g. *Xenopeltis, unicolor* and *Cylindrophis rufus*), and contributes to the formation of the crista circumfenestralis of most snakes. Expansion of the prootic crest, along with an expansion of the crista interfenestralis, contributes to the formation of a distinct kind of crista circumfenestralis in later evolving mosasauroid reptiles (Rieppel & Kearney 2002).

142. Prootics, alar crest: absent (0)/ present (1) (E88, Ch. 49—modified; Fig. in G12, Ch. 305).
Remarks: The alar crest is a thin bony flange projecting anteriorly on prootics, located just anterior to the anterior semicircular canals (Oelrich 1956; Rieppel 1984a). The alar crest is absent in most iguanians, but it is common among other squamate lineages. It is very elongated in some taxa, such as *Varanus* and mosasauoirds, occasionally contacting the parietal, as in some mosasauroids.

143. Prootics, supratrigeminal process: absent (0)/ present (1) (E88, Ch. 5; Fig. in G12, Ch. 306).

144. Prootics, anterior inferior process: present (0)/ absent (1)/ (D98, Ch. 48).

145. Prootics, lateral wall, facial foramen: absent (0)/ present (1) (L98, Ch. 68; Fig. in G12, ch. 313).
Remarks: Opening for the exit of the facial nerve (VII) on the lateral wall of the braincase.

146. Prootics, lateral wall, facial foramen, division: single (0)/ double (1) (Lee97, Ch. 42; Fig. in G12, Ch. 313).

Remarks: The facial nerve (VII) leaves the braincase through a single opening on the lateral wall of the prootics and then branches off into its hyomandibular (Vidian nerve) and palatine branches in *Ctenosaura* (Oelrich 1956). However, this division may occur inside the braincase, with each branch exiting through separate openings (state "2" herein). In the latter case, there is usually an anteroventrally located opening for the hyomandibular branch and a more ventral opening for the palatine branch, which then passes anteriorly through the Vidian groove or canal.

Parasphenoid

147. Parasphenoid, teeth: absent (0)/ present (1) (B85, Ch. B9).

148. Parasphenoid, orbitosphenoid processes: absent (0)/ present (1) (NEW).
Remarks: The orbitosphenoid processes of the parabasisphenoid in contact the orbitosphenoid in amphisbaenians.

Opisthotics

149. Opisthotics, crista interfenestralis: present (0)/ absent (1) (G12, Ch. 311, Fig. in Ch. 311 therein).
Remarks: The crista or processus interfenestralis separates the fenestra ovalis and the lateral aperture of recessus scale tympani (LARST). The crista is absent in amphisbaenians and *Anniella pulchra* among squamates. In *Acontias,* separate openings for the fenestra ovalis, LARST and vagus foramen are present, despite the LARST being reduced by a close apposition between the crista interfenestralis and the crista tuberalis.

Exoccipitals

150. Exoccipitals, lateral flange: absent (0)/ present (1) (Lee93, Ch. A4).
Remarks: This character is inapplicable when the exoccipitals are fused to the opisthotics. Observed within pareiasaurs, turtles and rhynchosaurs.

151. Exoccipitals, fusion: unfused (0)/ to opisthotics only (1)/ to opisthotics and prootics (2) (G88b, Ch. 80 - modified).

Remarks: The exoccipitals become fused to the opisthotics (forming otoccipitals) in squamates. In some snakes, the otoccipitals are also fused to the prootics (state “2”). Fusion of the exoccipitals to the basioccipital may also occurs in some taxa (character 132). However, they are treated as separate characters because the distribution of these sequences of fusion among the observed taxa suggests both belong to independent transformation series. For instance, in all taxa studied herein, the fusion of the exoccipitals to the prootics only takes place when they are also fused to the opisthotics. However, fusion of the exoccipitals (or otoccipitals) to the basioccipital may occur regardless of its fusion to the prootics (e.g. *Cordylus niger*). The fusion of the otoccipitals to the prootics may vary during post-embryonic ontogeny in many squamates (Maisano 2002), which may also occur in other reptiles, and thus only adults specimens are scored for his character.

152. Exoccipitals, occipital condyle process: absent (0)/ present (1) (G88b, Ch. 81 - modified).
Remarks: The exoccipitals usually contribute to the formation of the single occipital condyle of reptiles by means of two processes abutting each lateral side of the basioccipital occipital condyle. However, many taxa do not have such processes, and the occipital condyle is thus formed solely by the basioccipital. This character is inapplicable when the exoccipitals and basioccipitals are fused.

153. Exoccipitals, crista tuberalis: absent (0)/ present (1) (G12, Ch.312—modified, Fig. in Ch. 311 therein).
Remarks: The fissura metotica (Rieppel 1985) can be undivided (foramen metoticum) as in most reptiles, or divided by a crista tuberalis (from the exoccipitals) as in squamates. The formation of the crista tuberalis creates two separate openings on the external wall of the braincase: the jugular or vagus foramen for nerves X and XI, and the lateral aperture of the recessus scalae tympani (LARST) (=foramen rotundum), through which the glossopharyngeal nerve (IX) exits the braincase. This division of the braincase also occurs on the medial wall of the braincase in squamates, where the medial aperture of the recessus scalae tympani is separated from the jugular foramen. However, in some squamates the external division of the fissure metotica by the crista tuberalisis is absent (although the medial wall remains divided), such as in *Xantusia vigilis*, *Coleonyx variegatus*, and *Acontias plumbeus*, where the exit for the nerve IX is confluent with the exit of the vagus nerve.

Among other reptiles, in some turtles (e.g. *Chelonia*) the glossopharyngeal nerve exits laterally though a separate opening from the vagus nerve, the foramen externum nervi glossopharyngei (Gaffney 1972). However, the latter foramen is enclosed within the processus (= crista) interfenestralis. This condition is quite distinct from the condition seen in squamates, because the separation between both nerve openings is not due to a division of the LARST by a bony process from the exoccipitals. In some other turtles (e.g. *Chelydra*), a bony flange from the exoccipital and opisthtotics forms a lateral division between the LARST and the posterior opening for the vagus nerve, similar to what is observed in squamates. The latter condition is probably a derived condition within Testudinata (not sampled herein), because the earliest fossil turtles (e.g. *Proganochelysi*) show a condition more similar to *Chelonia,* without this external division by the exoccipitals/opistothics (Rieppel 1985).

154. Exoccipitals (or otoccipitals), contact to each other, medially: absent (0)/ present (1) (G12, Ch. 353, Fig. in Ch. 353 therein).
Remarks: the otoccipitals expand and contact each other medially above the foramen magnum within snakes. The condition in amphisbaenians (where a fused occipital complex occurs) is indeterminate.

Stapes (= columella)

155. Stapes, dorsal process: present (0)/ absent (1) (G88b, Ch. 69 - modified).
Remarks: The stapes bears a dorsal process in early reptiles (e.g. captorhinids).

156. Stapes, stapedial foramen: present (0)/ absent (1) (B85, Ch. C5).
Remarks: The stapes is perforated by a stapedial foramen in early reptiles (e.g. captorhinids and *Youngina*). In squamates, only some gekkotans (e.g. *Coleonyx*) and dibamids possess a stapedial foramen (Rieppel 1984b; Rieppel 1984a; Evans 2008). Even among gekkotans, the stapedial foramen is absent in pygopodids (when the stapes is ossified), *Gekko*, among others (Underwood 1957; Rieppel 1984b; Evans 2008).

Laterosphenoid (= pleurosphenoid): endochondral ossification of the pila antotica (Gauthier et al. 1988b).

157. Laterosphenoids: absent (0)/ present (1) (B85, Ch. L4).
Remarks: Positioned anteriorly to the trigeminal notch on the prootic, forming a trigeminal foramen with the latter element.

Orbitosphenoid (= postoptic Cope 1892**)**: Endochondral ossification of the bulk of the pila metoptica and part of the taenia parietalis, forming the posterior margin of the optic foramen. (Oelrich 1956).

158. Orbitosphenoids: absent (0)/ present (1) (Wu96, Ch. 86).
The orbitosphenoid is ossified in squamates, becoming enlarged and fused medially in most amphisbaenians.

159. Orbitosphenoids, fusion to each other: unfused (0)/ fused medially (1) (G12, Ch. 318, Fig. in Ch. 318 therein). L*.

Sphenethmoid: Ossified anterior extension of the interorbital septum. It can be Y or V shaped. When Y shaped, its ventral projection forms the interorbital septum. The sphenethmoid therefore has similar developmental origins to the pleurosphenoid, and it may enclose cranial nerves II if expanded ventrally, and a concavity or foramina for nerves III and IV when expanded posteriorly (Romer 1956, p. 68; Holmes 1984). Oelrich (1956) calls the sphenethmoid bone an ossification of the interorbital septum, but we attain here to the nomenclature present in Romer (1956).

160. Ossified sphenethmoid: present (0)/ absent (1) (DBR97, Ch. 70—modified).

161. Ossified sphenethmoid, shape: without orbital septum (0)/ with orbital septum also ossified (1) / only orbital septum (2) (DBR97, Ch. 70—modified).
Occurrence: An ossification of the sphenethmoid occurs within lepidosaurs, especially revealed by CT-scan data (e.g. Digimorph repository). However, the shape of the ossified element can be quite variable, including the absence (“V” shaped) or presence (“Y” shaped) of an orbital septum, or with only the orbital septum being ossified (“I” shaped).

Mandibles:

162. Anterior mylohyoidal foramen: absent (0)/ present (1) (G12, Ch. 379, Fig. in Ch. 353 therein).
Remarks: Located within the splenial in most reptiles. This foramen serves for passage of the anteromedial branch of the inferior alveolar nerve (mylohyoideus nerve) in lizards (Oelrich 1956), turtles [where it is termed foramen intermandiularis oralis (Gaffney 1972)], and rhynchosaurs [where it is termed anterior meckelian foramen (Benton 1983)].

163. Posterior mylohyoidal foramen: absent (0)/ present (1) (CoN06, Ch. 112).
Remarks: Usually located within the angular in squamates. This foramen serves for passage of the posteromedial branch of the inferior alveolar nerve in lizards (Oelrich 1956), turtles [where it is termed foramen intermandiularis caudalis (Gaffney 1972)], and rhynchosaurs [where it is termed posterior meckelian foramen (Benton 1983)].

164. Anterior inferior alveolar foramen: absent (0)/ present (1) (NEW)

Remarks: Usually located on the splenial, or between the splenial and dentary in squamates. Serves for the passage of the inferior alveolar nerve and a medial branch of the internal mandibular artery in lizards (Oelrich 1956).

Dentaries

165. Dentaries, symphyses, fusion to each other: unfused (0)/ fused (1) (NEW).
Remarks: The mandibular symphysis may become fused in some sauropterygians, some turtles and *Trilophosaurus*.

166. Dentaries, symphysial area, shape: flat (0)/ convex (1) (Lee 1998, Ch. 110, Fig. in G12, Ch. 355).
Remarks: The mandibular symphysis may have a distinct flat area in lizards, a rounded surface (resulting into a movable symphysial articulatory surface) as in snakes.

167. Dentaries, anterior end, split by Meckelian canal: absent (0)/ present (1) (NEW).
Remarks: Most reptiles have the Meckelian canal open medially. However, even in cases where the Meckelian canal is open throughout most of the extension of the dentary, the anterior tip of the dentary is still formed by a contact between its dorsal and ventral margins (that frame the Meckelian canal), as seen in most squamates. In some reptiles, however, this anterior end is split (or indented) by the Meckelian canal, which becomes open anteriorly. When the Meckelian canal is closed by the dentary (e.g. geckoes, xantusiids, and *Rhineura*), this character is inapplicable.

168. Dentaries, anterior end, symphysial articulatory facet, position: on dorsal margin only (0)/ on dorsal and ventral margins (1)/ on ventral margin only (2) (Lo12, Ch. 612).

Remarks: The articulatory facet of the dentary symphysis is usually located dorsally to the Meckelian canal, on the subdental crest/ridge. However, in some taxa (e.g. many amphisbaenians, rhynchocephalians, turtles, captorhinids, among others) it is also located ventrally on the anterior tip of the dentary, on a medial projection of the dentary ventral margin. When the symphysial facet occurs both dorsally and ventrally, these facets can either be separated (e.g. most squamates), or connected, forming a single and dorsoventrally deep symphysial facet, as occurring in some sphenodontians (e.g. *Sphenodon, Priosphenodon*) and amphisbaenians among lepidosaurs, and captorhinids and turtles among other diapsid reptiles. However, in taxa such as *Iguana iguana* and some acrodontans, a deep symphysis is present, but the symphysial facet is located only dorsally (on the anterior tip of the subdental shelf, or subdental ridge), thus indicating this character can be assessed independently of symphysial depth, and these conditions are nor primarily homologous to state "1' herein. Furthermore, an elongate symphysis may also occur in earlier diverging amniotes and non-amniotes, including *Limnoscelis*, caseid synapsids, and placodonts. In such cases, the symphysial process of the splenial forms the ventral part of the elongate symphysis, also making the condition in these taxa not primarily homologous to the condition represented by state "1". When the ventral surface of the dentary is fused to the subdental shelf and the dentary tapers anteriorly (such as in geckoes), this character is indeterminate, and it is thus scored as inapplicable.

169. Dentaries, subdental shelf: present (0)/ absent (1) (E88, Ch. 59).
Remarks: This refers to the lingual bony projection supporting the dentary teeth (Rage & Augé 2010). The absence and presence of a subdental shelf is mostly considered a lepidosaurian character, as it becomes reduced or absent in certain clades, including platynotans (McDowell & Bogert 1954), in which the teeth attach directly to the lingual side of the lateral wall of the dentary. The subdental shelf is also reduced in taxa bearing acrodont dentition, including acrodontans (Cooper *et al.* 1970; Cooper & Poole 1973; Simões *et al.* 2015b), priscagamids (Borsuk-Białynicka & Moody 1984; Borsuk-Białynicka 1996) and most sphenodontids (Evans 2008), in which mandibular teeth are placed apically on the lateral wall of the dentary. In non-lepidosaurian reptiles, however, this character is also informative. A shelf is present in a large number of reptiles, including forms with teeth set in sockets (the sockets themselves being placed on the shelf). In edentulous taxa, however, the scoring of this character can be problematic. Also, in rhynchosaurs the teeth are placed apically on the dentary, but it is uncertain whether this condition is a result of the loss of the subdental shelf as in lepidosaurs with acrodont dentition. In such instances, we leave this character unscored (?) because of the lack of a reasonable indication on the absence or presence of a subdental shelf. In others, a reasonable estimate can be made. In turtles, for instance, *Proganochelys* displays small tooth alveoli in a dental sulcus, enclosed by labial and lingual walls. This indicates a subdental shelf was present among stem turtles.

170. Dentaries, dorsal margin, contact, with ventral margin in medial view: absent (0)/ present (1) (E88, Ch. 55—modified).
Remarks: The degree of contact between both margins along the length of the dentary is a variable with a continuous range of variation, which we do not attempt to code herein. Only the absence/presence of that contact is considered for this character. Because the contact between both margins results mostly from a ventral expansion of the subdental crest of the dentary in all of the observed taxa, we consider this feature to be primarily homologous among the sampled species.

171. Dentaries, dorsal margin, fusion, with ventral margin in medial view: absent (0)/ present (1) (E88, Ch. 55—modified).

172. Dentaries, coronoid process: absent (0)/ present (1) (E88, Ch. 60—modified)..
Remarks: The coronoid process is the edentulous posteriorly projecting area of the dentary bone. Some taxa lack this process entirely, whereas in others the coronoid process may be extremely reduced and it is hard to be noticed in lateral aspect, but it is still present if observed in dorsal view (e.g. *Pristidactylus scapulatus* and *Polychrus marmoratus*). In taxa with edentulous dentaries (e.g. most turtles) this character is impossible to determine with confidence.

173. Dentaries, coronoid process, dorsal expansion: absent (0)/ present (1) (E88, Ch. 60—modified).
Remarks: A dorsal expansion of the coronoid process is observed within lepidosaurs, butting against the lateral margin of the dorsal process of the coronoid bone (e,g, sphenodontians) or the anterior margin of the same (e.g. cordylids and scincids).

174. Dentaries, coronoid process, division: single (0)/ double (1) (NEW).
Remarks: In sphenodontians and some acrodontan lizards, the coronoid process is posteriorly divided, with one process extending posteriorly and another one dorsally (covering the coronoid bone laterally) (Simões *et al.* 2015b).

175. Dentaries, posteroventral process: absent (0)/ present (1) (G88a, Ch. 66—modified).
Remarks: In most reptiles, only the coronoid (posterodorsal) process of the dentary is present. In lepidosaurs (mostly squamates), a posteroventral process occurs (as in *Huehuecuetzpalli*, acrodontans, xantusiids, among others) below the level of the anterior surangular foramen.

Splenials

176. Splenials: absent (0)/ present (1) (B85, Ch. Z12).

177. Splenials, fusion to dentary: unfused (0)/ fused (1) (G12, Ch. 374—modified, Fig. in Ch. 374 therein). L*.
Remarks: According to Estes *et al.* (1988), the splenial becomes fused to the dentary in xantusiids (also, TRS pers. obs.). The fusion of the splenial to the dentary in xantusiids does not seem to belong to the same transformation sequence of the fusion of the post-dentary elements that results in the compound bone of snakes and amphisbaenians. In all of the studied taxa, fusion of the articular to the prearticular, surangular, and angular, always precedes fusion to the splenial. However, in xantusiids, splenial fusion to the dentary occurs without fusion of the splenial to other lower jaw elements. Therefore, we treat fusion of the splenial to the dentary under a separate character in relation to the sequence of fusions that leads to the formation of the compound bone in some taxa (see below).

178. Splenials, symphysial process: absent (0) / present (1) (LR95, Ch. 80).

179. Splenials, anterior border, shape: rounded (0)/ notched (1)/ flat (2)/ tapering (3) (Lee93, Ch. D6 - modified).

Angulars

180. Angulars: present (0)/ absent (1) (E88, Ch. 72).
Remarks: According to Estes *et al.* (1988), the angular is absent in many gekkotans, and it is a separate distinct element in adult eublepharids (Evans 2008). However, there is a suture separating the angular from the prearticular in some of the observed specimens of *Coleonyx variegatus* and *Gekko gecko*. Therefore, it seems that the angular undergoes fusion with the prearticular in geckoes where a distinct angular is not visible. Developmental evidence would help to assess if the supposed absence of angular in some geckoes actually represents fusion, or only an elongation of the prearticular. In *Xantusia vigilis*, the angular may occur in some posthatchlings (Estes *et al.* 1988). In adults, however, this suture disappears and both elements are fused, with the the fused prearticular+angular extending well anteriorly, contacting the fused dentary+splenial.

181. Angulars, anterior end, medial view, position relative to splenial: lateral (0)/ dorsal (1)/ ventral (2)/ posterior (3) (L97, Ch. 70—modified)

Remarks: The splenial is in contact with the angular in the vast majority of studied taxa. Additionally, despite a considerable variation in shape of the splenial, the posteroventral end of the splenial is almost invariably in contact with the ventral margin of the dentary. Therefore, this region becomes a useful landmark to assess the position of the angular in the lower jaw. In most cases, the angular is always positioned dorsally to the splenial in medial view. In some taxa (e.g. *Tanystropheus*), however, it is placed ventrally to it. This occurs regardless of the relative lengths of each of these elements. Finally, the angular may butt against the splenial posteriorly, as in mosasauroids and snakes.

Surangulars

182. Surangulars, coronoid process: absent (0)/ present (1) (G88a, Ch. 69, Fig. in G12, Ch. 400).
Remarks: The surangular may have a dorsal contribution to the coronoid eminence of the mandible, with variable degrees of contribution of the coronoid dorsal process.

183. Surangulars, lateral adductor crest: absent (0)/ present (1) (LR95, Ch. 73—modified, Fig. in G12, Ch. 399).
Remarks: The adductor crest, defining a lateral adductor fossa, is considered herein primarily homologous to the "lateral shelf" on the surangular described by Laurin & Reisz (1995), since both represent attachment areas for the external adductors, most likely the *M. adductor mandibularis externus superficialis* of extant reptiles (Oelrich 1956; Haas 1973). A distinct adductor crest/fossa system is absent in most early reptiles, but it is common within diapsids.

184. Surangulars, anterior surangular foramen: absent (0)/ present (1) (MS04, Ch.145).
Remarks: Located anterodorsally on the lateral side of the surangular, usually ventral to the suture with the coronoid process of the dentary (Simões *et al.* 2015b). This foramen serves as passage for the posterior cutaneous branch of the inferior alveolar nerve (Oelrich 1956).

185. Surangulars, posterior surangular foramen: absent (0)/ present (1) (MS04, Ch.146).
Remarks: Located posterodorsally on the lateral side of the surangular, close to the glenoid. This foramen serves as passage for the posterior cutaneous branch of the inferior alveolar nerve (Oelrich 1956) [termed foramen nervi auricolotemporalis in turtles (Gaffney 1972)].

186. Surangulars, mandibular fenestra: absent (0)/ present (1) (D98, Ch. 76).
Remarks: Large fenestra enclosed by the surangular, with some occasional contribution of the dentary to its anterior margin. Occurrence within archosauriforms.

Articular

187. Articulars, lateral shelf: absent (0)/ present (1) (LR95, Ch. 78).
Remarks: Lateral expansion of the dorsal surface of the articular, both in the glenoid and retroarticular areas, likely serving as an expanded area of attachment for the pterigoideal adductor system. Occurs in taxa such as pareiasaurians (Laurin & Reisz 1995), *Proganochelys*, *Trilophosaurus*, and within archosauriforms (e.g. *Erythrosuchus*, *Prestosuchus*).

188. Articulars, fusion: unfused (0)/ to prearticular only (1)/ to prearticular + surangular only (2)/ to prearticular + surangular + angular only (3)/ to prearticular + surangular + angular + splenial (4) (B85, Ch. Y16).
Remarks: This character assesses the fusion of the post-dentary elements. The articular and prearticular are fused in most, if not all, adult squamates, and may become further fused to other post-dentary elements in what, as assessed herein, seems to follow a particular sequence of events: fusion of the articular+prearticular to the angular, and then to the surangular too, and eventually to also include the splenial in some amphisbaenians.

189. Articulars, foramen chorda tympani: absent (0)/ present (1) (NEW).

190. Articulars, retroarticular process: absent (0)/ present (1) (LR95, Ch. 76—modified).

191. Articulars, retroarticular process, dorsal fossa: absent (0)/ present (1) (E88, Ch. 74).

192. Articulars, retroarticular process, lateral notch: absent (0)/ present (1) (E88, Ch. 77, Fig. in G12, Ch. 409).

193. Articulars and prearticulars, medial process: absent (0)/ present (1) (E88, Ch. 73, modified as in Co08, Ch. 209) .
Remarks: A medial process on the posterior end of the lower jaw is observed in a variety of reptilian groups for the attachment of the pterygoideus adductor complex (Haas 1973). This medial process may be formed by the articular or the articular and prearticular, and in squamates it is usually termed angular process. Relative to the longitudinal axis of the lower jaw, the medial process is usually located medial to the glenoid cavity for the articulation with the quadrate, but may also be entirely medial to the retroarticular process.

194. Articulars and prearticulars, medial process, prearticular crest: absent (0)/ present (1) (E88, Ch. 73—modified). L*.
Remarks: Commonly observed in teiioids and some borioteiioids, this crest in located on the dorsal surface of the medial (angular) process of the articular and prearticular.

Prearticular

195. Prearticulars, retroarticular process: absent (0)/ present (1) (LR95, Ch. 77 – modified).
Remarks: This character refers only to the prearticular contribution to the retroarticular process. This process of the prearticular may or may not occur in conjunction with the retroarticular process of the articular when both bones are not fused, thus indicating they should be treated as separate chatacters.

196. Prearticulars, mandibular fossa: present (0)/ absent (1) (L97, Ch. 80—modified).
Remarks: The prearticular bears a posteriomedial concavity that contributes to the formation of the mandibular fossa.

Coronoid:

197. Coronoids, dorsal process: absent (0)/ present (1) (B85, Ch. J7—modified, Fig. in G12, Ch. 386).

198. Coronoids, anterolateral (=labial) process: absent (0)/ present (1) (E88, Ch. 68—modified).

199. Coronoids, anteromedial process: present (0)/ absent (1) (LC00, Ch. 138, Fig. in G12, Ch. 391).

200. Coronoids, posterodorsomedial process: present (0)/ absent (1) (NEW)

201. Coronoid, posteroventromedial process: present (0)/ absent (1) (G12, Ch. 393, Fig. in Ch. 393 therein).

Dentition

202. Dentition, crown apical striations, labial side: absent (0)/ present (1) (Co08, Ch. 219).

203. Dentition, mesiodistal serration: absent (0)/ present (1) (D98, Ch. 57).
Remarks: Occurrence within archosauriformes and varanids.

204. Posterior dentition, accessory cusps, mesiodistally oriented: absent (0)/ present (1) (NEW).
Remarks: Accessory cusps may be distributed mesiodistally on the tooth crown, as in some iguanians and lacertids among squamates. Mesiodistally distributed accessory cusps were also observed in tanystropheids and *Langobardisaurus*. Due to their topological difference, these cusps are primarily non-homologous to labiolingually arranged accessory cusps (e.g. as in *Trilophosaurus*).

205. Posterior dentition, accessory cusps, labiolingually oriented: absent (0)/ present (1) (Lo12, Ch. 620).
Remarks: see comments for character 204 above.

206. Posterior dentition, replacement teeth: absent (0)/ present (1) (P86, Ch. 26—modified).

207. Posterior dentition, resorption pits: present (0)/ absent (1) (E88, Ch. 85, Fig. in G12, Ch. 431).
Remarks: Among squamates, snakes, varanids, lanthanotids, helodermatids, and some anguids have tooth replacement, but lack resorption pits (Edmund 1960; 1969; Lee 1997a). Rhynchosaurs have multiple rows of dentary and maxillary teeth positioned mostly apically and ankylosed to the jaws. Differently from the condition in most acrodontan lizards and sphenodontians, however, at least in *Hyperodapedon gordoni* and *Stenaulorhynchus stockleyi*, tooth replacement with resorption pits is present (Benton 1984). In *Captorhinus aguti*, in which multiple tooth rows also occur, resorption pits have been documented, although replacement was certainly slow, and was likely to be very similar to the replacement pattern in rhynchosaurs (Fox & Bowman 1966; de Ricqlès & Bolt 1983; Benton 1984). Therefore, the previously reported pattern of tooth replacement without resorption pits appears to be conspicuous to some squamates only.

208. Posterior dentition, replacement teeth, position in relation to functional teeth: lingual (0)/ posterolingual (1) (P86, Ch. 26 – modified).

209. Posterior dentition, tooth shape, concave anteriorly: absent (0)/ present (1) (NEW).
Remarks: observed in some rhynchocephalians.

210. Posterior dentary teeth, position, relative to dentary crista dorsalis (apex of labial wall) of dentary: lingual (0)/ apical (1)/ apicolingual (2) (G88, Ch. 75 – modified).

Remarks: The classical categories of “tooth attachment”, such as acrodonty, pleurodonty and thecodonty usually mix a combination of distinct features, such as tooth position on the jaws, ankylosis, and mode of replacement. However, tooth ankylosis to its surrounding tissue of attachment may occur in reptiles in combination with different kinds of tooth topologies, and replacement modes. For instance, teeth set in four-sided sockets may or may not be ankylosed to alveolar bone, suggesting both are independent characters. Therefore, here we divide the classical tooth attachment classifications into its different properties that seem to vary independently in at least part of the sampled taxa: tooth position on the jaw bone (relative to the jaws labial wall apical margins), tooth ankylosis, tooth delimitation (e.g. three-sided vs four-sided sockets), and presence or absence of replacement. In the present character, tooth position can be defined as: lingual to the dentary/maxillary labial wall; apically on the labial wall (sitting entirely on the crest forming the apex of the labial wall of the tooth bearing bones), such as in chamaeleonids, some priscagamids (e.g. *Mimeosaurus crassus*), and most sphenodontians (e.g. *Kallimodon*, *Pleurosaurus* and *Sphenodon*); or apicolingually, in which part of the tooth base lies apically to the dorsal crest, but they also extend lingually to it, such as in many agamids and priscagamids (Borsuk-Białynicka & Moody 1984; Borsuk-Białynicka 1996; Evans *et al.* 2002; Simões *et al.* 2015b), a condition previously described as “pleuroacrodonty” (Evans *et al.* 2002; Simões *et al.* 2015b).

Importantly, dental position (or topography) and tooth delimitation (see below) characters refer to position and enclosure of the dental tissues by jaw bone only. Therefore, conditions in which alveolar bone or cementum create an apparent apical placement of teeth on the jaw, such as seen in *Dracaena* and *Tupinambis*, are not considered as apically placed teeth, as the dental tissues in these cases are still placed lingually to the labial wall of the jaw bone. In some instances, the scoring for these conditions follows the literature on the subject (e.g. Edmund 1960; de Ricqlès & Bolt 1983; Budney 2004; Budney *et al.* 2006), but in others (especially fossils) an external morphological differentiation between dental tissue and jaw bone is readily visible and enhanced by the differential degree of mineralization of those tissues in fossils. This approach towards considering the distinct histological locators (or homologs) provides a better approach towards the coding of dental characters.

211. Posterior dentary teeth, ankylosis to crista dorsalis (apex of labial wall) of dentary: absent (0)/ present (1) (NEW).

Remarks: See comments above for character 210. Most acrodontan species with teeth placed at the apex or apicolingually on the jaws also have their teeth ankylosed to the labial wall of the jaw. This is also the case in most sphenodontians, rhynchosaurs and *Captorhinus*. This character refers to the externally observable fusion of the dentition to the jaw bone. Although many squamates fuse their tooth bases to the labial wall of the jaw bone, the apical margin of the bone is still distinct from the tooth crown. However, in most acrodontan lizards and sphenodontians the tooth crowns are fused to the apical margin of the jaw bone.

212. Posterior dentary teeth, delimitation by tooth bearing bone: by a labial wall only (0)/ by a three-sided socket (1)/ by a four-sided socket (2)/ by a lingual and labial wall only (3) (NEW). Remarks: See comments above for character 210. The three-sided socket condition occurs when interdental ridges are present connecting to the labial wall of the jaws. The four-sided socket condition occurs when the teeth are fully enclosed inside a socket or alveolus on the jaws. When teeth are at the apex of the labial wall, instead of medially to it, this character is scored as inapplicable.

213. Posterior maxillary teeth, delimitation by tooth bearing bone: by a labial wall only (0)/ by a three-sided socket (1)/ by a four-sided socket (2)/ by a lingual and labial wall only (3) (NEW). Remarks: See comments above for character 210. Due to differences in jaw bone morphology when the dentaries and maxillae are compared, tooth delimitation by the jaw bone is treated separately for dentaries and maxillae in the present dataset.

214. Posterior dentary dentition, lingual and labial carinae: absent (0)/ present (1) (L97, Ch. 87).

215. Anterior dentary teeth: present (0)/ absent (1). (NEW).

216. Anterior dentary teeth, position relative to the jaw apical margin (dentary dorsal crest or maxillary ventral crest): lingual (0)/ apical (1)/ apicolingual (2) (G88a, Ch. 75 – modified). Remarks: : See comments above for character 210. The distinction on the placement between the anterior and posterior teeth series is observed in acrodontans lizards and a few rhynchocephalians among lepidosaurs. It also observed in other reptiles, such as some captorhinids.

217. Posterior maxillary teeth, posteromedial ridge: absent (0)/ present (1) (Ev88, Ch. K6). Remarks: occurrence within sphenodontians (e.g. *Kallimodon pulchellus*)

218. Anterior maxillary teeth, alternating teeth series: absent (0)/ present (1) (NEW). Remarks: In *Sphenodon* there are five generations of teeth, the first three ones occurring in the embryo. The fourth and fifth generations occur after hatching and are termed successional teeth (or replacement teeth). Each of these successional teeth replace two or more of the teeth from the preceding generation (Harrison 1901), but some of the hatchling dentition is kept with the larger successional teeth on the maxilla, creating a pattern of alternating teeth. This alternating teeth pattern is also observed in adults of fossil sphenodontians, such as *Diphyodontosaurus* (Whiteside 1986).

Postcranium

Axial skeleton

Atlas and axis

219. Atlas, pleurocentrum, fusion to axis: unfused (0)/ fused (1) (G88b, Ch. 133).
Remarks: Within Reptilia, the atlas centrum fuses to the axis in birds and lepidosaurs, forming the odontoid process of the axis. Fusion is absent, however, in some squamates, such as uropeltid snakes (Hoffstetter & Gasc 1969).

220. Atlas, neural arches: separate (0)/ sutured to each other (1)/ sutured to axis neural spine (2) (NEW).
Remarks: The neural arches are separate in most reptiles, but they may become sutured to each other in many lizards. In some taxa, such as *Polychrus marmoratus* and *Leiocephalus carinatus*, the axis neural spine extends anteriorly between the atlas neural arches, and becoming sutured to the latter. Considering the medial fusion of the atlas neural arches is dependent on the presence of the neural spine of the axis intervening between them, these three variables are coded under the same character. In some squamates, the neural arches are fused medially (e.g. *Bipes biporus*). However, this condition seems to be exteremly plastic and we do not make a distinction between sutured unfused neural arches to fused ones.

221. Atlas, neural arches, postzygapophyses: absent (0)/ present (1) (Lee97, Ch. 106).

222. Atlas, ribs: present (0)/ absent (1) (DBR97, Ch. 102).

223. Axis, pleurocentrum, fusion to neural arch: unfused (0)/ fused (1) (NEW).

224. Axis, intercentrum: present (0)/ absent (1) (NEW; Fig. 35 (Hoffstetter & Gasc 1969)).

225. Axis, connectivity to intercentra: to intercentra 2 only (0)/ to intercentra 2 and 3 (1) (NEW).
Remarks: Anguimorphs, amphisbaenians, snakes and mosasaurs have intercentra 2 and 3 on the axis (Russell 1967; Hoffstetter & Gasc 1969).

226. Axis, intercentrum, fusion to axial pleurocentrum: unfused (0)/ fused (1) (G88b, Ch. 131).

227. Axis, ribs: present (0)/ absent (1) (NEW).

Postaxial vertebrae: Presacral/precloacal pleurocentra

Most reptiles have a clearly discernable sacral region. This vertebral domain (as well as the cloacal domain in limbless forms), separates two other domains that usually have very distinct morphologies and represent serial homologs: the presacral and the caudal regions. The presacral region further comprises the cervical and dorsal (or trunk) domains, but their distinction is rather difficult for a number of taxa. A cervical region is defined as comprising all vertebrae anterior to the first vertebra bearing ribs contacting the sternal plate in lepidosaurs, for instance (Hoffstetter & Gasc 1969). However, this is can be hardly discerned in limbless squamates, which usually lose part or all of the pectoral girdle elements. In non-squamate fossil diapsids it also can be hard to identify distinct domains in the presacral region with precision because of lack of articulation between the ribs and other skeletal elements. For these reasons, we avoided the usage of the cervical and dorsal (trunk) domains for many characters, aiming for characters that are more easily identifiable (and less prone to erroneous scoring) throughout the entire presacral region. For some characters, clear differences between the cervical and dorsal regions are easily discernable—e.g. some features that occur only in the cervical region (or the anteriormost presacrals of limbless taxa). In such cases, we included these features among our characters. Whenever a particular feature could not be confidently attributed to either a cervical or a dorsal region when these domains were used, taxa were scored with missing data.

228. Presacral pleurocentra, orientation of centrum: amphicoelous (0)/ procoelous (1)/ opistocoelous (2)/ platycoelous (3)/ amphyplatyan (4) (G88a, Ch.84—modified).
Remarks: *Trilophosaurus* displays procoely among its cervicals and most of its dorsals, but it has amphicoelous dorsals close to the sacral region. Contrary to scorings in previous datasets (de Braga & Rieppel 1997; Müller 2004), choristoderes have amphyplatyan centra [(Brown 1905; Gao & Fox 2005; Katsura 2007) and TRS personal observation]. Defining distinct domains within serial homologues, such as vertebrae, can be problematic (as discussed above), especially when unusual variations occur (e.g. variation in centrum orientation in the presacral region). Polymorphic scoring is not justifiable under the circumstances observed in *Trilophosaurus*, as polymorphism applies to different individuals within a species displaying different states (not distinct regions within the same individual). Additionally, because the distinct centrum conditions may belong to distinct vertebral domains, the conjunction criterion of similarity (Patterson 1982) is also not applicable to justify the creation of a new character-state. Therefore, in such instances, we score the most frequently observed condition within the vertebral sequence of *Trilophosaurus* (procoely).

229. Presacral pleurocentra, notochord, persistent in adults: present (0)/ absent (1) (B85, Ch. C6; Fig. 34 (Hoffstetter & Gasc 1969)).

Remarks: Although persistent notochords are most commonly seen in taxa with amphicoelic vertebrae, this character undergoes variation independent of the orientation of the pleurocentra. For instance, most geckos have amphicoelic vertebrae with notochordal canals, but geckos with procoelic vertebrae, such as *Sphaerodactylus parkeri*, also have a persistent notochord (Holder 1960).

230. Presacral parapophyses: present (0)/ absent (1) (LR97, Ch. 116—modified).
Remarks: When the parapophyses are absent, the vertebral connection to the ribs is established by the diapophyses only.

231. Presacral pleurocentra, midventral crest, cervical vertebrae: absent (0)/ present (1) (G88b, Ch. 139; Fig. 37 (Hoffstetter & Gasc 1969)).
Remarks: A midventral crest connecting to the hypapophyses occurs in *Blanus* among other amphisbaenians, but it is indeterminate in rhineurids. Despite snakes not having a clear difference between the cervical and dorsal regions, the anteriormost precloacal vertebrae of most observed taxa lack a midventral crest, and therefore they could be safely scored as "0" in such instances. *Xenopeltis unicolor*, on the other hand, has a ventral keel throughout the entire column, and was thus coded with state "1".

232. Presacral pleurocentra, midventral crest, posterior dorsal vertebrae: absent (0)/ present (1) (Ev88, Ch. B2; Fig. 34 (Hoffstetter & Gasc 1969)).
Remarks: Despite snakes not having a clear difference between the cervical and dorsal regions, even the posteriormost precloacal vertebrae of most observed taxa lacked a midventral crest, and therefore they were scored as "0" in such instances. *Xenopeltis unicolor*, on the other hand, has a ventral keel throughout the entire column, and was thus coded with state "1".

233. Posterior presacral pleurocentra, precondylar constriction: absent (0)/ present (1) (E88, Ch. 94).
Remarks: Precondylar constriction usually occurs in most presacral vertebrae of platynotan lizards. However, it is more clearly discernable in the posteriormost presacral vertebrae. Therefore, we use that particular region as the vertebral domain (locator) under comparison. This character is inapplicable for taxa without a condyle (e.g. with amphicoelic vertebrae).

234. Posterior presacral pleurocentra, dorsal vertebrae, margo ventralis (= ventrolateral crest): absent (0)/ present (1) (NEW; Fig. 69 (Hoffstetter & Gasc 1969)).

Remarks: This crest, also named posterior centrosynapophyseal lamina crest (Tschopp 2016) connects the parapophyses (or fused synapophyses) to the vertebral condyle (Hoffstetter & Gasc 1969). This feature is most commonly observed in squamates, including snakes, teiids, *Crotaphytus*, among others. When present, the margo ventralis usually occurs in most presacral vertebrae. However, it is more clearly discernable in the posteriormost presacral vertebrae of squamates.

Sacral vertebrae

235. Sacral vertebrae, number: zero (0)/ one (1)/ two (2)/ three (3)/ four (4) (G88b, Ch. 141 - modified).
Remarks: Squamates with body elongation and limb reduction usually have a defined cloacal region that bears distally forked ribs (Hoffstetter & Gasc 1969). However, it is not possible to determine if all these cloacal ribs are modifications from sacrals, or if they include some of the anterior caudal vertebrae too. For this reason, only clearly defined sacrals (bearing distally expanded ribs attaching to the ilium) are considered herein.

Caudal vertebrae

236. Caudal vertebrae, autotomic septum: absent (0)/ present (1) (P86, Ch. 52; Fig. 52 (Hoffstetter & Gasc 1969))
Remarks: There is only one autotomic vertebra in some taxa, such as *Bipes biporus.* However, the vast majority of squamates bear vertebrae with autotomic septum past the first 10 or 15 caudals. An autotomic septum has also been identified in the captorhinids *Captorhinus* and *Labidosaurus* (Price 1940).

Intercentra

237. Intercentra, on cervical vertebrae: absent (0)/ present (1) (G88b, Ch. 129).

238. Intercentra, on cervical vertebrae, position: intervertebral (0)/ on preceding centrum body (1)/ on following centrum body (2) (E88, Ch. 97 and 98—modified; Fig. 44 (Hoffstetter & Gasc 1969)). L*.

239. Intercentra, on dorsal vertebrae: absent (0)/ present (1) (B85, Ch. L5).

240. Intercentra, on anteriormost caudal: absent (0)/ present (1) (NEW).
Remarks: The anteriormost caudal region (pygals) usually have intercentra that differ from the more posteriorly located intercentra (haemal arches) in both their presence and shape.

241. Intercentra, on anteriormost caudal, shape: wedge-like elements (0)/ modified into chevron elements (1) (NEW).
Remarks: The anteriormost caudals that bear intercentra may have intercentra that differ in shape from the more posteriorly located intercentra, suggesting this region corresponds to a different domain in the caudal series. If any variation in the anterior caudal series occurs, this should be observed in the first caudal. Therefore, we score the condition for the anterior caudal intercentra based on the anteriormost caudal. Such variation is observed, for instance, in *Sphenodon*, which has wedge-like intercentra in the anteriormost caudals followed posteriorly by the intercentra forming chevron elements (forming the haemal arches).

242. Intercentra, on posterior caudals (chevron bones): present (0)/ absent (1) (NEW).

243. Chevron bones, articulation: between pleurocentra (0)/ with pleurocentrum, on articulatory facets (1)/ with pleurocentrum, on haemapophyses (=pedicles) (2) (P86, Ch. 54—modified).
Remarks: The condition when the chevrons articulate with the vertebral condyle is considered as either states “1” or” 2”, depending on the kind of articulation. State “0” occurs when the chevrons do not articulate directly with the pleurocentrum, but between them. These conditions are mutually exclusive, justifying their coding under the same character.

244. Chevron bones, fusion to pleurocentrum: unfused (0)/ fused (1) (Lee98, Ch. 184).
Remarks: When the chevrons lay in between the pleurocentra, then the present character is considered to be inapplicable.

245. Chevron bones, distal fusion: separate elements (0)/ “V” shaped (1) / “Y” shaped (2)/ eliptically shaped (3) (NEW).
Remarks: The chevrons may fuse distally into a V-shaped condition, or may have a ventrally directed spine, thus becoming Y-shaped. *Megalancosaurus* has a peculiar elliptically shaped haemal arch, with the two halves being fused proximally and distally (“3”).

Neural arch and neural spine

246. Neural arches, dorsal vertebrae, ventral bridge, posterior borders of neural arches: absent (0)/ present (1) (Lee93, Ch. D9).
Remarks: A bony lamella may occur on the posterior border of the neural arches, connecting its two halves ventrally and bridging the gap between them. This condition is observed in captorhinids and in some sauropterygians.

247. Neural arches, prezygapophyses, presacral vertebrae, processes ventrolaterally on prezygapophyses: absent (0)/ present (1) (LS02, Ch. 200).
Remarks: Observed in many snakes, amphisbaenians and dibamids.

248. Neural arches, presacral vertebrae, zygosphenes: absent (0)/ present (1) (LC00, Ch. 186; Fig. 41 (Hoffstetter & Gasc 1969)).

249. Neural arches, presacral vertebrae, zygosphenes orientation: facing dorsolaterally (0)/ facing ventrolaterally (1) (LC00, Ch. 187; Fig. 41 (Hoffstetter & Gasc 1969)).). L*.
Remarks: The zygosphenes in neural arches with a zygosphene/zygantra articulation system, can be facing dorsolaterally, as in *Lacerta, Cordylus* and *Zonosaurus* and some iguanians (e.g. *Hoplocercus*), or ventrolaterally, as in *Iguana iguana*, snakes and mosasauroids (Hoffstetter & Gasc 1969; Rieppel & Zaher 2000).

250. Neural arches and pleurocentrum, diapophysis, anterior dorsal vertebrae, fusion to parapophysis: absent (0)/ present (1) (NEW).
Remarks: This character refers to the fusion of the para- and diapophyses only, regardless of the number of rib heads (in many instances the two apophyses are confluent, although the ribs still have two separate heads). The degree of fusion between the para- and diapophyses throughout the dorsal region may vary within individuals among some reptiles, usually fusing on the posterior dorsals and decreasing in the degree of fusion further anteriorly. This is very evident in ichthyosaurs (McGowan & Motani 2003), for instance. For this reason, we scored taxa based on the anterior dorsals, as they are the most conservative region on the dorsals regarding this character. Most taxa without a clear dorsal region (e.g. snakes and amphisbaenians) have the same condition visible throughout all, or almost all of their postaxial vertebrae, thus being able to be scored for this particular character.

Kuehneosaurus has three cervical rib attachment surfaces: two in the neural arch (what apparently is a double diapophyses) and one on the anterior border of the pleurocentrum (the true parapophysis)—see also Robinson (1962) and Colbert (1970). The anterior dorsals bear double diapophyses, but the parapophysis is absent. Further posteriorly, on the mid-dorsal region, the number of lateral apophyses is reduced and the vertebrae bear only a single elongated transverse processes. Therefore, it is considered herein that the transverse processes of *Kuehneosaurus* (and which also seems to be the case in *Icarosaurus*), represents only the fusion of the double diapophyses (due to the apparent loss of the parapophyses on the anterior dorsals), instead of a being a true synapophysis by the definition of Hoffstetter & Gasc (1969).

251. Neural arches, margo lateralis, posterior presacral vertebrae: absent (0)/ present (1) (NEW; Fig. 69 (Hoffstetter & Gasc 1969)).).
Remarks: Crest joining pre- and postzygapophyses (Hoffstetter & Gasc 1969).

252. Neural spine, cervical vertebrae, posterior notch: absent (0)/ present (1) (NEW).
Remarks: In some squamates (e.g. anguids) a posterior notch occurs on the apex of the cervical neural spines.

253. Neural spine, cervical vertebrae, apically, lateral expansion: absent (0)/ present (1) (N11, Ch. 191—modified).
Remarks: Occurrence in *Prolacerta*, *Youngina, Icarosaurus* [see also Colbert (1970)], *Kuehneosaurus* and within archosauriforms. In these taxa, the neural spine has a flat apical surface with short laterally projecting apical borders, conferring a "T" shaped neural spine in cross section.

254. Dermal neural spine, dorsal vertebrae: absent (0)/ present (1) (NEW).
Remarks: This additional segment of the neural spine has been suggested to have a different embryological origin from the endochondral ossification leading to the formation of the neural spine of most vertebrates. It has been proposed to be of dermal origin and positioned above the endochondral neural spine (Carroll & Dong 1991). This additional segment of the neural spine has been observed in *Hupehsuchus* (Carroll & Dong 1991), *Nanchangosaurus* (Chen *et al.* 2014), and, within ichthyosaurs, *Stenopterygius* (McGowan 1992) and *Utatsusaurus* (TRS, pers. obs).

255. Neural spine, dorsal vertebrae: present (0)/ absent (1) (LS02, Ch. 190—modified).
Remaarks: Loss of the neural spine occurs within amphisbaenians, some snakes (mostly burrowing forms), and the dolichosaurid *Pontosaurus*.

256. Neural spine, dorsal vertebrae, anterior midline process: absent (0)/ present (1)/ (B85, Ch. R2).
Remarks: The anterior (accessory) midline process of the neural spine fits into paired posterior pits at the base of the neural spines of the vertebrae immediately anterior to it. This condition is observed in taxa such as *Hovasaurus*, *Youngina* [see also Currie (1981a) and Currie (1981b)] and the sauropterygians *Neusticurus*, *Serpianosaurus* and *Lariosaurus*. Much reduced midline processes and posterior pits occur in the cervicals and anteriormost dorsals of *Kuehneosaurus*. These anterior projections are considered to be non-primary homologous to the zygosphene-zygantra system (of the neural arches) observed within lepidosaurs, because the midline processes occur at the base of the neural arches (Rieppel 1989b).

257. Neural spine, dorsal vertebrae, mammillary process: absent (0)/ present (1) (Ev88, Ch. B3 – modified).
Remarks: These are accessory processes located on either side of the neural arches and occur in *Hovasaurus* and *Protorosaurus.*

258. Neural spine, dorsal vertebrae, apically, lateral expansion: absent (0)/ present (1) (N11, Ch. 197).
Remarks: The morphology of this attribute is similar to the neural spine expansion located on the cervical region. Occurrence within archosauromorphs, such as *Prolacerta* and *Prestosuchus*. A similar structure is also observed in the anteriormost dorsals of *Pleurosaurus goldfussi* (BSPG 1978 I 7) and kuehneosaurids. Some taxa bearing the lateral expansion on the cervical region lack it on the dorsal region (e.g. *Youngina*) or vice-versa (e.g. *Proterosuchus alexanderi*), suggesting these distinct vertebral domains have some degree of independent variation that is visible across disparate lineages.

Presacral ribs

259. Presacral ribs, anteroposterior crests: absent (0)/ present (1) (Ly13, Ch. 2).
Remarks: The development of anteroposterior crests on the dorsal ribs creates the T-shaped ribs observed in turtles (e.g.as early as in the stem turtles *Eunotosaurus, Odontochelys* and *Proganochelys*) as well as in *Sinosaurophargis*.

260. Presacral ribs, cervical ribs: present (0)/ absent (1) (NEW).
Remarks: Some protorosaurians lose their cervical ribs, such as observed in *Langobardisaurus* and *Megalancosaurus*.

261. Presacral ribs, cervical ribs, anterior process: absent (0)/ present (1) (G88b, Ch. 143 - modified).
Remarks: Anterior extensions of the rib shafts, as present on the cervical ribs of archosauriforms, rhynchosaurs, some sauropterygians, thallatosaurs and many protorosaurs.

262. Presacral ribs, uncinate processes, anterior dorsals: absent (0)/ present (1) (G88b, Ch. L17).
Remarks: Neomorph cartilages that calcify in *Sphenodon* and crocodiles, and ossify in birds (Gauthier et al. 1988b), as well as within some marine reptiles.

263. Presacral ribs, anteroventral process at rib head (= pseudotuberculum): absent (0)/ present (1) (Lee98, Ch. 187, Fig. 43 (Hoffstetter & Gasc 1969)).
Remarks: The posterodorsal process and the anterodorsal process may occur in conjunction or separately within squamates, justifying their placement as distinct characters.

264. Presacral ribs, posterodorsal process at rib head (= pseudotuberculum): absent (0)/ present (1) (Lee98, Ch. 188, Fig. 43 (Hoffstetter & Gasc 1969)).

265. Posteriormost presacral vertebra, ribs: present (0)/ absent (1) (NEW).

Remarks: Some lizards may lack rib attachment in the last presacrals, forming a “lumbar” region (Hoffstetter & Gasc 1969).

266. Posteriormost presacral vertebra, ribs articulation: ribs unfused (0)/ ribs fused (1) D98, Ch. 137).

267. Sacral ribs, distal forking: absent (0)/ on first sacral rib only (1)/ on first and second sacral ribs (2)/ on second sacral rib only (3) (Lee98, Ch. 189 - modified).
Remarks: Because of the uncertain homology of the sacral elements in squamates with reduced pelvic elements or reduced number of sacrals, this character is inapplicable in such cases (e.g. snakes and amphisbaenians). The forking on distinct sacral vertebrae are treated under the same character because the sacral region is a quite distinct domain and can be considered as a serial homolog in the vertebral column of most tetrapods.

268. Sacral/Cloacal ribs, fusion to pleurocentra: unfused (0)/ fused (1) (G88a, Ch. 87 - modified).

269. Anterior caudal ribs: absent (0)/ present (1) (NEW).
Remarks: Caudal ribs are present in the vast majority of reptiles, but are seemingly absent in *Protorosaurus speneri*, in which only short transverse processes are present (Gottmann-Quesada & Sander 2009) and *Coelurosauravus elivensis* (MNHN MAP 327b—old MNHN 1908-5-2b).

270. Anterior caudal ribs, fusion to pleurocentra: unfused (0)/ fused (1) (G88a, Ch. 87 - modified).
Remarks: The fusion of the anterior caudals to the pleurocentra forms the pleurapophyses observed in captorhinomorphs, in lepidosaurs (Gauthier *et al.* 1988a) as well as *Saurosternon*, squamates and sphenodontids (Carroll 1975). The interpretation of the anterior caudals “transverse processes” in lizards as fused caudal ribs is further supported by personal observation of juveniles of *Liolaemus signifier* (AMNH R80140) that still bear these anterior caudal ribs unfused, and attaching distally to the true transverse processes.

Presternum (=sternum of most reptiles). Squamates have a presternum, a mesosternum and a xiphisternum. The main sternal plate, homologous to other reptile sterna, is formed by the presternum (Russell & Bauer 2008).

271. Presternum, mineralized: absent (0)/ present (1) (B85, Ch. R5; Fig. 1.2 (Russell & Bauer 2008)).
Remarks: A mineralized presternum occurs among most lepidosaurs, but is also observed in “younginiforms” (e.g. *Hovasaurus* and *Thadeosaurus*), and *Saurosternon*.

Xiphisternum

272. Xiphisternum: absent (0)/ present (1) (G88a, Ch. 90—modified; Fig. 1.2 (Russell & Bauer 2008)).

Poststernal inscriptional ribs

273. Mineralized poststernal inscriptional ribs: absent (0)/ present (1) (E88, Ch. 110; Fig. 2 (Etheridge 1965)).
Remarks: Also termed postxiphisternal ribs, these are present posterior to the last presternal ribs and connected distally to the dorsal ribs in many instances. Alternatively, inscriptional ribs may occurs as "free" ribs, when not attaching to the dorsal ribs, such as in *Chalarodon* (Etheridge 1965). The latter condition is observed in many squamates and within rhynchocephalians (e.g. *Sphenodon punctatus* and *Kallimodon* pulchellus, but absent in observed specimens of pleurosaurs and *Clevosaurus hudsoni*). We only scored for mineralized inscriptional ribs, since cartilaginous ones may be incorrectly scored as absent in fossils. Also, as for other characters in this dataset, reduced but still present inscriptional ribs (e.g. as in *Uromastyx*) are scored with the present state. Within squamates, inscriptional ribs are absent or remain cartilaginous in some burrowing forms, and also in some non-burrowing taxa like *Lanthanotus borneensis*.

274. Distal ribs: absent (0)/ present (1) (NEW).
Remarks: In weigeltisaurids [e.g. *Coelurosauravus*—for the taxonomic status of the family, see Bulanov & Sennikov (2010)], there is a secondary set of ribs articulating distally to the proximal (or primary) set, and which is straight and directed laterally. This distal set of ribs is considered non-homologous to the laterally elongate ribs seen in other gliders, such as *Icarosaurus, Kuehneosaurus, Kuehneosuchus* and *Draco*. In the latter instances, the laterally elongate ribs are attaching to expanded transverse processes of the dorsal vertebrae, and are thus considered homologous to the ribs of other reptiles (or the proximal set of dorsal ribs of weigeltisaurids). The distal set of ribs of weigeltisaurids is also non-homologous to the inscriptional ribs, such as the ones present in most squamates. Despite both the distal ribs and inscriptional ribs attaching distally to the primary set of ribs, they are morphologically distinct in terms of shape and degree of mineralization.

Apendicular skeleton

Pectoral girdle

Scapula

275. Scapula, supraglenoid foramen: absent (0)/ present (1) (LR95, Ch. 97).
Remarks: This foramen is observed just above the glenoid, and it is more laterally placed in early reptiles. In some iguanian squamates, a supraglenoidal foramen is also observed, but placed more posteriorly on the scapula, as in *Crotaphytus collaris* and *Polychrus marmoratus*.

276. Scapula, supraglenoid buttress: absent (0)/ present (1) (G88b, Ch. 147).

277. Scapula, scapula ray: absent (0)/ present (1) (E88, Ch. 111 – modified; Fig. 1.2 (Russell & Bauer 2008)).

278. Scapula, dorsal acromion process: absent (0)/ present (1) (NEW).
Remarks: This character refers to the dorsalmost region of the scapular blade (and part of the suprascapular) that might be expanded anterodorsally, as observed in many squamate clades.

279. Scapula, supracoracoidal acromion process: absent (0)/ present (1).
Remarks: The present structure is located on the anteroventral margin of the scapula, as seen in *Proganochelys* and other turtles, and is not homologous to the structure of similar name seen in squamates, and which is located anterodorsally.

280. Scapula, posterior emargination: absent (0)/ present (1) (NEW).
Remarks: Observed among many sauropterygians and protorosaurs.

281. Scapula, anterior emargination: absent (0)/ present (1) (E88, Ch. 111).
Remarks: In squamates, the anterior margin is not truly emarginated. In most squamates the anterior margin is relatively straight or convex. Iguanians may bear a scapular ray (see above), but the margin to which it connects to is straight too. Some rhynchocephalians have a true emargination, with the anterior margin being concave anteriorly, and which is not homologous to the scapular "emargination" or fenestra to which the scapular ray contributes to delimit in some squamates.

Procoracoid. The squamate coracoid is homologous to the procoracoid (= anterior coracoid) of early deriving amniotes (Russell & Bauer 2008, p. 84) which bears the supracoracoid foramen.

282. Procoracoid, supracoracoid foramen: absent (0)/ notch (1)/ complete foramen (2) (R94, Ch. 71-modified; Fig. 1.2 (Russell & Bauer 2008)).
Remarks: In *Placodus gigas* and *Neusticosaurus (= Pachypleurosaurus) edwardsi* the supracoracoid foramen is actually a notch on the proximal margin of the coracoid.

283. Procoracoid, angulation medially: absent (0)/ present (1) (NEW).
Remarks: Observed within sauropterygians.

284. Procoracoid, coracoid emargination: absent (0)/ anterior emargination (1)/ anterior and posterior emarginations (2) (P86, Ch. 56 and 57; Fig. 1.2, 1.3 and 1.5 (Russell & Bauer 2008)).
Remarks: The anterior coracoid emargination is separated from the scapulocoracoid emargination dorsally by the first (anterior) coracoid ray and the posterior coracoid emargination is separated from an anterior coracoid emargination by the second (posterior) coracoid ray. The posterior emargination only occurs if the anterior one is also present; thus they are part of the same transformation series and logically nested. Therefore, this character is treated as ordered.

Posterior coracoid

285. Posterior coracoid: absent (0)/ present (1) [G88b, Ch. 148; Fig. 142 and 143 in Romer (1956)]
Remarks: The posterior coracoid occurs in early amniotes, such as early synapsids and reptiles. Whereas the anterior coracoid (procoracoid) is homologous with the single coracoid of most reptiles, the posterior coracoid in homologous to the mammalian coracoid (Romer 1922; Romer 1956; Russell & Bauer 2008).

286. Epicoracoids: absent (0)/ present (1) (NEW; Fig. 1.2 (Russell & Bauer 2008)).
Remarks: Present as a calcified cartilage within lepidosaurs.

Clavicles. Considered homologous to the epiplastron of turtles (Gaffney 1990; Lyson *et al.* 2013b; Rice *et al.* 2015; Rice *et al.* 2016).

287. Clavicles, secondary curvature anteroposteriorly: absent (0)/ present (1) (E88, Ch. 116; Fig. in G12, Ch. 502).
Remarks: In some squamate taxa, the clavicle is curved posterolaterally, and then anteromedially on its most dorsal portion, such as in *Lacerta viridis*.

288. Clavicles, proximoventral fenestration: absent (0)/ present (1) (LC00, Ch. 218—modified; Fig. in G12, Ch. 500).
Remarks: In the present character, the absent condition may include ventrally emarginated or hook-shaped clavicles that do not constitute fully fenestrated clavicles.

289. Clavicles, posterior process: absent (0)/ present (1) (NEW).
Remarks: Observed in scleroglossans lizards, such as some anguids, scincids and cordylids.

290. Clavicles, dorsolateral flange: absent (0)/ present (1) (NEW).
Remarks: Observed within sauropterygians and saurospharids.

291. Clavicles, position (at point of contact), in relation to anterior margin of scapula: laterally (0)/ medially (1)/ anteriorly (2) (R94, Ch. 65 – modified).
Remarks: Whereas in most reptiles the clavicles are positioned laterally or anteriorly to the anterior edge of the scapula, in sauropterygians the clavicles are positioned medially to the scapula.

292. Clavicles, position (at point of contact), in relation to anterior margin of the interclavicle: ventrally (0)/ dorsally (1)/ anteriorly (2) (R94, Ch. 62 and DBR96, Ch. 54).
Remarks: The clavicles are positioned ventrally to the anterior margin of the interclavicle in most reptiles, but in many sauropterygians the clavicles are positioned dorsally. The clavicles are positioned anteriorly in procolophonians (de Braga & Reisz 1996), captorhinids, some early diapsids, and in various groups of squamates.

Interclavicle: considered homologous to the entoplastron of turtles (Gaffney 1990; Lyson *et al.* 2013b; Rice *et al.* 2015; Rice *et al.* 2016).

293. Interclavicle, anterior process: absent (0)/ present (1) (P86, Ch. 59).
Remarks: A distinct anterior process of the interclavicle is absent in the earliest amniotes, which had a polygonal shaped interclavicle. However, an anterior process becomes distinct and present when a cruciform interclavicle is acquired in later forms. The anterior process is absent or reduced in some diapsid taxa, including sauropterygians and some rhynchocephalians.

294. Interclavicle, posterior process: present (0)/ absent (1) (G88b, Ch. 156).
Remarks: The posterior process of the interclavicle is present in most reptiles, with the exception of sauropterygians.

Cleithra: considered homologous to the turtle nuchal bone (Lyson *et al.* 2013b).

295. Cleithra: present (0)/ absent (1) (B85, Ch. C8).

Pelvic girdle

Ilia

296. Ilia, posterodorsal notch, on acetabular margin: absent (0)/ present (1) (NEW).
Remarks: This notch occurs on the posterodorsal margin of the acetabulum of most reptiles, but is absent within sauropterygians.

297. Ilia, supraacetabular buttress: absent (0)/ present (1) (G88b, Ch. 179).

Remarks: There may also exist some contribution from the pubis for the formation of the supraacetabular buttress.

298. Ilia, anterior pubic process: absent (0)/ present (1) (B85, Ch. J12).
Remarks: The anterior extension of the ilium dorsally to the pubis is present in some early reptiles (e.g. *Hovasaurus* and *Acerosodontosaurus*) and most squamates, but this process is absent in many reptilian lineages, such as *Youngina*, *Prolacerta*, rhynchosaurs, and early archosauriformes, such as *Erythrosuchus*, *Proterosuchus* and *Euparkeria*.

299. Ilia, anterior (=preacetabular) process: absent (0)/ present (1) (Lee97, Ch. 132; Fig. 1.14 (Russell & Bauer 2008)).
Remarks: Process located on the iliac blade or the anterior extension of the ilium (character #).

Pubes

300. Pubes, obturator foramen: absent (0)/ complete foramen (1)/ notch (2) (NEW).
Remarks: The obturator foramen becomes incorporated into a thyroid fenestra in extant turtles (Romer 1956) and some ichthyosaurs (McGowan & Motani 2003) . A notch on the lateral margin of the pubes is seen in some sauropterygians and saurophargids (e.g. *Largocephalosaurus*).

301. Pubes, pubic tubercle: absent (0)/ present (1) (B85, Ch. J11; Fig. 1.14 (Russell & Bauer 2008)).

Ischia

302. Ischia, fusion to pubes: absent (0)/ present (1) (NEW).
Remarks: In some captorhinids (e.g. *Captorhinus aguti* and *Labidosauru hamatus*), the pubes and ischia are fused into a single bony plate.

303. Ischia, anterior border, emargination: absent (0)/ present (1) (NEW).
Remarks: The thyroid fenestra is usually formed by an anteromedial emargination on the ischium and another emargination on the posterior border of the pubis. In some taxa, however, the thyroid fenestra is formed only by the anterior concavity of the isquia (e.g. *Utatsusaurus hataii*). The present character construction avoids scoring taxa with different kinds of thyroid fenestra under the same character-state by coding the actual bone morphology that results in the formation of the fenestra. When the ischium and pubes are fused (e.g. *Captorhinus aguti* and *Labidosauru hamatus*), then the shape of the anterior border cannot be assessed.

304. Ischia, ischiadic tuberosity: absent (0)/ present (1) (J94, Ch. 10—modified; Fig. 1.14 (Russell & Bauer 2008)).

305. Ischia, isquiadic neck: absent (0)/ present (1) (NEW).
Remarks: Thick “neck-like”region observed on the dorsal surface of the ischium, extending from the acetabular region to the symphysial margin of the ischium.

306. Ischia, facet, for hypoisquium: absent (0)/ present (1) (NEW; Fig. 1.14 (Russell & Bauer 2008)).
Remarks: Rather than coding for the absence or presence of the hypoisquium, coding the facet for it allows its scoring for fossil forms with less ambiguity and missing data.

Anterior propodial (= stylopodial)

Humeri

307. Humeri, ectepicondyle foramen: absent (0)/ groove (1)/ notch (2)/ complete foramen (3) (G88b, Ch. 162 and 163—modified).
Remarks: When the ectepicondyle foramen is incomplete and forms a notch, then a supinator process becomes evident, such as observed in *Paleothyris*. When this foramen is complete, such as in *Protorothyris*, then the supinator process is absent. For this reason, we consider the character presence or absence of the supinator process as part of the transformation series of the ectepicondyle foramen. In some taxa, only a groove with no foramen or notch is present, such as in *Placodus gigas*. Considering that an ectepicondylar groove may occur even in the absence of a distinct epicondyle (as it can be located on the humeral shaft), this character is scored even in the absence of the epicondyles.

308. Humeri, epicondyles: present (0)/ absent (1) (R94, Ch. 75).
Remarks: In all observed taxa, when one of the epicondyles is absent, the other is missing too, thus we code both epicondyles together to avoid overweighting these variables.

309. Humeri, entepicondyle foramen: absent (0)/ opening dorsally only (1)/ opening ventrally only (2)/ fully open ventrally and dorsally (3) (B85, Ch. C9 - modified).
Remarks: Most reptiles with an entepicondylar foramen display it on the dorsal surface of the distal end of the humerus, state “1”. However, some sphenodontians develop this foramen ventrally only, and in sauropterygians and early reptiles there is a full opening connecting the dorsal and ventral sides of the humerus. The character states herein do not occur in conjunction, thus being mutually exclusive and being better coded as different character states within a single character instead of split into contingently coded characters.

310. Humeri, expanded radial condyle (= capitelum): present (0)/ absent (1) (NEW).

311. Humeri, pectoral process: present (0)/ absent (1) [DBC93, Ch. 107—modified; Fig. 163-165 in Romer (1956)]
Remarks: In some early reptiles, the pectoral process is a distinct element, separate from the humeral head. When the pectoral and deltoid processes are connected to the humeral head, a deltopectoral crest is formed.

312. Humeri, pectoral process, connection to humeral head: separate (0)/ connected (1) [DBC93, Ch. 107—modified; Fig. 166 and 167 in Romer (1956)]

313. Humeri, shaft angulation: straight (0)/ angulate posteriorly (1) (R94, Ch. 74).
Remarks: Humeral shaft posteriorly angulated within sauropterygians and in some "younginiforms".

314. Humeri, secondary ossification of epiphyses: absent (0)/ present (1) (B85, Ch. X1—modified).
Remarks: Observed in squamates and rhynchocephalians.

315. Humeri, anterior flange: absent (0)/ present (1) (Ch14, Ch. 209; Fig. 2 (Motani 1999a)).
Remarks: Present on the humerus of ichthyosaurs.

Anterior epipodials (= zeugopodials)

Radia

316. Radia, distal epiphysis, styloid process: absent (0)/ present (1) (G88a, Ch. 99; Fig. 9 in G88a).
Remarks: Observable in ventral and medial aspect in articulation with the radiale. This feature may not be seen in fossil taxa with the epiphyses not preserved (in which case they are scored as missing data).

317. Radia, anteroproximal process: absent (0)/ present (1) (NEW; Fig. 6b (Motani 1999a)).
Remarks: Similar in shape in lateral aspect (dorsal aspect in the forefin plane of orientation) to the olecranon process of the ulna. Present in the radius of early ichthyosaurs.

Ulnae

318. Ulnae, ossified olecranon process: present (0)/ absent (1) (B85, Ch. B11).

319. Ulnae, distal epiphysis, expansion: absent (0)/ present (1) (B85, Ch. X3; Fig. 9 in G88a).
Remarks: A distally expanded or “ball-like” distal epiphysis of the ulna is observed within squamates. The presence of a proximal concavity on the ulnare of lizards is dependent upon the presence of a distal ball-like distal epiphysis of the ulna and the formation of a ball-socket articulation. Therefore, a character on the proximal concavity on the ulnare is not included in the present dataset.

Anterior mesopodials (= carpals)

320. Perforating foramen, manus: absent (0)/ between ulnare and intermedium (1)/ between radiale and intermedium (2) (B85, Ch. C10 and DBR97, Ch. 131).
Remarks: The perforating foramen is usually present between the ulnare and intermedium, such as in *Hovasaurus* (Currie 1981a), but may also occur between the radiale and intermedium, such as in *Trilophosaurus* (Gregory 1945). This character refers to the mutually exclusive positions of the perforating artery. Therefore, character state “0” is mutually exclusive to states “1”, “2” and “3” herein, and does not justify its splitting into two contingent characters.

Intermedium

321. Intermedium: present (0)/ absent (1) (Ev88, Ch. E8).

Pisiform

322. Pisiform: absent (0)/ present (1) (Mo99, Ch. 67).
Remarks: Postaxial element, positioned ventrally to the ulnare in squamates and other reptiles.

Palmar sesamoid

323. Palmar sesamoid: absent (0)/ present (1) (G12, Ch. 539, Fig. 539).

Distal carpal 1:

324. Distal carpal 1: present (0)/ absent (1) (G88a, Ch. 103; Fig. 4c and d in G88a).

Remarks: The element that partially occupies the position of the first distal carpal in lizards represents the medial centrale(Russell & Bauer 2008) [lateral central *sensu* Romer (1956)], resulting from the fusion of the first carpal to the first metacarpal, and a slight shift in position of the medial centrale (Carroll 1977; Gauthier *et al.* 1988a). This fusion usually results in an enlarged epiphysis of the first metacarpal (which also occupies part of the position of the first carpal) followed by a reduced number of anterior carpal elements. Because the underlying developmental process of fusion cannot be assessed in the vast majority of sampled taxa, the wording of the present character reflects the absence of DC1 only. Nevertheless, among all taxa studied herein the absence of a distinct DC1 always seemed to reflect the fusion of the latter to the first metacarpal (by possessing an expanded proximal epiphysis on MC I). Therefore, all taxa scored with the absent condition herein are primarily homologous based on similarity, likely all due to the fusion of the DC1 to the first metacarpal.

Distal carpal 5

325. Distal carpal 5: present (0)/ absent (1) (NEW).
Remarks: Absent in a variety of taxa, including *Hupehsuchus*, ichthyosaurs, *Askeptosaurus*, at least some sauropterygians, *Protorosaurus* and *Mesosuchus*.

Anterior metapodials (metacarpals)

Femora

326. Femora: present (0)/ absent (1) (G12, Ch. 548).

327. Femora, internal trochanter: present (0)/ absent (1) (G12, Ch. 550; Fig. 1.35 in (Russell & Bauer 2008)).
Remarks: The minor trochanter of turtles is considered to be primarily homologous with the internal trochanter of other reptiles, whereas the greater trochanter is unique to them and distinct from the mammalian one (Romer 1956). Despite the femur being present in some amphisbaenians and snakes, its highly reduced morphology makes the scoring of this character (and subsequent ones) inapplicable.

328. Femora, fourth trochanter: absent (0)/ present (1) (B85, Ch. I4).

329. Femora, intertrochanteric fossa: present (0)/ absent (1) (G88b, Ch. 184—modified; Fig. 1.35 in (Russell & Bauer 2008)).

Tibiae

330. Tibiae, distal epiphysis, notch: absent (0)/ present (1) (E88, Ch. 123—modified; Fig. 555 in G12).
Remarks: When the distal epiphysis notch is present it creates the saddle-shaped joint between the tibia and the astragalocalcaneum observed in some lizards. This feature is observable in ventral and dorsal aspects, but may not be seen in fossil taxa with the epiphyses not preserved (in which case they are scored as missing data).

Posterior mesopodials (= tarsals)

Astragalus

331. Astragalus and calcaneum: as totally separate elements (0)/ fused (1) (B85, Ch. X10).

332. Astragalus, shape, concave laterally: absent (0)/ present (1) (B85, Ch. C12-modified).
Remarks: This character refers to the lateral concavity of the astragalus that serves for the reception of the calcaneum in some archosauromorphs.

Calcaneum

333. Calcaneum, lateral tuber (or process) of the calcaneum: present (0)/ absent (1) (G88b, Ch. 198; Fig. 1.18 (Russell & Bauer 2008)).
Remarks: The lateral flange of the calcaneum is present in many reptiles but is most commonly observed among lepidosaurs.

334. Calcaneum, foramen for perforating artery, position: absent (0)/ between astragalus and cacaneum (1)/ between proximal ends of tibia and fibula (R94, Ch. 87).
Remarks: A notch on both the astragalus and calcaneum characterizes the opening between both for the perforating artery (Romer 1956, p. 392). The opening for the artery is displaced proximally in lepidosaurs and turtles (between the distal heads of the tibia and fibula), to allow for the formation of an active joint between the astragalus and calcaneum (Rieppel 1993b; O'Keefe *et al.* 2006). A similar active joint between the astragalus and calcaneum is seen in captorhinids, but the perforating artery is, instead, displaced distally (Holmes 2003; O'Keefe *et al.* 2005; O'Keefe *et al.* 2006). This character refers to the mutually exclusive positions of the perforating artery. Therefore, character state “0” is consideres to be mutually exclusive to states “1” and “2” herein, and does not justify its splitting into two contingent characters.

Lateral centrale

335. Pedal lateral centrale: absent (0)/ present (1) (B85, Ch. X11; Fig. 8 in G88a).
Occurrence: The pedal lateral central is absent in lepidosaurs.

Distal tarsal 1 (Dt1)

336. Distal tarsal 1: present (0)/ absent (1) (B85, Ch. X12).

Distal tarsal 2 (Dt2)

337. Distal tarsal 2: present (0)/ absent (1) (Ev88, Ch. L20).
Remarks: Absent in squamates, and some rhynchocephalians, protorosaurs, and sauropterygians.

Distal tarsal 4 (Dt4)

338. Distal tarsal 4, proximal peg: present (0)/ absent (1) (Ev88, Ch. J1; Fig. 1.20 (Russell & Bauer 2008)).
Remarks: This proximal peg is better observed in ventral aspect of the tarsus of lizards, in articulation with the astragalocalcaneum. The proximal peg is responsible for the mesotarsal articulation in lizards, and is also observed in other reptilian groups. The presence of a distomesial articulatory surface on the astragalocalcaneum that articulates with this proximal peg is dependent upon this character, and therefore it is not included as a character here to avoid redundancy.

Distal tarsal 5 (Dt5):

339. Distal tarsal 5: present (0)/ absent (1) (R99, Ch. 114).
Remarks: The absence of the distal tarsal 5 may be due to its fusion to the metatarsal V, forming a hooked fifth metatarsal. However, numerous taxa that lack distal tarsal 5 do not have a hooked fifth metatarsal (e.g. sauropterygians, thalattosaurs, *Protorosaurus,* ichthyosaurs and *Odontochelys*). Therefore, we coded both features as separate characters herein.

Posterior metapodials (metatarsals)

Metatarsal 5 (Mt5)

340. Metatarsal 5, hooked: absent (0)/ present (1) (B85, Ch. C14; Fig. 1.20 (Russell & Bauer 2008)).

Remarks: Benton (1985) described this character originally as a non-lepidosaur type of hooked fifth metatarsal, such as lacking the plantar tubercle observed in lepidosaurs. However, the latter feature is placed herein as a distinct character.

341. Metatarsal 5, plantar tubercle: absent (0)/ present (1) (DBR97, Ch. 156; Fig. 1.20 (Russell & Bauer 2008)).

Other ossifications

342. Gastralia: absent (0)/ present (1) (G88a, Ch. 136).
Remarks: These are dermal ossifications that should not be confused with the inscriptional ribs (of endochondral ossification) structure present in lizards, sometimes erroneously referred to as "abdominal ribs", "gastralia", "parasternal chevrons" or "parasternal ribs" (Etheridge 1965).

343. Dorsal trunk osteoderms: absent (0)/ present (1) (B85, Ch. K9).

344. Dorsal trunk osteoderms, imbrication: not imbricated (1)/ imbricated (2) (G12, Ch. 570).

345. Plastron plate: absent (0)/ present (1) (Ly13, Ch. 11).
Remarks: The gastral plates in the plastron of turtles are considered a derivative from the ventral ribs (gastralia) of most other reptiles (Scheyer *et al.* 2008; Lyson *et al.* 2013b; Rice *et al.* 2016). Because we adopted a contingent coding scheme here, the plastron condition is scored as a distinct character, instead of forming an ordered multistate character related to the gastralia.

346. Neural plates: absent (0)/ present (1) (Ly13, Ch. 8).
Remarks: The homology of the neural and costal plates of turtles has long been debate, but more recent data suggests they are periosteal derivatives of the axial skeleton, thus not being independent centres of ossification (Scheyer *et al.* 2008). Yet, their distinct morphology, topology and connectivity indicate that (even if connected to the vertebrae and ribs), the neural and costal plates can be characterized as a distinct locator, and thus an independent character of its own. The same occurs for the distal ribs seen in kuehneosaurids and the inscriptional ribs of many squamates.

347. Costal plates: absent (0)/ present (1) (NEW).
Remarks: see character 346, above.

Synonyms between some of the anatomical terms used herein and terms used by other authors.

Meckel's (or Meckelian) canal (Oelrich 1956) = mandibular canal (Lee *et al.* 2001); Internal mental canal (Gauthier 1982) = intramandibular canal (Gauthier *et al.* 2012); Posterior surangular foramen (Oelrich 1956) = foramen nervi auriculotemporalis (Gaffney 1972); Posterior mylohyoidal foramen (Oelrich 1956) = foramen intermandiularis caudalis (Gaffney 1972) = posterior mekelian foramen (Benton 1983); Anterior mylohyoidal foramen (Oelrich 1956) = foramen intermandiularis oralis (Gaffney 1972) = anterior mekelian foramen (Benton 1983); Suborbital fenestra = suborbital foramen = inferior orbital foramen (Oelrich 1956) = palatine fontanelle (Jollie 1960); Infraorbital foramen (Oelrich 1956; Kluge 1962) = maxillopalatine foramen = infraorbital canal (Jollie 1960) = foramen alveolare superior (Gaffney 1972); Trigeminal notch (McDowell & Bogert 1954) = prootic incisures (Romer 1956) = Incisura prootica; Supratemporal process of parietal (Oelrich 1956) = Postparietal process (Evans 2008); Quadrate conch (Jollie 1960) = tympanic recess (Clark & Hernández 1994); Adductor fossa (Romer 1956) = mandibular foramen (Oelrich 1956) = Mandibular fossa (Jollie 1960); Atlas zygapophyseal articulation (Hoffstetter & Gasc 1969) = Atlas postzygapohysis (used herein) = posterodorsal process (Čerňanský *et al.* 2014; Čerňanský 2016); Margo ventralis (Hoffstetter & Gasc 1969) = subcentral ridge (Auffenberg 1963) = posterior centrosynapophyseal lamina (Tschopp 2016); Margo lateralis (Hoffstetter & Gasc 1969) = interzygapophyseal ridge (Auffenberg 1963) = postzygoprezygapophyseal lamina (Tschopp 2016).

Part 3. Supplementary Tables

Supplementary Table S1. GenBank accession numbers

Taxon	BDNF	CAND1	C-*mos*	CXCR4
Anilius scytale	EU402625.1	GU432630.1	AF544722.1	JN702453.1
Bipes biporus	JN654794.1	JN881176.1	AF039482.1	JN702381.1
Blanus cinereus			AY444019.1	
Broadleysaurus major	HM160588.1		EU366459.1	
Coleonyx variegatus	HQ876231.1	JF818522.1	EU116676.1	JN702309.1
Cordylus niger	KT941174.1		KT941211.1	
Crotaphytus collaris	JF806021.1	JF818552.1	AY987985.1	JN702405.1
Cylindrophis ruffus	EU402635.1	JF818530.1	AF471133.1	JN702366.1
Dactylocnemis pacificus				
Dibamus novaeguineae	GU457863.1	GU432611.1	EF450999.1	JN702424.1
Elgaria multicarinata	GU457854.1	GU432602.1	AF039479.1	JN702462.1
Gekko gecko	EU402614.1	GU432614.1	EU366455.1	JN702441.1
Heloderma suspectum	GU457856.1	GU432604.1	AY487348.1	
Hoplocercus spinosus				
Iguana iguana	KR350713.1		AF148708.1	
Lacerta viridis	GU457875.1	GU432624.1	DQ097132.1	JN702397.1
Lanthanotus borneensis	GU457859.1	GU432607.1	AY662564.1	JN702444.1
Leiocephalus carinatus	AY987970.1			
*Liolaemus signifier**			JN683118.1	
Mabuya mabouya				
Oplurus cyclurus	GU457850.1	GU432597.1	EU099679.1	JN702378.1
Petracola ventrimaculatus			AY507910.1	
Phrynosoma modestum	DQ385325.1	KR360318.1		KR359901.1

Plestiodon fasciatus	HQ876228.1	JF818524.1	HQ655218.1	JN702435.1
Polychrus marmoratus	HQ876222.1	JF818569.1	AY987983.1	JN702359.1
*Pristidactylus scapulatus**	JF806025.1	JF818559.1	KT342956.1	JN702459.1
Pseudopus apodus	GU457851.1	GU432599.1		
Rhineura floridana	GU457878.1	GU432628.1	AY444021.1	JN702310.1
Sphenodon punctatus	GU457846.1	GU432592.1	AF039483.1	JN702443.1
*Stenocercus scapularis**	HQ876224.1	JF818571.1		JN702380.1
Teius teyou	JN654803.1	JN881211.1		JN702400.1
Timon lepidus			EF632290.1	
Trioceros jacksonii	KC507666.1		AF137528.1	
Uromastyx aegyptia			AF137531.1	
Varanus salvator	EU402618.1	GU432610.1	AF435017.1	JN702430.1
Xantusia vigilis	EU402620.1	JF818525.1	EU116833.1	JN702337.1
Xenopeltis unicolor	EU402668.1	GU432635.1	AF544689.1	JN702383.1
Xenosaurus grandis	GU457858.1	GU432606.1	AY662567.1	JN702341.1

Taxon	**NGFB**	**NTF3**	**PDC**	**R35**
Anilius scytale	EU437988.1	AY988055.1		HQ876355.1
Bipes biporus	JN662833.1	JN568335.1		HQ876353.1
Blanus cinereus		EU108015.1		
Broadleysaurus major		EU636222.1		HM161062.1
Coleonyx variegatus	JF818314.1	JF804539.1	EF534817.1	HQ876371.1
Cordylus niger				KT941339.1
Crotaphytus collaris	JF818338.1	JF804542.1		JF804586.1
Cylindrophis ruffus	EU437999.1	EU390915.1		JF804588.1
Dactylocnemis pacificus			GU459586.1	
Dibamus novaeguineae	GU432728.1	JF804544.1	HQ426251.1	

Elgaria multicarinata	GU432720.1	GU456010.1		HQ876338.1
Gekko gecko	EU437977.1	EU390898.1	EF534854.1	HQ876378.1
Heloderma suspectum	GU432722.1	GU456012.1	HQ426254.1	HQ876340.1
Hoplocercus spinosus				
Iguana iguana		HM352530.1		KR350699.1
Lacerta viridis	GU432740.1	GU456031.1		JF804593.1
Lanthanotus borneensis	GU432725.1	GU456015.1		
Leiocephalus carinatus		AY987999.1		KU979291.1
*Liolaemus signifier**				
Mabuya mabouya	JF498230.1			KJ574880.1
Oplurus cyclurus	GU432716.1	GU456006.1		HQ876332.1
Petracola ventrimaculatus				
Phrynosoma modestum	KR360303.1	KR360083.1		KJ124012.1
Plestiodon fasciatus	JF498300.1	JF804547.1		HQ907629.1
Polychrus marmoratus	JF818355.1	JF804564.1		HQ876335.1
*Pristidactylus scapulatus**	JF818345.1	JF804565.1		JF804601.1
Pseudopus apodus	GU432717.1	GU456007.1		JN703073.1
Rhineura floridana	GU432743.1	GU456034.1	EU293714	DQ119613.1
Sphenodon punctatus	GU432712.1	GU456002.1	HQ426257.1	HQ876320.1
*Stenocercus scapularis**	JF818357.1	JF804570.1		HQ876337.1
Teius teyou	JN662830.1	JN568323.1		JN568511.1
Timon lepidus			KX080818.1	
Trioceros jacksonii		AY988006.1		
Uromastyx aegyptia				
Varanus salvator	EU437981.1	EU390902.1		JN568500.1
Xantusia vigilis	EU437983.1	EU390904.1	HQ426258.1	HQ876351.1
Xenopeltis unicolor	EU438032.1	DQ465562.1		

Xenosaurus grandis	GU432724.1	GU456014.1		JN703069.1

Taxon	RAG1	ND2	ZEB2	FSHR
Anilius scytale	EU402834.1	NC_014343.1	EU390857.1	EU391110.1
Bipes biporus	HQ876445.1	NC_006287.1	JN568546.1	
Blanus cinereus	EU108523.1	NC_012433.1		
Broadleysaurus major		KF717422.1		
Coleonyx variegatus	HQ876448.1	NC_008774.1	JF804620.1	JF804389.1
Cordylus niger	KT941374.1	AY519699.1		
Crotaphytus collaris	JF806206.1	U82681.1	JF804623.1	JF804392.1
Cylindrophis ruffus	EU402842.1	AB179619.1	EU390866.1	EU391120.1
Dactylocnemis pacificus	GU459392.1	GU459794.1		
Dibamus novaeguineae	GU457986.1	FJ195390.1		
Elgaria multicarinata	GU457977.1	AF085620.1	GU456232.1	GU455976.1
Gekko gecko	EU402824.1	NC_007627.1	EU390847.1	EU391100.1
Heloderma suspectum	GU457979.1	NC_008776.1	GU456234.1	GU455978.1
Hoplocercus spinosus	AY662592.1	U82683.1		
Iguana iguana	KR350706.1	JF498123.1		
Lacerta viridis	GU457997.1	NC_008328.1	GU456253.1	GU455996.1
Lanthanotus borneensis	GU457982.1	AF407541.1	GU456237.1	GU455981.1
Leiocephalus carinatus	AY662598.1	AF049864.1		
*Liolaemus signifier**		AF099266.1		
Mabuya mabouya		JF498123.1		
Oplurus cyclurus	GU457973.1		GU456228.1	GU455972.1
Petracola ventrimaculatus				
Phrynosoma modestum	KR360097.1	AY297484.1	KR360287.1	KR360399.1
Plestiodon fasciatus	HQ876444.1	AY607299.1	JF804627.1	JF804396.1

Polychrus marmoratus	HQ876438.1	NC_012839.1	JF804644.1	JF804413.1
*Pristidactylus scapulatus**	JF806210.1	AF528732.1	JF804645.1	JF804414.1
Pseudopus apodus	GU457974.1	AF085623.1	GU456229.1	GU455973.1
Rhineura floridana	GU458000.1	NC_006282.1	GU456256.1	GU455999.1
Sphenodon punctatus	GU457969.1	KP996625.1	GU456224.1	GU455968.1
*Stenocercus scapularis**	HQ876440.1	DQ080223.1	JF804650.1	JF804419.1
Teius teyou	JN654865.1	JN700172.1	JN568560.1	JN568475.1
Timon lepidus	EF110996.1	DQ902256.1		
Trioceros jacksonii	JQ073211.1	AF448753.1		
Uromastyx aegyptia		AB619817.1		
Varanus salvator	EU402828.1	NC_010974.1	EU390851.1	EU391104.1
Xantusia vigilis	EU402830.1	EU130279.1	EU390853.1	EU391106.1
Xenopeltis unicolor	EU402870.1	NC_007402.1	EU390897.1	EU391152.1
Xenosaurus grandis	GU457981.1	U71333.2	GU456236.1	GU455980.1

Taxon	**TRAF6**	**FSTL5**	**12S**	**16S**
Anilius scytale	EU391058.1	EU402785.1	NC_014343.1	NC_014343.1
Bipes biporus	JN568459.1	JN654834.1	NC_006287.1	NC_006287.1
Blanus cinereus			NC_012433.1	NC_012433.1
Broadleysaurus major			AJ416921.1	AJ416922.1
Coleonyx variegatus	JF804342.1	JF806108.1	NC_008774.1	NC_008774.1
Cordylus niger			HQ167106.1	HQ167217.1
Crotaphytus collaris	JF804345.1	JF806134.1	L40439.1	L41443.1
Cylindrophis ruffus	EU391069.1	EU402795.1	AB179619.1	AB179619.1
Dactylocnemis pacificus				GU459993.1
Dibamus novaeguineae			FJ195390.1	FJ195390.1
Elgaria multicarinata	GU456155.1	GU457947.1	AY649110.1.1	

Gekko gecko	EU391048.1	EU402775.1	NC_007627.1	NC_007627.1
Heloderma suspectum	GU456157.1	GU457948.1	NC_008776.1	NC_008776.1
Hoplocercus spinosus				
Iguana iguana			NC_002793.1	NC_002793.1
Lacerta viridis	GU456176.1	GU457964.1	NC_008328.1	NC_008328.1
Lanthanotus borneensis	GU456160.1	GU457951.1		
Leiocephalus carinatus				
*Liolaemus signifier**			KF969090.1	
Mabuya mabouya			JF497871.1	AY070357.1
Oplurus cyclurus	GU456151.1	GU457943.1	U39585.1	
Petracola ventrimaculatus			KJ948193.1	KJ948144.1
Phrynosoma modestum	KR360111.1	KR360139.1	DQ385397.1	L41455.1
Plestiodon fasciatus	JF804349.1	JF806110.1	AY315505.1	AY308199.1
Polychrus marmoratus	JF804366.1	JF806144.1	NC_012839.1	NC_012839.1
*Pristidactylus scapulatus**	JF804367.1	JF806145.1	KT342931.1	
Pseudopus apodus	GU456152.1	GU457944.1	AF380955.1	JX987420.1
Rhineura floridana	GU456179.1	GU457967.1	NC_006282.1	NC_006282.1
Sphenodon punctatus	GU456147.1	GU457940.1	KP996625.1	KP996625.1
*Stenocercus scapularis**	JF804372.1	JF806148.1		L41481.1
Teius teyou	JN568447.1	JN654844.1	AY046461.1	AY046503.1
Timon lepidus			GQ142071.1	AF378949.1
Trioceros jacksonii			DQ397240.1	JN165401.1
Uromastyx aegyptia			FJ639656.1	FJ639621.1
Varanus salvator	EU391052.1	JF806113.1	NC_010974.1	NC_010974.1
Xantusia vigilis	EU391054.1	EU402781.1	AY218042.1	KC621482.1
Xenopeltis unicolor	EU391099.1	EU402823.1	NC_007402.1	NC_007402.1
Xenosaurus grandis	GU456159.1	GU457950.1		

Supplementary Table S2. List of fossil taxa and updated ages used for tip-calibrations.

Fossil Taxa	Chronostratigraphy	Age	Age references
EARLY REPTILES			
Protorothyris archeri	Sakmarian, Cisuralian, Lower Permian	295-290.1	Clark & Carroll (1973); Lucas (2006); Ogg et al (2016)
Protocaptorhinus pricei	late Artinskian, Cisuralian, Lower Permian	286-283.5	Clark & Carroll (1973); Lucas (2006); Ogg et al (2016)
Captorhinus aguti	Early to Late Cisuralian, Lower Permian	298.9-272.3	Fox & Bowman (1966); Cisneros et al. (2015); Ogg et al (2016)
Labidosaurus hamatus	Kungurian, Cisuralian, Lower Permian	282-272.3	Lucas (2006); Ogg et al (2016)
Eunotosaurus africanus	middle Capitanian to Capitanian/Wuchiapingian boundary, Middle Permian	265.8-260.4	Day et al. (2013)
Proganochelys queensdedti	Late Norian, Late Triassic	218-210	Menning et al. (2011); Ogg et al. (2016)
Odontochelys semitestacea	Lower Carnian, Late Triassic	237-232	Li et al. (2008); Ogg et al (2016)
Kayentachelys aprix	Sinemurian-Pliensbachian, Lower Jurassic	199.4-183.7	Padian (1989); Ogg et al (2016)
Petrolacosaurus kansensis	Stephanian of Europe [equivalent to the Kasimovian, Late Pennsylvanian, Carboniferous	307-303.7	Peabody (1952); Ogg et al. (2008); Ogg et al (2016)
Araeoscelis gracilis	Late Kungurian, Cisuralian, Lower Permian	278-272.3	Lucas (2006); Ogg et al (2016)
Araeoscelis casei	Artinskian and lower Kungurian, Cisuralian, Lower Permian	290.1-280	Lucas (2006); Ogg et al (2016)
Claudiosaurus germaini	Lopingian, Late Permian	257-255.2	Lucas (2006); Smith et al. (2012); Rubidge et al. (2013)
Youngina capensis	Lopingian, Late Permian	257-255.2	Smith et al. (2012); Rubidge et al. (2013)
Hovasaurus boulei	Lopingian, Late Permian to Induan, Early Triassic	257-251.2	Lucas (2006); Smith et al. (2012); Rubidge et al. (2013); Ketchum & Barret (2004)
Acerosodontosaurus piveteaui	Lopingian, Late Permian	257-255.2	Lucas (2006); Smith et al. (2012); Rubidge et al. (2013)
Coelurosauravus jaekeli	Middle Wuchiapingian, Lopingian, Late Permian	258-256	Menning et al. (2011)
Coelurosauravus elivensis	Lopingian, Late Permian	257-255.2	Lucas (2006); Smith et al. (2012); Rubidge et al. (2013)
Hupehsuchus nanchangensis	Spathian, late Olenkian, Lower Triassic	250-247.2	Carroll & Dong (1991); Chen et al. (2014)
Parvinatator wapitiensis	Spathian, late Olenekian, Lower Triassic - latest Ladinian, Middle Triassic	248.4-237	McGowan & Motani (2003); Ogg et al (2016)
Gulosaurus helmi	Spathian, late Olenekian, Lower Triassic-latest Ladinian, Middle	248.4-237	Brinkman, Zhao & Nicholls (1992); McGowan & Motani

	Triassic		(2003); Ogg et al (2016)
Utatsusaurus hataii	Spathian, late Olenkian, Lower Triassic	250-247.2	Motani et al. (1998)
Mixosaurus panxianensis	late Pelsonian, Anisian, Middle Triassic	244-243.5	Benton et al. (2013); Ogg et al (2016)
Protorosaurus speneri	Middle Wuchiapingian, Lopingian, Late Permian	258-256	Menning et al. (2011)
Prolacerta broomi	Induan-Olenekian, Early Triassic	251.9-246.8	Smith et al. (2012)
Macrocnemus bassanii	Late Anisian to early Ladinian, Middle Triassic	243.5-239	Rieppel (1993); Furrer (1995); Ogg et al. (2016)
Macrocnemus fuyuanensis	Longobardian, late Ladinian, Middle Triassic	239-237	Li et al. (2007); Benton (2013); Ogg et al. (2016)
Langobardisaurus tonelloi	Late Alaunian-early Sevatian, late Norian, Late Triassic	217-212	Saller, renesto & Dalla Vechia (2013); Ogg et al. (2016)
Tanystropheus longobardicus	Late Anisian to early Ladinian, Middle Triassic	243.5-239	Rieppel (1993); Furrer (1995); Ogg et al. (2016)
Megalancosaurus preonensis	Middle Norian, Late Triassic	228-218	Renesto et al. (2010); Ogg et al. (2016)
Endennasaurus acutirostris	Middle-late Norian, Late Triassic	223-217	Tintori (1995); Gaetani et al. (1998); Ogg et al. (2016)
Askeptosaurus italicus	Late Anisian to early Ladinian, Middle Triassic	243.5-239	Rieppel (1993); Furrer (1995); Ogg et al. (2016)
Xinpusaurus kohi	Carnian, Late Triassic	237.5-228.5	Jiang et al. (2005); Ogg et al. (2016)
Champsosaurus lindoei	Mid-Campania, Late Cretaceous	79-76	Gao & Brinkman (2005); Ogg et al. (2016)
Phylidrosaurus proseilus	Albian, Early Cretaceous	113.1-100.5	Gao & Fox (2005); Ogg et al. (2016)
Trilophosaurus buettneri	Middle Otischalkian, lower Carnian, Late Triassic to late Adamanian, latest Carnian, Late Triassic	237-228.5	Spielmann et al. (2008); Ogg et al. (2016)
Mesosuchus browni	Earliest to middle/late Anisian, Middle Triassic	246.8-243.5	Dilkes (1998); Smith et al. (2012)
Howesia browni	Earliest to middle/late Anisian, Middle Triassic	246.8-243.5	Dilkes (1995); Smith (2012)
Teyumbaita sulcognathus	Early Norian, Late Triassic	228.5-223	Langer et al. (2007); Montefeltro, Langer & Schultz (2010); Ogg et al. (2016)
Hyperodapedon huenei	Latest Carnian-earliest Norian, Late Triassic	230-225	Langer et al. (2007); Ogg et al. (2016)
Proterosuchus fergusi	Induan-Olenekian, Early Triassic	251.9-246.8	Smith et al. (2012)
Proterosuchus alexanderi	Induan-Olenekian, Early Triassic	251.9-246.8	Smith et al. (2012)
Erythrosuchus africanus	Earliest to middle/late Anisian, Middle Triassic	246.8-243.5	Dilkes (1995); Smith (2012)
Euparkeria capensis	Earliest to middle/late Anisian, Middle Triassic	246.8-243.5	Dilkes (1995); Smith (2012)

Placodus gigas	Early Anisian to early Ladinian, Middle Triassic	246-240	Menning et al. (2011); Ogg et al. (2016)
Cyamodus hildegardis	Late Anisian to early Ladinian, Middle Triassic	243.5-239	Rieppel (1993); Furrer (1995); Ogg et al. (2016)
Largocephalosaurus qianensis	Late Pelsonian, Anisian, Middle Triassic	244-243.5	Benton et al. (2013); Ogg et al. (2016)
Sinosaurosphargis yunguiensis	Late Pelsonian, Anisian, Middle Triassic	244-243.5	Benton et al. (2013); Ogg et al. (2016)
Serpianosaurus mirigioliensis	Late Anisian to early Ladinian, Middle Triassic	243.5-239	Rieppel (1993); Furrer (1995); Ogg et al. (2016)
Wumengosaurus delicatomandibularis	late Pelsonian, Anisian, Middle Triassic	244-243.5	Benton et al. (2013); Ogg et al (2016)
Lariosaurus calcagnii	Lower Ladinian, Middle Triassic	241.5-239	Furrer (1995); Ogg et al. (2016)
Pistosaurus longaevus	Illyrium, late Anisian, Middle Triassic	243.5-241.5	Menning et al. (2011); Ogg et al. (2016)
Palaegama vielhaueri	Middle Lopingian, Late Permian-middle Olenekian, Early Triassic	258-247.5	Smith et al. (2012)
Paliguana whitei	Middle Lopingian, Late Permian-middle Olenekian, Early Triassic	258-247.5	Smith et al. (2012)
Saurosternon bainii	Middle Wuchiapigian-latest Changhsingian, Lapingian, Late Permian	258-251.9	Smith et al. (2012)
Pamelina polonica	Early late Olenekian, Early Triassic	248.5-247.5	Shishkin & Sulej (2009)
Sophineta cracoviensis	Early late Olenekian, Early Triassic	248.5-247.5	Shishkin & Sulej (2009)
Megachirella wachtleri	Pelsonian, Anisian, Middle Triassic	244.5-243.5	Renesto & Bernardi (2014)
Kuehneosaurus latus	Carnian-Rhaetian, Late Triassic	237-201.4	Fraser (1994); Evans & Jones (2010)
Icarosaurus siefkeri	Tuvalian, Carnian, Late Triassic	233-228.5	Lucas (1998); Ogg et al. (2016)
Marmoretta oxoniensis	Late Bathonian, Middle Jurassic to Kimmeridgian, Late Jurassic	167-152.1	Evans & Kermack (1994); Ogg et al (2016)
Gephyrosaurus bridensis	Haettagian or Sinemurian, Lower Jurassic	201.4-191.4	Evans & Kermack (1994); Evans & Jones (2010); Ogg et al (2016)
Diphyodontosaurus avonis	Carnian-Rhaetian, Late Triassic	237-201.4	Fraser (1994); Evans & Jones (2010)
Planocephalosaurus robinsonae	Carnian-Rhaetian, Late Triassic	237-201.4	Fraser (1994); Evans & Jones (2010)
Clevosaurus hudsoni	Carnian-Rhaetian, Late Triassic	237-201.4	Fraser (1994); Evans & Jones (2010)
Palaeopleurosaurus posidoniae	Toarcian, Early Jurassic	183.7-174.2	Carroll (1985); Ogg et al. (2016)
Homeosaurus maximiliani	Latest Kimmeridgian-early Tithonian, Late Jurassic	155-150	Schweigert (2007); Ogg et al (2016)
Kallimodon pulchellus	Latest Kimmeridgian-early Tithonian, Late Jurassic	155-150	Schweigert (2007); Ogg et al (2016)

Priosphenodon avelasi	Cenomanian-Turonian, Late Cretaceous	100.5-89.8	Apesteguía & Novas (2003); Ogg et al (2016)
Sphenodon punctatus			
Eichstaettisaurus schroederi	Latest Kimmeridgian-early Tithonian, Late Jurassic	155-150	Schweigert (2007); Ogg et al (2016)
Ardeosaurus brevipes	Latest Kimmeridgian-early Tithonian, Late Jurassic	155-150	Schweigert (2007); Ogg et al (2016)
Paramacellodus oweni	Berriasian, Early Cretaceous	145-139.4	Evans 2003; Ogg et al (2016)
Huehuecuetzpalli mixtecus	Late Albian, Early Cretaceous	105-100	Benammi et al. (2006)
Tepexisaurus tepexi	Late Albian, Early Cretaceous	105-100	Benammi et al. (2006)
Priscagama gobiensis	Campanian-earliest Maastrichtian, Late Cretaceous	84.2-71	Jerzykiewicz et al. (1993); Dashzeveg et al. (2005); Dingus et al. (2008); Ogg et al (2016)
Pleurodontagama aenigmatoides	Campanian, Late Cretaceous	84.2-72.1	Eberth (1993); Jerzykiewicz et al. (1993); Dingus et al. (2008); Ogg et al (2016)
Igua minuta	Campanian, Late Cretaceous	84.2-72.1	Jerzykiewicz et al. (1993); Dingus et al. (2008); Ogg et al (2016)
Polrussia mongoliensis	Campanian, Late Cretaceous	84.2-72.1	Jerzykiewicz et al. (1993); Dingus et al. (2008); Ogg et al (2016)
Gilmoreteius chulsanensis	Campanian, Late Cretaceous	84.2-72.1	Dingus et al. (2008); Ogg et al (2016)
Gobinatus arenosus	Campanian, Late Cretaceous	84.2-72.1	Jerzykiewicz et al. (1993); Dingus et al. (2008); Ogg et al (2016)
Gobekko cretacicus	Late Campanian-earliest Maastrichtian, Late Cretaceous	75-71	Dashzeveg et al. (2005)
Meyasaurus diazromerali	Barremian, Early Cretaceous	130.8-126.3	Buscalioni & Fregenal-Martínez (2010); Ogg et al (2016)
Globaura venusta	Campanian-earliest Maastrichtian, Late Cretaceous	84.2-71	Dashzeveg et al. (2005); Dingus et al. (2008); Ogg et al (2016)
Slavoia darevskii	Campanian, Late Cretaceous	84.2-71	Dashzeveg et al. (2005); Dingus et al. (2008); Ogg et al (2016)
Dalinghosaurus longidigitus	Earliest Hautuverian-Barremian/Aptian, Early Cretaceous	134.7 to 126.3	Sha (2007); Ogg et al. (2016)
Dinilysia patagonica	Santonian to early/middle Campanian, Late Cretaceous	86.3-77	Leanza & Hugo (2001); Scanferla & Canale (2007); Filippi & Garrido (2012); Ogg et al. (2016)
Najash rionegrina	Cenomanian-Turonian, Late Cretaceous	95-89.8	Corbella et al. (2004); Zaher et al. (2009); Ogg et al. (2016)
Pachyrhachis problematicus	lower Cenomanian, Late Cretaceous	100.5-97	Lee & Caldwell (1998); Ogg et al. (2016)
Spathorhynchus fossorium	Early to Middle Eocene, Paleogene	56-45	Berman (1977); Ogg et al. (2016)
Aigialosaurus	Late Cenomanian-Early Turonian, Late Cretaceous	97-92	Gušić & Jelaska (1993); Ogg et al. (2016)

Adriosaurus suessi	late Cenomanian- late Turonian, Late Cretaceous	97-90	Gušić & Jelaska (1993); Lee & Caldwell (2000); Ogg et al. (2016)
Pontosaurus	Early-middle Cenomanian , Late Cretaceous (oldest record of the genus)	100.5-97	Dal Sasso & Pinna (1997); Ogg et al. (2016)

Table S3. List of taxa for leaf stability index analysis depicted in Extended Data Figure 9.

Number	Taxon	Completeness	Comb_Bayes	Comb_Bayes_Cal_Tip
1	Acerosodontosaurus piveteaui	0.34017595	0.962152	0.908309
2	Adriosaurus suessi	0.2748538	0.956248	0.956339
3	Aigialosaurus	0.5945122	0.956237	0.956328
4	Anilius scytale	0.97119342	0.958804	0.959452
5	Araeoscelis casei	0.59292035	0.962772	0.910641
6	Araeoscelis gracilis	0.59940653	0.962787	0.910641
7	Ardeosaurus brevipes	0.22418879	0.885262	0.904393
8	Askeptosaurus italicus	0.81268882	0.955652	0.911004
9	Bipes biporus	0.98513011	0.977336	0.958663
10	Blanus cinereus	0.94262295	0.977336	0.958663
11	Broadleysaurus major	0.99402985	0.973275	0.950836
12	Captorhinus aguti	0.9244713	0.963932	0.910634
13	Champsosaurus lindoei	0.73111782	0.884349	0.78622
14	Claudiosaurus germaini	0.57227139	0.95841	0.907198
15	Clevosaurus hudsoni	0.70694864	0.962838	0.960308
16	Coelurosauravus elivensis	0.32835821	0.956084	0.892316
17	Coelurosauravus jaekeli	0.37724551	0.956084	0.892316
18	Coleonyx variegatus	0.97749196	0.969812	0.950728
19	Cordylus niger	0.98802395	0.973275	0.950836
20	Crotaphytus collaris	1	0.961666	0.956926
21	Cyamodus hildegardis	0.5074184	0.960744	0.918726
22	Cylindrophis ruffus	0.97119342	0.958806	0.959452
23	Dactylocnemis pacificus	0.96485623	0.969719	0.95063
24	Dalinghosaurus longidigitus	0.38392857	0.974663	0.957222
25	Dibamus novaeguineae	0.95867769	0.97163	0.93664
26	Dinilysia patagonica	0.76383764	0.957702	0.959312
27	Diphyodontosaurus avonis	0.48071217	0.964906	0.960323
28	Eichstaettisaurus schroederi	0.50453172	0.94097	0.938666
29	Elgaria multicarinata	1	0.949526	0.957921
30	Endennasaurus acutirostris	0.48203593	0.954134	0.910997
31	Erythrosuchus africanus	0.76331361	0.931479	0.860712
32	Eunotosaurus africanus	0.70414201	0.962036	0.898578
33	Euparkeria capensis	0.82890855	0.931471	0.860721
34	Gekko gecko	0.99361022	0.969801	0.95074
35	Gephyrosaurus bridensis	0.71856287	0.916428	0.943606
36	Gilmoreteius chulsanensis	0.8902439	0.975325	0.957829
37	Globaura venusta	0.60895522	0.974063	0.953875
38	Gobekko cretacicus	0.24776119	0.969772	0.950881
39	Gobinatus arenosus	0.69552239	0.975317	0.957828
40	Gulosaurus helmi	0.38235294	0.96053	0.91411

41	Heloderma suspectum	0.99384615	0.949491	0.957887
42	Homeosaurus maximiliani	0.3880597	0.963147	0.959109
43	Hoplocercus spinosus	0.9939577	0.960882	0.956013
44	Hovasaurus boulei	0.49853372	0.962139	0.908218
45	Howesia browni	0.37790698	0.930622	0.858453
46	Huehuecuetzpalli mixtecus	0.54848485	0.981662	0.959917
47	Hupehsuchus nanchangensis	0.49122807	0.96086	0.91413
48	Hyperodapedon huenei	0.80120482	0.930009	0.849181
49	Icarosaurus siefkeri	0.36390533	0.956633	0.908467
50	Igua minuta	0.26530612	0.96126	0.953559
51	Iguana iguana	1	0.964159	0.958863
52	Kallimodon pulchellus	0.70392749	0.963542	0.959193
53	Kayentachelys aprix	0.69180328	0.961909	0.897687
54	Kuehneosaurus latus	0.60843373	0.956634	0.908468
55	Labidosaurus hamatus	0.95180723	0.963932	0.910634
56	Lacerta viridis	0.98776758	0.977283	0.958607
57	Langobardisaurus pandolfii	0.40672783	0.956627	0.908707
58	Lanthanotus borneensis	1	0.949554	0.957956
59	Largocephalosaurus qianensis	0.60843373	0.96075	0.918735
60	Lariosaurus calcagnii	0.73413897	0.960835	0.918792
61	Leiocephalus carinatus	0.99698795	0.96217	0.957885
62	Liolaemus signifer	1	0.962401	0.957932
63	Mabuya mabouya	0.99079755	0.973021	0.950835
64	Macrocnemus bassanii	0.60486322	0.95301	0.906555
65	Macrocnemus fuyuanensis	0.48502994	0.95301	0.906555
66	Marmoretta oxoniensis	0.23976608	0.957512	0.955068
67	Megachirella wachtleri	0.49253731	0.958161	0.950858
68	Megalancosaurus preonensis	0.37091988	0.94443	0.896143
69	Mesosuchus browni	0.86176471	0.930657	0.858454
70	Meyasaurus diazromerali	0.54896142	0.949009	0.955181
71	Mixosaurus panxianensis	0.64776119	0.960479	0.914062
72	Najash rionegrina	0.17589577	0.95845	0.959302
73	Odontochelys semitestacea	0.33923304	0.961909	0.897684
74	Oplurus cyclurus	0.98159509	0.962528	0.958215
75	Pachyrhachis problematicus	0.53405018	0.95849	0.959302
76	Palaegama vielhaueri	0.22222222	0.848587	0.847395
77	Palaeopleurosaurus posidoniae	0.72256098	0.963552	0.959554
78	Paliguana whitei	0.19710145	0.852412	0.831552
79	Pamelina polonica	0.31952663	0.953214	0.905014
80	Paramacellodus oweni	0.21613833	0.952589	0.85434
81	Parvinatator wapitiensis	0.24927536	0.960528	0.914108
82	Petracola ventrimaculatus	0.97859327	0.975089	0.957983
83	Petrolacosaurus kansensis	0.76190476	0.962309	0.910619

84	Philydrosaurus proseilus	0.62275449	0.884349	0.78622
85	Phrynosoma modestum	0.975	0.966252	0.95824
86	Pistosaurus longaevus	0.47239264	0.960759	0.918688
87	Placodus gigas	0.93209877	0.960729	0.918704
88	Planocephalosaurus robinsonae	0.43843844	0.965075	0.96045
89	Plestiodon fasciatus	0.99384615	0.973024	0.950835
90	Pleurodontagama aenigmatoides	0.38392857	0.967595	0.959013
91	Polrussia mongoliensis	0.27728614	0.964168	0.945868
92	Polychrus marmoratus	0.99695122	0.961863	0.957326
93	Pontosaurus	0.61111111	0.956117	0.956021
94	Priosphenodon avelasi	0.6375	0.963713	0.959748
95	Priscagama gobiensis	0.62732919	0.968126	0.959592
96	Pristidactylus scapulatus	0.99697885	0.962528	0.958215
97	Proganochelys queensdedti	0.91515152	0.961909	0.897687
98	Prolacerta broomi	0.89552239	0.931275	0.86065
99	Proterosuchus alexanderi	0.74926254	0.93141	0.860698
100	Proterosuchus fergusi	0.48823529	0.931351	0.86065
101	Protocaptorhinus pricei	0.47181009	0.963928	0.910614
102	Protorosaurus speneri	0.65373134	0.932596	0.898021
103	Protorothyris archeri	0.71428571	0.963928	0.910614
104	Pseudopus apodus	0.99652778	0.949526	0.957921
105	Rhineura floridana	0.97083333	0.977335	0.958663
106	Saurosternon bainii	0.19476744	0.952625	0.907698
107	Serpianosaurus mirigioliensis	0.82317073	0.96076	0.918732
108	Sinosaurosphargis yunguiensis	0.49386503	0.960748	0.918734
109	Slavoia darevskii	0.74404762	0.973912	0.945952
110	Sophineta cracoviensis	0.30409357	0.880758	0.908308
111	Spathorhynchus fossorium	0.46540881	0.977335	0.958663
112	Sphenodon punctatus	0.99691358	0.963714	0.948019
113	Stenocercus scapularis	0.99390244	0.964182	0.958857
114	Tanystropheus longobardicus	0.64939024	0.956559	0.908655
115	Teius teyou	1	0.975072	0.957983
116	Tepexisaurus tepexii	0.48816568	0.971429	0.95435
117	Teyumbaita sulcognathus	0.72891566	0.930009	0.849181
118	Timon lepidus	0.98791541	0.977283	0.958607
119	Trilophosaurus buettneri	0.82066869	0.929982	0.849137
120	Trioceros jacksonii	0.96763754	0.968248	0.959907
121	Uromastyx aegyptia	0.99692308	0.968246	0.959905
122	Utatsusaurus hataii	0.49552239	0.960481	0.914064
123	Varanus salvator	0.98784195	0.949554	0.957956
124	Wumengosaurus delicatomandibularis	0.54896142	0.960528	0.918775
125	Xantusia vigilis	0.99369085	0.972481	0.950663

126	Xenopeltis unicolor	0.99126638	0.958806	0.959452
127	Xenosaurus grandis	1	0.949494	0.957887
128	Xinpusaurus kohi	0.5	0.955476	0.910996
129	Youngina capensis	0.65384615	0.957561	0.907039

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