Supporting information for **Anatomy and phylogenetic relationships of *Temnodontosaurus zetlandicus* (Seeley, 1880) comb. nov. (Reptilia: Ichthyosauria)**

Text S1: Character list copied from the study of Maxell & Cortés (2020) and character coding revision. This character list is originally provided from Moon (2017) and includes changes made by studies of Maxwell *et al*. (2019) and Maxwell & Cortés (2020).

Skull

Character 1: Snout – extremely slender premaxillary segment, < 1⁄4 the maximum lateral width of the posterior of the skull: (0) absent (1) present (Motani, 1999: character 34). This is modified from Motani's (1999) character 34 by defining a specific boundary of 'slender'. Motani's original character separates several taxa, especially his 'Eurhinosauria'. To maintain this distinction, this character is defined as the width of the snout where the premaxillae exclude the nasals from dorsal view – the nasals anteriormost dorsal exposure – compared to the maximum width of the post-narial skull.

Character 2: Premaxilla – supranarial process: (0) present (1) absent (modified from Maisch & Matzke, 2000: character 9; and Maxwell, 2012: character 1).

Character 3: Premaxilla – size of supranarial process: (0) large, extending > 1⁄3 of the external narial length (1) small, extending < 1⁄3 of the external narial length (modified from Maisch & Matzke, 2000: character 9; and Maxwell, 2012: character 1).

Character 4: Premaxilla – subnarial process: (0) absent (1) present (modified from Maisch & Matzke 2000: character 10; and Maxwell, 2012: character 1).

Character 5: Premaxilla – size of the subnarial process: (0) small, extending < 1⁄3 of the external narial length (1) large, extending > 1⁄3 of the external narial length (modified from Maisch & Matzke, 2000: character 10; and Maxwell, 2012: character 1).

Character 6: Premaxilla-palatine – contact in ventral view: (0) absent (1) present, relatively broad (Druckenmiller & Maxwell, 2010: character 15).

Character 7: Maxilla – reduction: (0) absent, ≥ 1⁄2 of the length of the snout (1) present, < 1⁄2 the length of the snout (modified from Sander *et al.,* 2011: character 106). The reduction of the maxilla is defined more specifically than Sander *et al.*'s (2011) character 106. While this is defined relative to the length of the snout as a whole, the dorsoventral exposure and contribution should also be considered (see character 9).

Character 8: Maxilla – bearing teeth: (0) present (1) absent. See character 7.

Character 9: Maxilla – location of the laterally exposed greatest dorsoventral extent: (0) posterior to the external naris (1) ventral or anterior to the external naris (modified from Druckenmiller & Maxwell, 2010: character 4). State one has been modified to include 'ventral to the external naris'.

Character 10: Maxilla – length of the premaxillary process: (0) short, extends approximately one or less narial lengths anterior to the external naris (1) long, extends approximately 1.5 or more narial lengths anterior to the external naris (Maxwell, 2012: character 2).

Character 11: Maxilla – postnarial process exposed laterally: (0) present (1) absent (modified from Maisch & Matzke, 2000: character 11). The postnarial process of the maxilla is a dorsal extension of the maxilla posterior to the external naris, this is the *processus postnarialis* of Maisch & Matzke (1997); it is equivalent to the dorsal lamina of Motani (1999).

Character 12: Maxilla – size of the postnarial process exposure: (0) large (1) tiny (modified from Maisch & Matzke, 2000: character 11). Clarified that this refers to exposure of the postnarial process.

Character 13: Maxilla – size of the jugal process: (0) long, extending as far under the orbit as the lachrymal in lateral view (1) short, hidden in lateral view by the jugal (Maxwell, 2012: character 3).

Character 14: Maxilla – contacts prefrontal: (0) absent (1) present (Maisch & Matzke, 2000: character 12).

Character 15: Maxilla – contacts external naris in external lateral view: (0) present (1) absent (modified from Fernández, 2007: character 2; after Fischer *et al.*, 2011: character 9; and Fischer, 2013: character 9).

Character 16: Nasal – anteroposterior extent of dorsal exposure in the prenarial rostrum: (0) substantial, over 40% (1) reduced, less than 40% (Maxwell, 2012: character 4).

Character 17: Nasal posterior extent: (0) reaches back to the orbit (1) reaches distinctly over the orbit (Maisch & Matzke, 2000: character 14).

Character 18: Narial shelf: (0) absent (1) present (Jiang *et al.,* 2006: character 4). This narial shelf is anterior to the external naris, bordered medially by the nasosupraorbital ridge (Jiang *et al.*, 2006).

Character 19: Nasal – borders external naris: (0) present (1) excluded (Sander, 2000: character 7).

Character 20: Nasal – descending process on the interior posterior border of the nares: (0) absent (1) present (Fernández, 2007: character 2).

Character 21: Nasal-postfrontal – contact: (0) absent (1) present (modified from Nicholls & Manabe, 2001: character 3).

Character 22: Nasal-postfrontal contact – size: (0) small (1) extensive, separating frontals and prefrontals in dorsal view (modified from Nicholls & Manabe, 2001: character 3).

Character 23: *Excavatio internasalis*: (0) absent (1) present (Maisch & Matzke, 2000: character 16).

Character 24: Lachrymal – anterior extent: (0) reaches external naris (1) is excluded from the external naris by the dorsal process of the maxilla and/or the ventral process of the nasal (Sander, 2000: character 10). The polarity of this character was reversed by Maxwell (2012: character 5).

Character 25: Lachrymal – numerous small-to- medium-sized nutritive foramina: (0) absent (1) present (Sander *et al.*, 2011: character 111). This character refers to millimetre-size nutritive foramina that perforate the lachrymal and are only recorded in *Shastasaurus*.

Character 26: External nares – shape: (0) small, round to ovate (1) elongate (2) elongate and complexly lobate (Sander, 2000: character 8). As this character defines shape, states one and two are considered suitably different that this should not be coded with reductive methods.

Character 27: External nares – orientation: (0) dorsolateral (1) lateral, scarcely visible in dorsal view (Motani, 1999: character 4).

Character 28: Jugal – shape: (0) triradiate (1) lunate or J-shaped (Motani, 1999: character 24). Compare this with character 31.

Character 29: Jugal – anterior margin shape: (0) tapering, running between the lachrymal and maxilla (1) broad and fanlike, covering a large area of the maxilla ventrolaterally (Druckenmiller & Maxwell, 2010: character 6).

Character 30: Jugal – extent of anterior margin: (0) terminates posterior to the anterior end of the lachrymal (1) reaches or surpasses the anterior end of the lachrymal (Roberts *et al.*, 2014: character 11).

Character 31: Jugal – dorsal ramus shape: (0) well- developed and strongly curved dorsally (1) poorly developed, jugal essentially straight (Maxwell, 2012: character 8). This character is exclusive of character 28: poor development of the dorsal ramus does not preclude a J-shaped or triradiate jugal, although this may be less apparent.

Character 32: Jugal – contact between the postorbital process and the squamosal: (0) absent (1) present (Sander, 2000: character 31).

Character 33: Jugal-quadratojugal – external contact: (0) absent (1) present (Motani, 1999 : character 23). This was included as a new character by Roberts *et al.* (2014), who explicitly included the postorbital to separate the jugal and quadratojugal.

Character 34: Jugal-quadratojugal notch – deep, forming a pronounced ventral emargination of the cheek: (0) present (1) absent (Jiang *et al.*, 2005: character 24). This character is exclusive of character 79 as the ventral margin of the quadratojugal may be concave without forming a distinct emargination of the cheek.

Character 35: Prefrontal – dorsal exposure: (0) broadly exposed (1) present, but limited by the anterior process of the postfrontal and posterior process of the nasal (2) little to none (modified from Maxwell, 2012: character 12).

Character 36: Prefrontal-external naris – contact: (0) absent (1) present (Druckenmiller & Maxwell, 2010: character 7).

Character 37: Prefrontal-postfrontal – contact: (0) absent, the dorsal margin of the orbit is formed by the frontal (1) present, eliminating the frontal from the dorsal margin of the orbit (Motani, 1999: character 8). This character incorporates the revised interpretation of the skull of Ichthyosaurus and Stenopterygius (Motani, 2005), but character states may have been revised. This also applies to subsequent skull roof characters.

Character 38: Prefrontal and postfrontal – high supraorbital crest: (0) absent (1) present (Maisch & Matzke, 2000: character 22).

Character 39: Frontals – dorsal view: (0) strongly convex at the anterior edge of the parietal foramen (1) flat to concave, overlapped by surrounding elements (Maxwell, 2012: character 13). Overlapping by surrounding elements may be separated into another character, however, this has not clearly been seen to warrant this distinction.

Character 40: Frontal – location of the widest exposure: (0) located posteriorly (1) at nasal suture (Motani, 1999: character 15).

Character 41: Frontal – temporal process: (0) absent (1) present (Fischer *et al.*, 2011: character 14).

Character 42: Frontal – participates in the supra- temporal fenestra in dorsal view: (0) absent (1) present (modified from Druckenmiller & Maxwell, 2010: character 9; and Fischer *et al.*, 2011: character 14). This and the next character are separated for reductive coding.

Character 43: Frontal – size of participation in the supratemporal fenestra: (0) small (1) extensive (modified from Druckenmiller & Maxwell, 2010: character 9).

Character 44: Frontal and parietal – relative dorsal exposure size: (0) frontal as large or larger than the parietal (1) frontal smaller than the parietal (Maisch & Matzke, 2000: character 17).

Character 45: Parietal – dorsal view contribution to the anterior margin of the supratemporal fenestra: (0) no contribution (1) minor contribution (2) large, almost completely excluding the postfrontal from contact (modified from Maxwell, 2012: character 14).

Character 46: Parietal ridge: (0) absent (1) present (Motani, 1999: character 17).

Character 47: Parietal shelf – orientation (0) obliquely oriented; (1) horizontally oriented (modified from Nicholls & Manabe, 2001: character 8).

Character 48: Parietal shelf – size: (0) large (1) reduced (modified from Nicholls & Manabe, 2001: character 8).

Character 49: Parietals – separation of anterior processes of the right and left: (0) narrow, forming parietal fork, and frontal dorsally visible along the pineal foramen (1) widely open, resulting in absence of clear fork (Motani, 1999: character 19). This character may be coded as inapplicable if the anterior processes of the parietals contact (character 50).

Character 50: Parietals – location of the parietal foramen: (0) contact between the left and right parietals present anteriorly, frontal excluded from the parietal foramen; (1) on the frontoparietal suture; (2) entirely surrounded by the frontals (modified from Motani, 1999: character 19).

Character 51: Parietals – anterior fork elevated: (0) absent (1) present (Nicholls & Manabe, 2001: character 10). This character is coded as inapplicable if no anterior parietal fork is present (character 49).

Character 52: Postparietals – additional bone separating the parietal and supratemporal: (0) absent (1) present (modified from Thorne *et al.,* 2011: character 18).

Character 53: Parietal – size of the supratemporal process: (0) short (1) long (modified from Thorne *et al.*, 2011: character 18).

Character 54: Parietal foramen – anteroposterior position: (0) approximately equal to the anterior edge of the supratemporal fenestra (1) well anterior to the anterior edge of the supratemporal fenestra (Maxwell, 2012: character 15).

Character 55: Postfrontal – size of the posterior flange: (0) delicate and narrow, not extending ventrally to the posterior orbital rim (1) robust and triangular, approaching posterior orbital rim (Druckenmiller & Maxwell, 2010: character 12). The posterior flange on the postfrontal is found in all ichthyosaurs (Motani, 1999; Thorne *et al.*, 2011), but the size of this varies (Druckenmiller & Maxwell, 2010).

Character 56: Postfrontal-postorbital – size of contact: (0) narrow (1) broad (Roberts *et al.*, 2014: character 16).

Character 57: Postfrontal-supratemporal – contact: (0) absent (1) present (Sander, 2000: character 28). This is exclusive of character 55 as contact between the postfrontal and supratemporal may be made whether the posterior flange is large or small.

Character 58: Postorbital – shape: (0) triradiate (1) lunate, without posterior process (Motani, 1999: character 11).

Character 59: Postorbital – size: (0) broad (1) narrow (Fernández, 2007: character 7).

Character 60: Postorbital – participates in the supratemporal fenestra: (0) present (1) absent (Motani, 1999: character 12).

Character 61: Postorbital-supratemporal – contact in external view: (0) present (1) absent (Maxwell, 2012: character 6).

Character 62: Supratemporal – enlargement: (0) small, minimal posterior exposure (1) moderate, forming posterior border of the supratemporal fenestra (2) strongly enlarged, forms significant portion of the posterior and lateral borders to supratemporal fenestra and skull roof (modified from Sander, 2000: character 26). The definitions for 'small' and 'enlarged' are clarified.

Character 63: Supratemporal – anterodorsal sheet overhanging the supratemporal fenestra: (0) absent (1) present (Maisch & Matzke, 2000: character 25).

Character 64: Supratemporal – size of the descending ramus: (0) pronounced, reaching at least half of the total height of the quadrate (1) reduced, a small process medial to the quadrate articulation (Maxwell, 2012: character 17).

Character 65: Supratemporal-stapes – contact: (0) absent (1) present (Fischer *et al.,* 2013: character 52).

Character 66: Sagittal eminence: (0) present (1) absent (Fischer *et al.,* 2011: character 13).

Character 67: Supratemporal – orientation of parietal ramus in dorsal view (0) oblique, (1) horizontal. This character may not be independent from the orientation of the parietal shelf, but can be scored in the absence of a clear parietal shelf.

Character 68: Supratemporal – relative anterior extent of the lateral and parietal rami in dorsal view (0) subequal, (1) lateral ramus extending much further anteriorly.

Character 69: Squamosal: (0) present (1) absent. This character is added, and characters 70 to 72 are modified, and which may be coded as inapplicable, for reductive coding.

Character 70: Squamosal – shape: (0) triangular (1) squared (Fischer *et al*., 2011: character 16).

Character 71: Squamosal – posterior descending process: (0) absent (1) present (modified from Fernández, 2007: character 4). The absence of the squamosal is coded separately (character 69).

Character 72: Squamosal – participates in supra- temporal fenestra: (0) present (1) excluded by supratemporal and/or postfrontal (Nicholls & Manabe, 2001: character 6).

Character 73: Supratemporal fenestrae – width in dorsal aspect: (0) posterior half narrower than anterior half (1) anterior and posterior halves approximately equal in width (Druckenmiller & Maxwell, 2010: character 11).

Character 74: Anterior terrace of the supratemporal fenestra: (0) absent (1) present (modified from Motani, 1999: character 14).

Character 75: Anterior terrace of the supratemporal fenestra – extent: (0) small, reaching the posterior part of the frontal anteriorly (1) large, reaching the nasal anteriorly (modified from Motani, 1999: character 14). See character 74.

Character 76: Skull roof – posterior margin indented in dorsal view: (0) deep (1) moderate (Maisch & Matzke, 2000: character 27).

Character 77: Quadratojugal – location of the main body: (0) laterally (1) posteriorly (Maisch & Matzke, 2000: character 28).

Character 78: Quadratojugal – exposure: (0) broad in lateral view (1) narrow and most extensively exposed in posterior view (Maxwell, 2012: character 8).

Character 79: Quadratojugal – shape of the ventral edge: (0) concave (1) ventral edge straight or entirely covered by the jugal (Maxwell, 2012: character 9). See also character 34.

Character 80: Quadratojugal – distinctly offset quadrate process: (0) present (1) absent (Maisch & Matzke 2000: character 29).

Character 81: Quadrate – dorsal articulation location: (0) enclosed laterally by the squamosal (1) articulates dorsomedially with the supratemporal only (Maxwell, 2012: character 11). This character may be coded as inapplicable if the squamosal is absent (character 69), although this implies state (1).

Character 82: Quadrate – location of the stapedial facet on the posterior surface: (0) ventral half (1) dorsal half (Druckenmiller & Maxwell, 2010: character 21).

Character 83: Orbit – shape of the anterior margin: (0) irregular (1) regularly rounded (2) angled (modified from Maisch & Matzke, 2000: character 23). The additional state 'angled' is added for the condition in e.g. *Cryopterygius kristiansenae*.

Character 84: Postorbital skull – length compared to orbital diameter: (0) > 1⁄3 (1) < 1⁄3 (Jiang *et al*., 2005: character 7).

Character 85: Cheek – orientation: (0) mostly lateral (1) largely posterior (Motani, 1999: character 25).

Character 86: Interpterygoidal vacuity: (0) present (1) absent (modified from Motani, 1999: character 27). Other characters referring to a 'closed palate' (Jiang *et al*., 2005: character 12) and exposure of the *basis cranii* (Maisch & Matzke, 2000: character 44) are included within this. This character is modified into a simple presence/absence dichotomy.

Character 87: Palatine – contributes to subtemporal fenestra: (0) posteriorly forms anterior edge (1) posteriorly excluded from the subtemporal fenestra (Maxwell, 2012: character 25).

Character 88: Pterygoid – transverse flange: (0) well-developed (1) poorly developed (modified from Motani, 1999: character 26). The development and orientation of the transverse flange of the pterygoid are separated for reductive coding (characters 88 and 89).

Character 89: Pterygoid – orientation of the trans- verse flange: (0) anterolateral (1) posterolateral (modified from Motani, 1999: character 26). See character 88.

Character 90: Pterygoid – posteromedial process: (0) present (1) absent (Maisch & Matzke, 2000: character 35).

Character 91: Vomer – number of dorsal processes: (0) one (1) two (Druckenmiller & Maxwell, 2010: character 17). The vomer, particularly dorsally, is poorly known; while this character is included, its coding completeness is low.

Character 92: Epipterygoid – ossified: (0) present (1) absent.

Character 93: *Basis cranii* – largely formed by: (0) parasphenoid (1) basisphenoid (Maisch & Matzke, 2000: character 41).

Character 94: Basioccipital – shape of the condyle: (0) flat or slightly concave (1) hemispherical (Motani, 1999: character 31).

Character 95: Basioccipital – notochordal pit on the condylar surface: (0) absent (1) present. See character 96.

Character 96: Basioccipital – location of notochordal pit on the condylar surface: (0) central (1) dorsal.

Character 97: Basioccipital peg: (0) present (1) absent (Fischer *et al*., 2011: character 20).

Character 98: Basioccipital – prominent ventral tubers separated by a deep notch: (0) present (1) absent (modified from Maxwell, 2012: character 24). This character has been simplified to presence/absence.

Character 99: Basioccipital – extracondylar area: (0) present (1) absent. This character is added as, in some taxa, the extracondylar area may be entirely lost. This is incorporated into Fischer *et al*. (2013: character 20).

Character 100: Basioccipital – size of the ventral extracondylar area: (0) larger than the dorsoventral height of the condyle (1) smaller than the condyle but still extensive (2) reduced to a thin strip (Maxwell, 2012: character 23). This is similar to Fischer *et al.,* (2013, character 20). This character is treated as ordered.

Character 101: Basioccipital – contribution to the floor of the foramen magnum: (0) absent, excluded by the exoccipitals (1) present, the portion contributing being flat, or concave, and covered in finished bone (Maxwell, 2012: character 21).

Character 102: Parabasisphenoid – base of basipterygoid processes in dorsal or ventral view: (0) offset and anteroposteriorly narrow, much less than half the anteroposterior length of the parabasisphenoid (1) markedly expanded, forming approximately 50% or more of the anteroposterior length of the parabasisphenoid.

Character 103: Carotid foramen – pairing: (0) paired (1) unpaired (modified from Maisch & Matzke, 2000: character 42; after Maxwell, 2010: character 10). These two characters are joined, as they are slightly different versions of each other.

Character 104: Carotid foramen – location: (0) basioccipital and (1) parabasisphenoid (modified from Maisch & Matzke, 2000: character 42; after Maxwell, 2010: character 10).

Character 105: Parasphenoid – shape of the base of the cultriform process: (0) wide, gently grading into the basal plate (1) distinctly narrowed, well offset from the basal plate (Maisch & Matzke, 2000: character 43).

Character 106: Parabasisphenoid – shape in dorsal or ventral view: (0) anterior edge (including basipterygoid processes) less than 2/3 as long as posterior edge (1) anterior and posterior edges similar in length; (2) posterior edge less than 2/3 as long as anterior edge.

Character 107: Parabasisphenoid – location of the carotid foramen: (0) opening near the middle of the ventral surface, (1) opening on the posterior third of the ventral surface, (2) opening on the posterior surface [treated as ordered] (modified from Maisch & Matzke, 2000: character 42; after Maxwell, 2010: character 10). See characters 103 and 104. In cases where the carotid foramen is on the basioccipital rather than the parabasisphenoid (character 104), character 107 is coded as inapplicable.

Character 108: Opisthotic – shape of the paraoccipital process: (0) short and robust (1) elongate and slender (Fischer *et al.,* 2012: character 20).

Character 109: Supraoccipital – orientation of the exoccipital processes: (0) parallel (1) divergent (Maxwell, 2012: character 19).

Character 110: Exoccipital – contribution to foramen magnum: (0) exoccipitals make up the largest lateral contribution (1) supraoccipital contribution almost equal to that of exoccipitals (Maxwell, 2012: character 20).

Character 111: Stapes – size of the proximal head: (0) slender, much smaller than opisthotic proximal head (1) massive, as large or larger than opisthotic (Fischer *et al.,* 2011: character 21).

Character 112: Stapes – relative size of heads: (0) lateral head less robust than the medial head (1) both medial and lateral heads robust (Maxwell, 2012: character 18).

Character 113: Stapes – size of shaft in adults: (0) thick (1) slender and gracile (Roberts *et al*., 2014: characters 25).

Character 114: Lower jaw: (0) well developed (1) reduced relative to lower jaw (Maxwell, 2012: character 26).

Character 115: Lower jaw – development: (0) nor- mal (1) slender, reduced in diameter (Sander *et al*., 2011: character 108).

Character 116: Lower jaw – ventral margin in lateral view: (0) straight, or nearly so (1) markedly concave approximately ventral to the external nares (modified from Sander, 2000: character 37).

Character 117: Dentary – labial shelf: (0) absent (1) present (Jiang *et al*., 2006: character 14).

Character 118: Surangular – makes up most of the posterior lateral surface of the lower jaw: (0) absent (1) present (Maisch & Matzke, 2000: character 38).

Character 119: Surangular – dorsal (paracoronoid) process just anterior to the jaw articulation: (0) absent (1) present (Sander, 2000: character 42).

Character 120: Angular – extent of anterior lateral exposure: (0) much smaller than the surangular's exposure (1) extensive, at least as high and anteriorly as the surangular exposure (modified from Motani, 1999: character 32; after Fischer *et al*., 2011: character 22; and Maxwell, 2012: character 28).

Character 121: Angular – extent of posterior lateral exposure: (0) minimal, covers less than half of the lateral surface of the retroarticular process (1) extensive, surangular exposure reduced to a thin strip on the lateral surface of the retroarticular process (Maxwell, 2012: character 29).

Character 122: Splenial – participation in the mandibular symphysis: (0) more extensive than the dentary (1) present but restricted to the posterior half (Maxwell, 2012: character 27).

Character 123: Coronoid – ossified: (0) present (1) absent (modified from Maisch & Matzke, 2000: character 45). This character is separated for reductive coding (see character 124).

Character 124: Coronoid – shape: (0) laterally flattened (1) narrow and elongate (modified from Maisch & Matzke, 2000: character 45). May be coded as inapplicable if the coronoid is not present/ ossified (character 123).

Character 125: Coronoid process: (0) flat (1) elevated (2) drawn into a pointed process (modified from Sander, 2000: character 41). This refers to the true process on the coronoid, so may be coded as inapplicable if this is not present/ossified (character 123).

Character 126: Lower jaw glenoid – deeply excavated: (0) absent (1) present (Sander, 2000: character 43).

Character 127: Articular – transverse width: (0) wide with dorsally deeply concave retroarticular process (1) narrow (Maisch & Matzke, 2000: character 47).

Character 128: Teeth: (0) present (1) absent (modified from Maisch & Matzke, 2000: character 4; after Fischer *et al*., 2011: character 4; and Sander *et al*., 2011: character 109). The presence/-absence of teeth is separated for reductive coding alongside character 129; subsequent dentition characters may become inapplicable in this case.

Character 129: Dentition – complete, well-developed dentition retained in adults: (0) present (1) strongly reduced (modified from Maisch & Matzke, 2000: character 4; after Fischer *et al.,* 2011: character 4; and Sander *et al.,* 2011: character 109). This character is separated from edentulism as it refers to the size and number of teeth (character 128).

Character 130: Dentition – tooth implantation after Motani (1997): (0) subthecodont (1) thecodont (2) aulacodont (modified from Sander, 2000: character 52). Here, ankylosed and ichthyosaurian thecodonty are separated into separate characters (character 131).

Character 131: Dentition – bony fixation: (0) present (1) absent (Motani, 1999: character 43).

Character 132: Plicidentine: (0) absent (1) present (Motani, 1999: character 36).

Character 133: Dentition – number of tooth rows: (0) one (1) two (2) irregular pavement (Sander 2000, character 50).

Character 134: Upper dental groove: (0) absent (1) present (modified from Motani, 1999: character 41). Motani's (1999) characters 41 and 42 have each been separated to form characters 134 to 137 by reductive coding. These are not excluded by edentulism (character 128): the dental groove may be retained.

Character 135: Upper dental groove – location: (0) throughout jaw margin (1) only anteriorly (modified from Motani, 1999: character 41). This character may be inapplicable if the upper dental groove is absent (character 134).

Character 136: Lower dental groove: (0) absent (1) present (modified from Motani, 1999: character 42). See character 134.

Character 137: Lower dental groove – location: (0) throughout jaw margin (1) only anteriorly (modified from Motani, 1999: character 42). This character may be inapplicable if the lower dental groove is absent (character 136).

Character 138: Dentition – number of maxillary positions ventral to the jugal: (0) less than three (1) four or more (Druckenmiller & Maxwell, 2010: character 16).

Character 139: Palatine teeth: (0) present (1) absent.

Character 140: Pterygoidal teeth: (0) present (1) absent (Motani, 1999: character 44).

Character 141: Dentition – replacement: (0) irregular (1) regular (Sander, 2000: character 51).

Character 142: Dentition – position of replacement teeth to the pulp cavity of the predecessor: (0) outside (1) inside (Motani, 1999: character 35).

Character 143: Dentition – ornamentation of the enamel: (0) prominent ridges and grooves (1) thin and smooth (2) thick and bumpy (Maxwell, 2012: character 30).

Character 144: Dentition – shape of the root cross- section in adults: (0) rounded (1) quadrangular (modified from Fischer *et al.,* 2011: character 3; after Fischer *et al*., 2012: character 3).

Character 145: Dentition – dentine infolding (0) striations not externally visible basal to the crown in the apical third of the root; (1) forming prominent grooves and ridges basal to the crown in the apical third of the root.

Character 146: Dentition – dentine infolding (0) creating clear externally visible striations in the basal half of the root in functional teeth, (1) completely obscured by cellular cementum.

Character 147: Dentition – definition of the base of the enamel layer: (0) poorly defined or invisible (1) well defined and precise (Fischer *et al.,* 2011: character 2).

Character 148: Dentition – horizontal section of the tooth crown: (0) circular (1) mesiodistally compressed (2) laterally compressed (modified from Motani, 1999: character 37). This has been restricted to the tooth crown only.

Character 149: Dentition – shape of the posterior tooth crown: (0) conical (1) rounded (2) flat (Motani, 1999: character 39).

Postcranial axial skeleton

Character 150: Atlas pleurocentrum – shape: (0) anteriorly convex (1) deeply concave (Maisch & Matzke, 2000: character 49).

Character 151: Atlas-axis: (0) separate (1) co-ossified in adults (Maisch & Matzke 2000: character 50).

Character 152: Atlas-axis – neural spines: (0) completely overlapping, may be fused (1) functionally separate, never fused (Druckenmiller & Maxwell, 2010: character 26).

Character 153: Presacral vertebrae – number: (0) $n < 40$ (1) $40 \leq n < 55$ (2) $55 \leq n$ (modified from Motani, 1999: character 95). [treated as ordered]

Character 154 Central facets: (0) bulging (1) central face straight sided (modified from Sander, 2000: character 58).

Character 155: 'Cervical' vertebrae – diapophysis- neural arch contact extent: (0) up to middle dorsal region (1) anterior dorsal region (Fischer *et al.,* 2011: character 23).

Character 156: 'Cervical' vertebrae – centrum to neural arch height: (0) < 2 (1) ≤ 2 (modified from Sander, 2000: character 61). This has been simplified to a dichotomy.

Character 157: 'Cervical' centra – bicipital rib facet: (0) absent (1) present (Motani, 1999: character 99).

Character 158: Postcervical to presacral centra – number of rib articulations: (0) holocephalous throughout (1) dicephalous in posterior dorsal and anterior caudal region, remainder holocephalous (2) dicephalous throughout (Nicholls & Manabe, 2001: character 38).

Character 159: Dorsal centra – increase in height from anterior to posterior: (0) absent (1) present (Sander, 2000: character 55).

Character 160: Anterior dorsal neural spine – shape: (0) normal (1) narrow, high and straight (Motani, 1999: character 102).

Character 161: Anterior dorsal/thoracic zygapophyses – pairing: (0) paired (1) bilobate (2) unpaired (modified from Maisch & Matzke, 2000: character 51). The additional state 'bilobate' is added to separate when the two zygapophyses meet medially.

Character 162: Anterodorsal centra – rib facet position: (0) confluent with anterior face in at least some centra (1) not confluent in any (Motani, 1999: character 101).

Character 163: Anterodorsal centra – synapophysis shape: (0) symmetrical, hourglass-shaped (1) asymmetrical with irregular swellings and constrictions (modified from Nicholls & Manabe, 2001: character 40).

Character 164: Posterior dorsal centra – outline: (0) $\leq 3.5 \times$ high as long (1) $\leq 4 \times$ high as long (Fischer *et al.*, 2011: character 24). These codings are the reverse of Maxwell (2010: character 15), but direction is defined by the outgroup to the clade where the state changes.

Character 165: Sacrum: (0) present, at least one morphologically differentiated sacral rib can be observed (1) absent, no truly sacral ribs are present (Motani, 1999: character 104 [part]).

Character 166: Sacral ribs: (0) two with distal expansion, (1) one with distal expansion, (2) present and morphologically distinct [see character 165] but no distal expansion present. Is inapplicable when sacrum is absent/undifferentiated (character 165).

Character 167: Tail – length relative to precaudal body: (0) longer (1) shorter (Maisch & Matzke 2000: character 65; Fischer *et al*., 2013: character 33).

Character 168: Tail – lunate tail fin: (0) none (1) well-developed (Maisch & Matzke 2000: character 66).

Character 169: Caudal peak: (0) absent (1) present (Motani, 1999: character 96). This character is separate from character 168: the caudal peak is interpreted as an early modification of the tail to an aquatic lifestyle, with development of a tail fin (Motani, 1999; McGowan & Motani, 2003).

Character 170: Caudal centra – mid-region height change: (0) gradual decrease (1) increase (2) sudden decrease (Motani, 1999: character 98).

Character 171: Caudal centra – elongation: (0) elongate (1) short (Maisch & Matzke 2000: character 59).

Character 172: Anterior caudal vertebrae – neural arch to centrum height: (0) < 2 (1) ≤ 2 (modified from Sander, 2000: character 63).

Character 173: Anterior to middle caudal centra – spinous process shape: (0) very long and slender (1) short and wide (Maisch & Matzke, 2000: character 61).

Character 174: Middle caudal centra – neural spine inclination: (0) distinctly anterior (1) vertical or posterior (Maisch & Matzke, 2000: character 60).

Character 175: Tail fin centra – shape: (0) strongly laterally compressed (1) as wide as high (Maxwell, 2010: character 16).

Character 176: Chevrons – ossified: (0) present (1) absent.

Character 177: Chevrons: (0) present throughout caudal region (1) absent in apical region.

Character 178: Rib – cross-sectional shape at mid- shaft: (0) oval or with posterior groove (1) figure of eight (2) round with anterior and posterior flanges (3) (modified from Sander, 2000: character 73). State three is added to code for the outgroup *Hupehsuchus nanchangensis*.

Character 179: Gastralia – V-shaped median element: (0) present (1) absent (modified from Sander, 2000: character 75).

Character 180: Gastralia – lateral elements: (0) one lateral element per side (1) two lateral elements per side (modified from Sander, 2000: character 75).

Appendicular skeleton

Character 181: Interclavicle – shape: (0) cruciform (1) triangular (1) T-shaped (Motani, 1999: character 45).

Character 182: Clavicle – expanded medial flange: (0) present (1) absent, clavicle slender and narrow medially (Maisch & Matzke, 2000: character 68).

Character 183: Coracoid – shape: (0) mediolaterally wider than anteroposteriorly long (1) approximately equidimensional (2) anteroposteriorly longer than mediolaterally wide (Maxwell, 2012: character 32).

Character 184: Coracoid – medial margin: (0) well- rounded (1) straight symphysis (Maisch & Matzke, 2000: character 73).

Character 185: Coracoid – anterior notch: (0) present (1) absent (modified from Maxwell, 2012: character 33).

Character 186: Coracoid – posterior notch: (0) present (1) absent (modified from Maxwell, 2012: character 34).

Character 187: Coracoid – lengths of anterior and posterior extensions: (0) anterior extension longer than posterior (1) reduced anterior extension (Maisch & Matzke, 2000: character 74).

Character 188: Coracoid – anteromedial process: (0) present (1) absent (Fischer *et al.,* 2011: character 29).

Character 189: Coracoid – glenoid and scapular facet sizes: (0) very small (1) enlarged (Maisch & Matzke, 2000: character 72).

Character 190: Coracoid – medial facet for the scapula: (0) absent (1) present (Arkhangelsky & Zverkov, 2014: character 52).

Character 191: Scapula – anterior expansion proximally: (0) present (1) absent (modified from Maxwell, 2012: character 31). Maxwell *et al.*'s (2012) character is modified to presence/- absence of acromion process, with anterior expansion (states 1 and 2) separated into character 192.

Character 192: Scapula – prominent acromion process: (0) present (1) absent (modified from Maxwell, 2012: character 31).

Character 193: Scapula – shape of the anterodorsal margin: (0) fan-shaped (1) emarginated (2) straight (Motani, 1999: character 46).

Character 194: Scapula – size of the glenoid contribution: (0) at least as large as the coracoid facet (1) markedly smaller than the coracoid facet (Fischer *et al.,* 2012: character 27).

Character 195: Scapula – posterior process: (0) distinct and large (1) reduced (Maisch & Matzke, 2000: character 71).

Character 196: Scapula – blade shaft: (0) absent (1) present at least proximally (Motani, 1999: character 47).

Character 197: Scapula – angle subtended by the axis and glenoid facet: (0) nearly parallel (1) 60° or more (Motani, 1999: character 48).

Character 198: Humerus – differentiated and offset proximal head: (0) present (1) absent (Maisch & Matzke, 2000: character 75).

Character 199: Humerus – anterior margin: (0) straight, convex (1) with small central notch (2) markedly concave (modified from Maisch & Matzke, 2000: character 77).

Character 200: Humerus – anterior flange: (0) absent (1) present (modified from Motani, 1999: character 53).

Character 201: Humerus – anterior flange size: (0) large, complete (1) reduced proximally (modified from Motani, 1999: character 53). See character 200.

Character 202: Humerus – relative width at mid-shaft, exclusive of anterior flange: (0) more than twice as proximodistally long as anteroposteriorly wide (1) approximately equidimensional (Motani, 1999: character 54).

Character 203: Humerus – dorsal trochanter: (0) none or incipient (1) well-developed (Maisch & Matzke 2000: character 78).

Character 204: Humerus – protruding deltopectoral crest: (0) absent (1) present (modified from Fischer *et al.,* 2011: character 31; after Fischer *et al.,* 2013: character 39).

Character 205: Humerus – development of protruding deltopectoral crest: (0) normal (1) large, matching the dorsal trochanter in height, and bordered by concave areas (modified from Fischer *et al.,* 2011: character 31; after Fischer *et al.,* 2013: character 39). See character 204.

Character 206: Humerus – relative anteroposterior width in dorsal view, excluding dorsal and ventral processes: (0) distal end wider than proximal (1) approximately equal or proximal end wider than distal (Fischer *et al*., 2011: character 32).

Character 207: Humerus – plate-like dorsal ridge: (0) absent (1) present (Druckenmiller & Maxwell, 2010: character 31).

Character 208: Humerus – position of distal facets: (0) not terminal (1) terminal (modified from Motani, 1999: character 52).

Character 209: Humerus – relative size of radial and ulnar facets: (0) radial facet is larger than the ulnar facet (1) radial and ulnar facets approximately equal size (modified from Motani, 1999: character 52). See character 208.

Character 210: Humerus – separation of radial and ulnar facets: (0) continuous (1) separated by notch (Maxwell, 2012: character 36). This is coded as inapplicable in taxa where the radial and ulnar facets are separated by e.g. the intermedial facet.

Character 211: Humerus – ulnar facet deflected posterodistally, distal facing radial facet: (0) absent (1) present (Fischer *et al.,* 2012: character 34).

Character 212: Humerus – tuberosity at the antero- distal extremity: (0) present (1) absent, acute angle (Fischer *et al.,* 2013: character 44).

Character 213: Humerus – anterodistal facet for sesamoid: (0) absent (1) present (Motani, 1999: character 57).

Character 214: Humerus – posterodistal facet for sesamoid: (0) absent (1) present (Druckenmiller & Maxwell, 2010: character 36).

Character 215: Humerus-intermedium – contact: (0) absent (1) present (Fernández, 2007: character 16).

Character 216: Forelimb – epipodial and metapodial shape: (0) flattened and plate-like (1) strongly thickened (Maisch & Matzke, 2000: character 94).

Character 217: Forelimb – notching of anterior face on leading edge elements [in adults]: (0) present (1) absent (Fischer *et al*., 2011: character 37).

Character 218: Forelimb – notching of posterior face on trailing edge elements [in adults]: (0) absent (1) present.

Character 219: Forelimb – number of postaxial 'complete' accessory digits: (0) none (1) one (2) two or more (Fischer *et al.,* 2011: character 38). This character is treated as ordered. See also characters 217, 283 and 284.

Character 220: Epipodials – relative size of anterior and posterior element: (0) radius/tibia much larger than ulna/fibula (1) equal in size (modified from Nicholls & Manabe, 2001: character 24).

Character 221: Epipodials – interosseous space between ulna and radius: (0) present (1) small foramen (2) absent (Sander, 2000: character 87).

Character 222: Radius – proximodistal length to anteroposterior width: (0) longer than wide (1) wider than long (Motani, 1999: character 61).

Character 223: Ulna – posterior margin: (0) concave (1) notched (2) straight or convex (modified from Motani, 1999: character 62). See character 199.

Character 224: Ulna – anteroposterior width: (0) proximal end narrower than distal (1) about equal widths (Maisch & Matzke, 2000: character 87).

Character 225: Ulna – shape of the posterior surface: (0) rounded or straight and nearly as thick as the rest of the element (1) concave with a thin, blade-like margin (Fischer *et al.,* 2012: character 36; 2013: character 45).

Character 226: Manual pisiform: (0) present (1) absent (Motani, 1999: character 67).

Character 227: Manual pisiform 2 (neomorph): (0) absent (1) present (Jiang *et al.,* 2006: character 20).

Character 228: Intermedium: (0) present (1) absent (modified from Motani, 1999: character 66).

Character 229: Intermedium-ulnare – relative size: (0) ulnare larger than intermedium (1) ulnare smaller than intermedium (modified from Motani, 1999: character 66). See character 228.

Character 230: Intermedium – location: (0) distal to the ulna (1) between radius and ulna (modified from Fernández, 2007: character 19).

Character 231: Intermedium – shape: (0) as wide or wider than long (1) longer than wide (modified from Jiang *et al*., 2006: character 22).

Character 232: Intermedium – proximal shape: (0) straight or notched (1) pointed (modified from Jiang *et al*., 2006: character 22).

Character 233: Intermedium – distal edge shape: (0) angular (1) flattened (Maxwell, 2010: character 27).

Character 234: Intermedium – number of digits directly supported: (0) one (1) two (2) three (modified from Fischer *et al.,* 2011: character 40). The intermedium must have substantial distal facets present for articulation with distal carpals, or con- tact a distal carpal over at least 30% of its proximal surface for a digit to be considered to be supported.

Character 235: Intermedium – size of distal facets: (0) subequal (1) one much larger than the other(s) (modified from Maxwell, 2012: character 43).

Character 236: Ulnare – number of distal facets: (0) primarily supporting a single digit (1) a posteriorly oriented facet for articulation with metacarpal V at least half the length of the facet for mcIV (Maxwell, 2012: character 44).

Character 237: Distal carpal – number: (0) five (1) four (2) three (3) two (modified from Sander, 2000: character 92). This refers only to 'true' distal carpals, and not accessory elements in the distal car- pal row (after Motani, 1999).

Character 238: Distal carpal 1-metacarpal V – relative size: (0) much smaller (1) similar size or larger (modified from Maisch &Matzke, 2000: character 95). This may be coded as inapplicable if either element is not present.

Character 239: Distal carpals 2–3-distal carpal 5 – relative size: (0) much smaller (1) of comparable size (Maisch & Matzke, 2000: character 96).

Character 240: Distal carpal 4-metacarpal V – relative size: (0) much smaller (1) comparable in size or larger (Maisch & Matzke, 2000: character 100).

Character 241: Manual digits – number of ossified elements in the metacarpal row: (0) four or fewer (1) five or more (Maxwell, 2012: character 45).

Character 242: Manual preaxial accessory digit: (0) absent (1) present (Fischer *et al*., 2011: character 39).

Character 243: Manual digit V reduction: (0) none (1) reduced to small floating elements (modified from Fischer *et al.,* 2013: character 55). The absence of digit five is removed from this character as it is coded by the loss of metacarpal V (character 247).

Character 244: Manual metacarpal I: (0) present (1) absent (modified from Motani, 1999: character 68).

Character 245: Manual metacarpal I – shape: (0) elongate (1) semilunate or rounded (modified from Maisch & Matzke, 2000: character 97).

Character 246: Manual metacarpals II–IV – shape: (0) elongate cylinder (1) rounded (Maisch & Matzke, 2000: character 98).

Character 247: Manual metacarpal V: (0) present (1) absent (modified from Maisch & Matzke, 2000: character 99).

Character 248: Manual metacarpal V – posterior margin: (0) convex (1) straight or concave (modified from Maisch & Matzke, 2000: character 99).

Character 249: Manual phalanges – maximum number in a single digit: (0) five or less (1) six or more (modified from Motani, 1999: character 77).

Character 250: Proximal manual phalanges – shape: (0) elongate or hourglass-shaped (1) mostly rounded (2) tightly packed rectangles/polygons (modified from Maisch & Matzke, 2000: character 102; after Fischer *et al.,* 2011: character 42).

Character 251: Distal manual phalanges – shape: (0) elongate (1) rounded (Maisch & Matzke 2000: character 101).

Character 252: Manual digital bifurcation: (0) absent (1) present in at least some individuals (modified from Fischer *et al.,* 2011: character 43).

Character 253: Pelvic girdle – size: (0) normal- sized (1) moderately reduced (2) strongly reduced (Sander, 2000: character 103).

Character 254: Ilium – blade shape: (0) with thick shaft (1) plate-like (2) narrow and styloidal (Motani, 1999: character 80).

Character 255: Ilium – anteromedial prominence: (0) present (1) absent (Motani, 1999: character 81).

Character 256: Ischium-pubis – medial fusion: (0) absent (1) present (modified from Maxwell, 2012: character 50).

Character 257: Ischium-pubis – lateral fusion: (0) absent (1) present (modified from Maxwell, 2012: character 51).

Character 258: Ischium and pubis – meet medially in well-defined symphysis: (0) present (1) strongly convex medial margins (Maisch & Matzke, 2000: character 108).

Character 259: Ischium and pubis – relative size: (0) pubis larger than ischium (1) similar size or ischium larger (Maisch & Matzke, 2000: character 107).

Character 260: Ischium or ischiopubis – shape: (0) plate-like, flattened (1) rod-like (Fischer *et al.,* 2011: character 45).

Character 261: Ischium – medial edge expansion: (0) great (1) little or none (Maxwell, 2012: character 53).

Character 262: Ischium – acetabular contribution: (0) greater than pubis (1) subequal with pubis (Maxwell, 2012: character 52).

Character 263: Pubis – obturator foramen: (0) present (1) absent (modified from Motani, 1999: character 84).

Character 264: Pubis – location of obturator foramen: (0) completely enclosed in pubis (1) mostly in pubis but open on one side (2) part of obturator fossa (Thorne *et al.,* 2011: character 84).

Character 265: Pubis – distance between the obturator foramen[/incisure] and the pubic symphysis: (0) closer to the glenoid than the pubic symphysis (1) closer to the pubic symphysis than to the glenoid (2) obturator fossa open medially (modified from Maisch & Matzke 2000: character 110).

Character 266: Femur – relative proximodistal length to anteroposterior width: (0) much (>2×) longer than wide (1) shorter and wider, with distinct medial constriction (Sander, 2000: character 110).

Character 267: Femur – prominent, ridge-like dorsal and ventral processes demarcated from the head and extending up to mid-shaft: (0) absent (1) present (Fischer *et al.,* 2011: character 46).

Character 268: Femur – ventral process size relative to dorsal process: (0) smaller (1) same size or larger, more prominent (Roberts *et al.,* 2014: character 52).

Character 269: Femur – wide distal blade: (0) present (1) absent, subequal proximal and distal widths (Fischer *et al*., 2013: character 61).

Character 270: Femur – anterodistal facet for anterior accessory epipodial element anterior to the tibia: (0) absent (1) present (Fischer *et al.,* 2011: character 48).

Character 271: Femur – tibial facet size relative to fibular facet: (0) larger (1) subequal (Maisch & Matzke, 2000: character 112).

Character 272: Tibia – proximodistal length to anteroposterior width: (0) longer than wide (1) wider than long (Motani, 1999: character 90).

Character 273: Tibia – anterior margin: (0) concave (1) notched (2) straight or convex (modified from Motani, 1999: character 92). See character 199.

Character 274: Tibia – posterior margin: (0) con- cave (1) notched (2) straight or convex (modified from Motani, 1999: character 91). See character 199.

Character 275: Tibia – proximodistal length relative to more distal elements: (0) approximately twice as long (1) only slightly longer (Maxwell, 2012: character 55).

Character 276: Tibia and fibula – relative size: (0) tibia larger than fibula (1) approximately equal (2) tibia proximodistally and anteroposteriorly smaller (Maxwell, 2012: character 56).

Character 277: Tibia and fibula – proximal contact: (0) absent (1) present (modified from Motani, 1999: character 88; after Maxwell, 2012: character 57).

Character 278: Fibula – anterior margin: (0) concave (1) notched (2) straight or convex (modified from Maxwell, 2012: character 59). See character 199.

Character 279: Fibula – position relative to femur: (0) not fixed, mobile relative to the femur (1) much posterior (2) about the same level (Motani, 1999: character 93).

Character 280: Astragalus – position: (0) between tibia and fibula (1) distal to tibia (Druckenmiller & Maxwell, 2010: character 48).

Character 281: Distal tarsals – number: (0) five (1) four (2) three (Sander, 2000: character 112).

Character 282: Pedal digit 1: (0) present (1) absent (Motani, 1999: character 89).

Character 283: Hindlimb – notching on anterior of leading edge metapodials: (0) absent (1) present (Maxwell, 2012: character 60). See also characters 217, 218 and 284.

Character 284: Hindlimb – notching on posterior of trailing edge metapodials: (0) absent (1) present.

Character 285: Pedal postaxial accessory digit: (0) absent (1) present (Fischer *et al*., 2011: character 50).

Character 286: Metatarsals – shape: (0) elongate or hourglass-shaped (1) shortened and rounded (2) polygonal (modified from Maisch &Matzke, 2000: character 118).

Character 287: Pedal phalanges – shape: (0) elongate or hourglass-shaped (1) rounded (2) polygonal (modified from Maisch & Matzke, 2000: character 119). See character 286.

Character coding revision. The revisions were applied to the matrix of Maxwell & Cortés (2020)

Besanosaurus leptorynchus: 6.? → 6.0; 9.? → 9.0; 11.1 → 11.0; 12.- → 12.0; 14.?→ 14.1; 16.? → 16.1; 19.1 → 19.0; 20.? → 20.0; 26.0 → 26.1; 28.? → 28.1; 29.? → 29.0; 30.? → 30.0; 31.1 → 31.0; 32.0 → 32.1; 38.0 → 38.1; 39.0 → 39.1; 45.1→ 45.0; 46.? → 46.1; 49.? → 49.1; 54.9 → 54.0; 55.? → 55.0; 56.1 → 56.?; 58.1 → 58.0; 64.? → 64.1; 67.? → 67.0; 68.? → 68.1; 69.? → 69.0; 70.? → 70.1; 71.? → 71.1; 72.? → 72.1; 73.? → 73.0; 74.? → 74.1; 75.? → 75.0; 80.1 → 80.0; 82.? → 82.0; 86.? → 86.1; 88.? → 88.1; 89.? → 89.1; 90.? → 90.1; 92.? → 92.0; 93.? → 93.0; 95.? → 96.1; 96.? → 96.1; 97.? → 97.0; 101.? → 101.0; 102.? → 102.0; 103.? →103.0; 104.? → 104.1; 105.? → 105.0; 106.? → 106.1; 107.? → 107.0; 108.? → 108.0; 109.? → 109.0; 111.? → 111.0; 112.? → 112.0; 113.? → 113.1 based on Bindellini *et al*. (2021) and Maisch & Matzke (1997).

Temnodontosaurus crassimanus: 9.? → 9.1; 20.? → 20.0; 29.0 → 29.?; 30.0 → 30.?; 39.1 → 39.?; 52.? → 52.0; 64.? → 64.1; 67.? → 67.0; 68.? → 68.1; 95.? → 95.1; 96.? → 96.0; 167;1 → 167.?; 178.0 → 178.?; 195.? → 195.1; 196.? → 196.1; 230.0 → 230.1; 286.2 → 286.1; 287.2 →287.1 based on pers. obs. of YORYM: 497 and on Swaby & Lomax (2020)

Temnodontosaurus eurycephalus: 3.1 → 3.0; 59.1 → 59.0; 79.? → 79.1; 125.? → 125.1 based on pers. obs. of NHMUK R1157

Temnodontosaurus nuertingensis: 23.? → 23.1; 122.? → 122.0 based on pers. obs. of SMNS 13488 and on Maisch & Hungerbühler (1997)

Temnodontosaurus platyodon: 29.1 → 29.0; 30.1 → 30.0; 34.1 → 34; 79.0 → 79.1; 111.0 → 111.? based on pers. obs. of NHMUK R 1158 and on Godefroit (1993)

Temnodontosaurus trigonodon: 53.1 → 53.0; 74.0 → 74.1; 100.1 → 100.0 based on pers. obs. of SMNS 13128, SMNS 15950, SMNS 17560 and on Maisch & Hungerbühler (2001)

OTU list modified from Moon (2017) with the information of Fischer *et al*. (2016) and Motani *et al.,* (2017)

1. ***Hupehsuchus nanchangensis*** Young & Dong, 1972 from the Olenekian (Early Triassic) of China.

2. ***Acamptonectes densus*** Fischer *et al.,*2012 from the Hauterivian (Early Cretaceous) of Germany and the UK.

3. ***Aegirosaurus leptospondylus*** (Wagner, 1853) from the Tithonian, Late Jurassic of Germany.

4. ***Arthropterygius chrisorum*** (Russell, 1993) from the Late Jurassic of Canada.

5. ***Arthropterygius lundi*** Roberts et al., 2014 from the Tithonian (Late Jurassic) of Spitsbergen. This species was recovered as a member of *Arthropterygius* according Zverkov & Prilepskaya (2019).

6. ***Athabascasaurus bitumineus*** Druckenmiller & Maxwell, 2010 from the Albian (Early Cretaceous) of Canada.

7. ***Barracudasauroides panxianensis*** (Jiang et al., 2006) from the Middle Triassic of China.

8. ***Besanosaurus leptorhynchus*** Dal Sasso & Pinna, 1996 from the uppermost Anisian (Middle Triassic) of Italy and of Switzerland since *Mikadocephalus gracilirostris* is refered as a synonym of *B. leptorhynchus* (Bindellini *et al.* 2021).

9. ***Brachypterygius extremus*** (Boulenger, 1904) from the Kimmeridgian–Tithonian (Late Jurassic) of the UK

10. ***Brachypterygius pseudoscythica*** (Efimov, 1998) from the Tithonian (Late Jurassic) of Russia.

11. ***Californosaurus perrini*** (Merriam, 1902) from the Carnian (Late Triassic) of the USA.

12. ***Callawayia neoscapularis*** (McGowan, 1994) from the Norian (Late Triassic) of the USA.

13. ***Cartorhynchus lenticarpus*** Motani *et al*., 2015 from the Olenekian (Early Triassic) of China.

14. ***Caypullisaurus bonapartei*** Fernández, 1997 from the Late Jurassic–Early Cretaceous of Argentina.

15. ***Chacaicosaurus cayi*** Fernández, 1994 from the Bajocian (Middle Jurassic) of Argentina.

16. ***Chaohusaurus chaoxianensis*** (Chen, 1985) from the Olenekian (Early Triassic) of China.

17. ***Chaohusaurus geishanensis*** Young & Dong, 1972 from the Olenekian (Early Triassic) of China.

18. ***Chaohusaurus zhangjiawanensis*** Chen *et al*., 2013 from the Olenekian (Early Triassic) of China.

19. ***Contectopalatus atavus*** (Quenstedt, 1852) from the Anisian (Middle Triassic) of China.

20. ***Cryopterygius kielanae*** Tyborowski, 2016 from the Tithonian (Late Jurassic) of Poland.

21. ***Cryopterygius kristiansenae*** Druckenmiller *et al*., 2012 from the Tithonian (Late Jurassic) of Svalbard.

22. ***Cymbospondylus buchseri*** Sander, 1989 from the Anisian (Middle Triassic) of Switzerland.

23. ***Cymbospondylus nichollsi*** Fröbisch et al., 2006 from the Anisian (Middle Triassic) of the USA.

24. ***Cymbospondylus petrinus*** Leidy, 1868 from the Anisian (Middle Triassic) of the USA.

25. ***Eurhinosaurus longirostris*** Mantell, 1851 from the Toarcian (Early Jurassic) of France, Germany, Luxembourg, Switzerland and UK.

26. ***Excalibosaurus costini*** McGowan 1986 from the Sinemurian (Early Jurassic) of the UK.

27. ***Gengasaurus nicosiai*** Paparella *et al*., 2016 from the Kimmeridgian–Tithonian (Late Jurassic) of Italy.

28. ***Grendelius alekseevi*** (Arkhangelsky, 2001) from the Tithonian (Late Jurassic) of Russia.

29. ***Grendelius zhuravlevi*** (Arkhangelsky, 1998a) from the Tithonian (Late Jurassic) of Russia.

30. ***Grippia longirostris*** Wiman, 1929 from the Olenekian (Early Triassic) of Svalbard.

31. ***Guizhouichthyosaurus tangae*** Cao and Luo, in Yin et al., 2000 from the Carnian (Late Triassic) of China.

32. ***Guizhouichthyosaurus wolonggangense*** (Chen et al., 2007) from the Carnian (Late Triassic) of China.

33. ***Gulosaurus helmi*** Cuthbertson et al., 2013 from the Spathian-Ladinian (Early–Middle Triassic) of Canada.

34. ***Hauffiopteryx typicus*** Maisch 2008 from the Toarcian (Early Jurassic) of Germany, Luxembourg and UK.

35. ***Himalayasaurus tibetensis*** Young & Dong, 1972 from the Norian (Late Triassic) of Tibet.

36. ***Hudsonelpidia brevirostris*** McGowan, 1995 from the Norian (Late Triassic) of Canada.

37. ***Ichthyosaurus anningae*** Lomax & Massare, 2015 from the Sinemurian–Pliensbachian (Early Jurassic) of the UK.

38. ***Ichthyosaurus breviceps*** Owen, 1881 from the Sinemurian (Early Jurassic) of the UK.

39. ***Ichthyosaurus communis*** Conybeare, 1822 from the lowermost Hettangian–late Sinemurian
40. (Early Jurassic) of the Belgium and UK.

41. ***Ichthyosaurus conybeari*** Lydekker, 1888 from the Sinemurian the Early Jurassic of the UK.

42. ***Ichthyosaurus larkini*** Lomax & Massare, 2016 from the Hettangian (Early Jurassic) of the UK.

43. ***Ichthyosaurus somersetensis*** Lomax & Massare, 2016 from the Hettangian (Early Jurassic) of the UK.

44. ***Keilhauia nui*** Delsett *et al*., 2017 from the Berriasian (Early Cretaceous) of Spitsbergen.

45. ***Leninia stellans*** Fischer *et al*., 2014b from the Aptian (Early Cretaceous) of Russia.

46. ***Leptonectes moorei*** McGowan & Milner, 1999 from the Pliensbachian (Early Jurassic) of the UK.

47. ***Leptonectes solei*** (McGowan, 1993) from the Sinemurian (Early Jurassic) of the UK.

48. ***Leptonectes tenuirostris*** (Conybeare, 1822) from the Hettangian to the Plienbachian (Early Jurassic) of the Germany, UK and Switzerland.

49. ***Macgowania janiceps*** (McGowan, 1996) from the Norian (Late Triassic) of Canada.

50. ***Maiaspondylus lindoei*** Maxwell & Caldwell, 2006 from the Albian (Early Cretaceous) of Canada.

51. ***Malawania anachronus*** Fischer et al., 2013 from the Hauterivian–Barremian (Early Cretaceous) of Iraq.

52. ***Mixosaurus cornalianus*** (Bassani, 1886) from the Anisian (Middle Triassic) of Italy and Switzerland.
53. ***Mixosaurus kuhnschneyderi*** (Brinkmann, 1998) from the Anisian Middle Triassic of Italy.

54. ***Mixosaurus xindianensis*** Chen & Cheng, 2010 from the Anisian (Middle Triassic) of China.

55. ***Mollesaurus periallus*** Fernández, 1999 from the Bajocian (Middle Jurassic) of Argentina.

56. ***Muiscasaurus catheti*** Maxwell *et al*., 2016 from the Barremian–Aptian (Early Cretaceous) of Colombia.

57. ***Nannopterygius enthekiodon*** (Hulke, 1871) from the Oxfordian?–Kimmeridgian (Late Jurassic) of the UK.

58. ***Ophthalmosaurus icenicus*** Seeley, 1874 from the Callovian–Oxfordian (Middle–Late Jurassic) of France and the UK.

59. ***Ophthalmosaurus natans*** (Marsh, 1879) from the Oxfordian (Late Jurassic) of the USA.

60. ***Ophthalmosaurus yasykovi*** (Efimov, 1999a) from the Tithonian (Late Jurassic) of Russia.

61. ***Palvennia hoybergeti*** Druckenmiller *et al*., 2012 from the Tithonian (Late Jurassic) of Spitsbergen.

62. ***Paraophthalmosaurus kabanovi*** (Efimov, 1999a) from the Tithonian (Late Jurassic) of Russia.

63. ***Parvinatator wapitiensis*** Nicholls & Brinkman, 1995 from the Olenekian (Early Triassic) of Canada.

64. ***Pervushovisaurus bannovkensis*** Arkhangelsky, 1998b from the Cenomanian (Late Cretaceous) of Russia

65. ***Pervushovisaurus campylodon*** (Carter, 1846) from the Cenomanian (Late Cretaceous) of the UK.

66. ***Pessopteryx nisseri*** Wiman, 1910 from the Early Triassic of Spitsbergen.

67. ***Nannopterygius saveljeviensis*** (Arkhangelsky, 1997) from the Tithonian (Late Jurassic) of Russia. This species was recovered as a member of *Nannopterygius* according Zverkov & Jacobs (2020).

68. ***Phalarodon callawayi*** Schmitz et al., 2004 from the Anisian (Middle Triassic) of Spitsbergen and the USA.

69. ***Phalarodon fraasi*** Merriam, 1910 from the Anisian (Middle Triassic) of China and Germany.

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70. ***Phantomosaurus neubigi*** (Sander, 1997) from the Anisian (Middle Triassic) of Germany.

71. ***Platypterygius americanus*** (Nace, 1939) from the Albian–Cenomanian (Early–Late Cretaceous) of the USA.

72. ***Platypterygius australis*** (M'Coy, 1867) from the Albian (Early Cretaceous) of Australia.

73. ***Platypterygius hauthali*** (Huene, 1927) from the Barremian (Early Cretaceous) of Argentina.

74. ***Platypterygius hercynicus*** Kuhn, 1946 from the Aptian (Early Cretaceous) of Germany.

75. ***Platypterygius platydactylus*** (Broili, 1907) from the Aptian (Early Cretaceous) of Germany.

76. ***Platypterygius sachicarum*** Páramo, 1997 from the Barremian–Aptian (Early Cretaceous) of Colombia.

77. ***Qianichthyosaurus xingyiensis*** Ji, Jiang & Motani in Yang et al., 2013 from the Ladinian (Middle Triassic) of China.

78. ***Qianichthyosaurus zhoui*** Li, 1999 from the Ladinian (Middle Triassic) of China.

79. ***Quasianosteosaurus vikinghoegdai*** Maisch & Matzke, 2003 from the Early Triassic of Spitsbergen.

80. ***Sclerocormus parviceps*** Jiang *et al.,* 2016 from the Olenekian (Early Triassic) of China.

81. ***Shastasaurus liangae*** (Yin, in Yin *et al*., 2000) from the Carnian (Late Triassic) of China.

82. ***Shastasaurus pacificus*** Merriam, 1895 from the Carnian (Late Triassic) of the USA.

83. ***Shastasaurus sikkaniensis*** (Nicholls & Manabe, 2004) from the Norian (Late Triassic) of Canada.

84. ***Shonisaurus popularis*** Camp, 1976 from the Carnian (Late Triassic) of the USA.

85. ***Simbirskiasaurus birjukovi*** Otschev & Efimov, 1985 from the Barremian (Early Cretaceous) of Russia.

86. ***Sisteronia seeleyi*** Fischer et al., 2014a from the Cenomanian (Late Cretaceous) of the UK.

87. ***Stenopterygius aaleniensis*** Maxwell et al., 2012 from the Aalenian (Middle Jurassic) of Germany.

88. ***Stenopterygius quadriscissus*** (Quenstedt, 1858) from the Toarcian (Early Jurassic) of Luxembourg and Germany.

89. ***Stenopterygius triscissus*** (Quenstedt, 1858) from the Toarcian (Early Jurassic) of Luxembourg, Germany and the UK.

90. ***Stenopterygius uniter*** Huene, 1931 from the Toarcian (Early Jurassic) of Germany.

91. ***Suevoleviathan integer*** (Bronn, 1844) from the Toarcian (Early Jurassic) of Germany.

92. ***Sveltonectes insolitus*** Fischer *et al*., 2011 from the Barremian (Early Cretaceous) of Russia.

93. ***Temnodontosaurus azerguensis*** Martin *et al*., 2012 from the Toarcian (Early Jurassic) of France.

94. ***Temnodontosaurus crassimanus*** (Blake, 1876) from the Toarcian (Lower Jurassic) of the UK.

95. ***Temnodontosaurus eurycephalus*** McGowan, 1974 from the Sinemurian (Early Jurassic) of the UK.

96. ***Temnodontosaurus nuertingensis*** (Huene, 1931) from the Pliensbachian (Early Jurassic) of Germany.

97. ***Temnodontosaurus platyodon*** (Conybeare, 1822) from the Hettangian–Sinemurian (Early Jurassic) of the Belgium and UK.

98. ***Temnodontosaurus trigonodon*** (Theodori, 1843) from the Toarcian (Early Jurassic) of Germany.

99. ***Temnodontosaurus zetlandicus*** (Seeley, 1880) from the Toarcian (Early Jurassic) of UK.

100. ***Thalattoarchon saurophagis*** Fröbisch *et al*., 2013 from the Anisian, Middle Triassic of the USA.

101. ***Tholodus schmidi*** Meyer, 1849 from the Ladinian (Middle Triassic) of Germany & Switzerland.

102. ***Toretocnemus californicus*** Merriam, 1903 from the Carnian (Late Triassic) of the USA.

103. ***Toretocnemus zitteli*** (Merriam, 1903) from the Carnian (Late Triassic) of the USA.

104. ***Undorosaurus gorodischensis*** Efimov, 1999b from the Tithonian (Late Jurassic) of Russia.

105. ***Undorosaurus trautscholdi*** Arkhangelsky & Zverkov, 2014 from the Tithonian (Late Jurassic) of Russia.

106. ***Utatsusaurus hataii*** Shikama *et al*., 1978 from the Olenekian (Early Triassic) of Japan.

107. ***Wahlisaurus massarae*** Lomax, 2016 from the Hettangian (Early Jurassic) of the UK.

108. ***Wimanius odontopalatus*** Maisch & Matzke, 1998 from the (Anisian-Ladinian) Middle Triassic of Switzerland.

109. ***Xinminosaurus catactes*** Jiang et al., 2008 from the Anisian (Middle Triassic) of China.

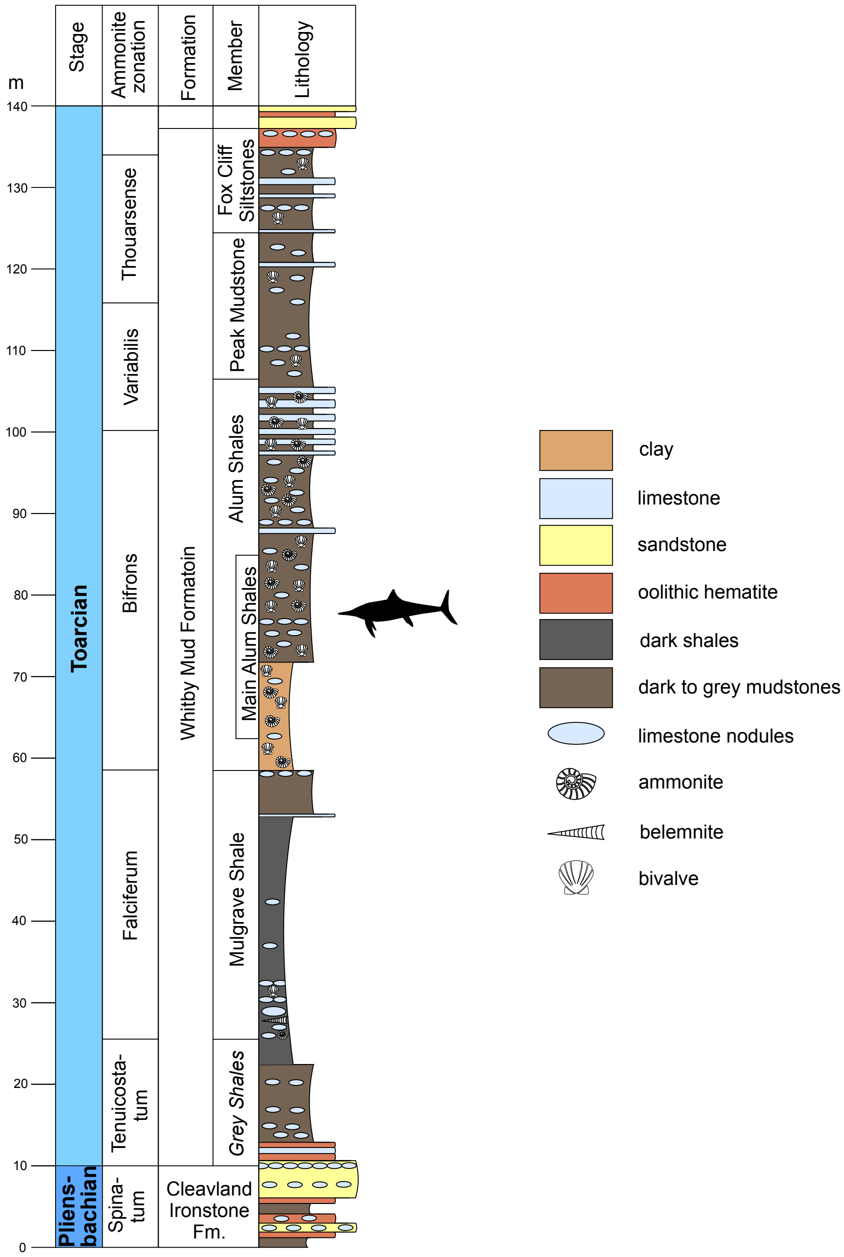

Figure S1: Schematic stratigraphic log of the Whitby coastal section in North Yorkshire (UK). The holotype of *Temnodontosaurus zetlandicus* is thought to have been found in calcareous concretions in the Main Alum Shales which corresponds biostratigraphically to the *Bifrons* Zone, Middle Toarcian.

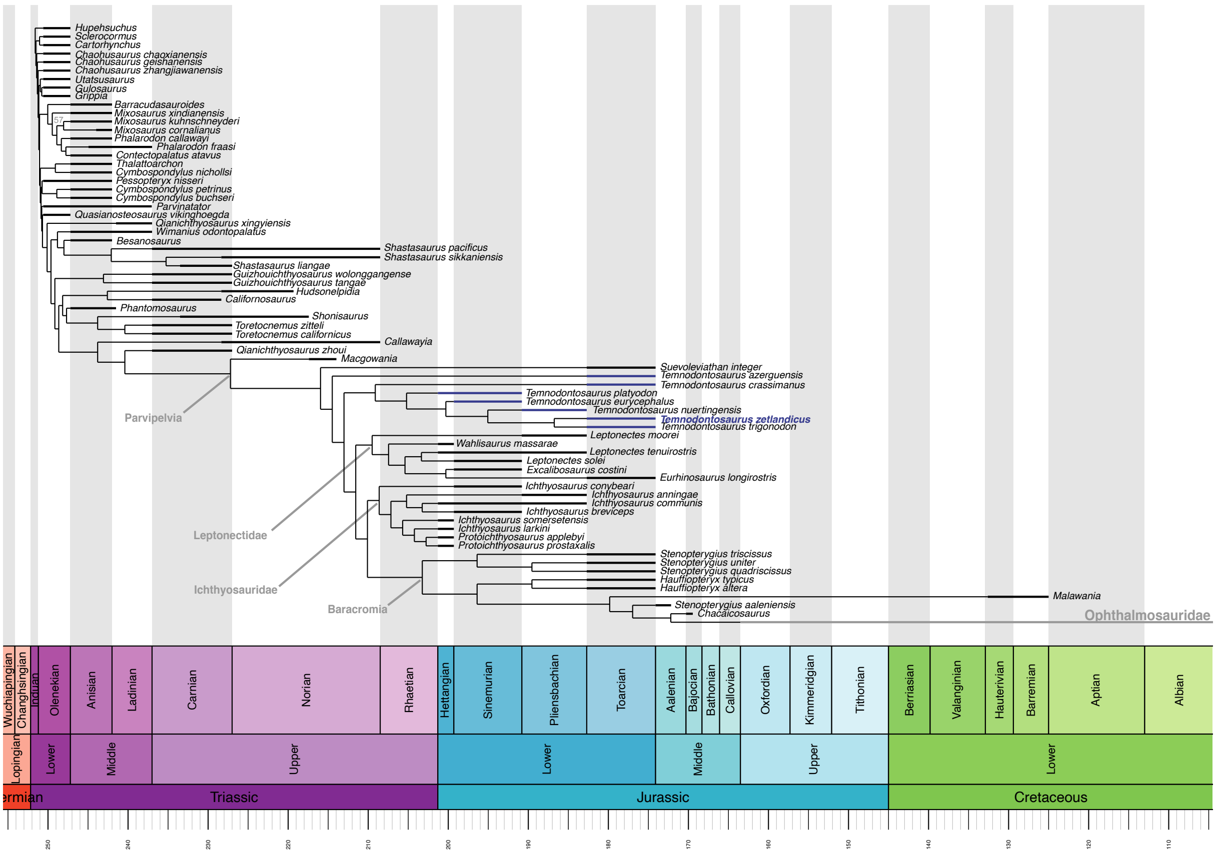

Figure S2: Time scaled phylogenetic tree arising from *implied weighting* (K=6) maximum parsimony analysis, in 'equal' reconstruction branches lengths. The tree has a score of 102.201. The Consistency Index is 0,189 and the Retention Index is 0,640. Branch values of resampling > 50 are indicated on the branches leading their corresponding nodes.

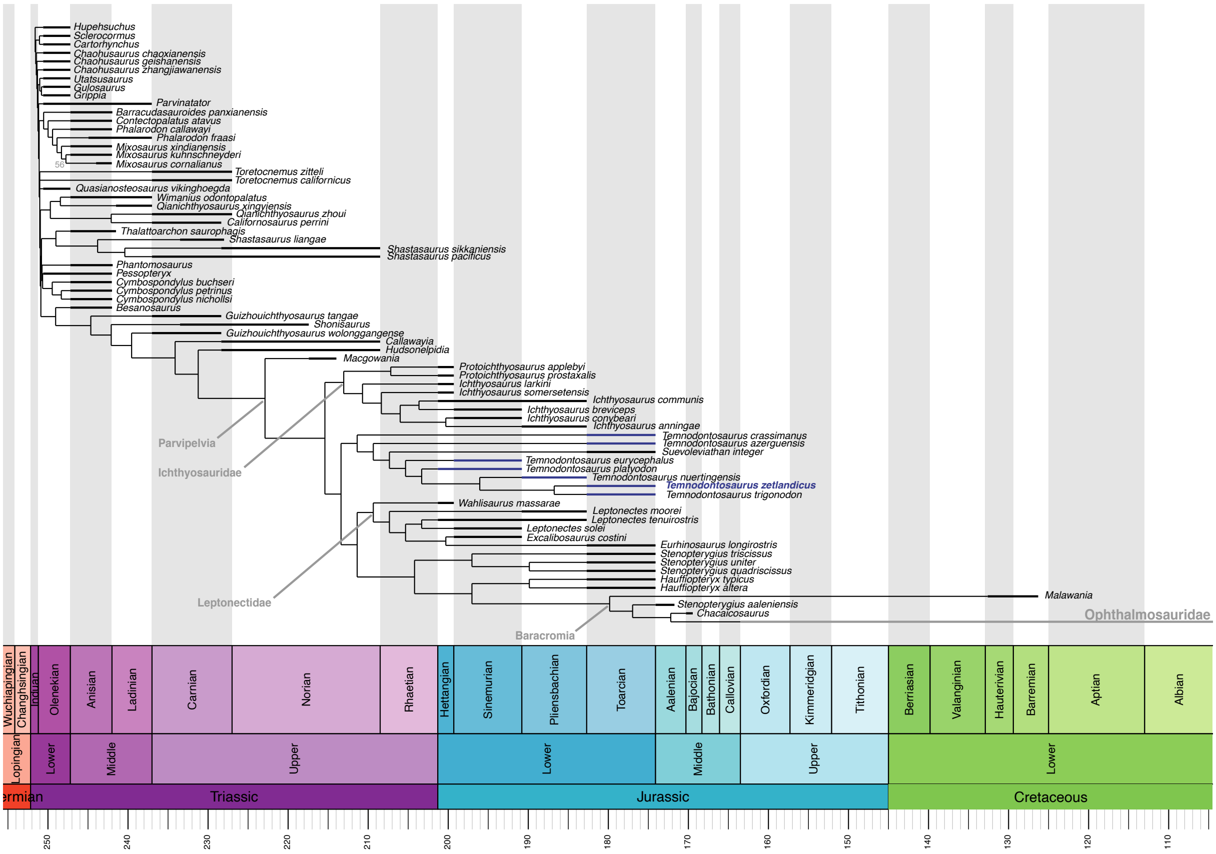

Figure S3: Time scaled phylogenetic tree arising from *implied weighting* (K=9) maximum parsimony analysis, in 'equal' reconstruction branches lengths. The tree has a score of 81.639. The Consistency Index is 0.191 and the Retention Index is 0.642. Branch values of resampling > 50 are indicated on the branches leading their corresponding nodes.

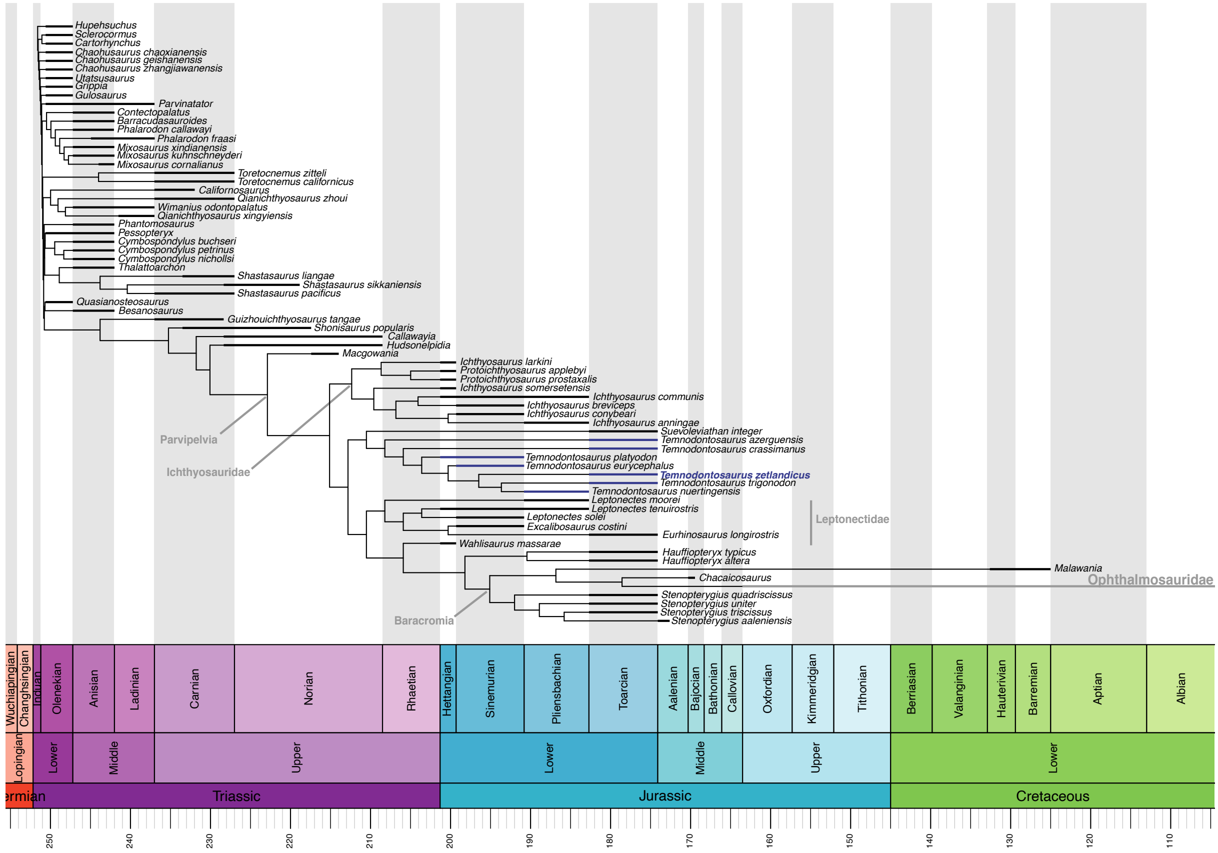

Figure S4: Time scaled phylogenetic tree in which the monophyly of *Temnodontosaurus* is forced, arising from *implied weighting* (K=12) maximum parsimony analysis, in ‘equal’ reconstruction branches lengths. The tree has a scores of 68.589. The Consistency Index is 0.192 and the Retention Index is 0.646.

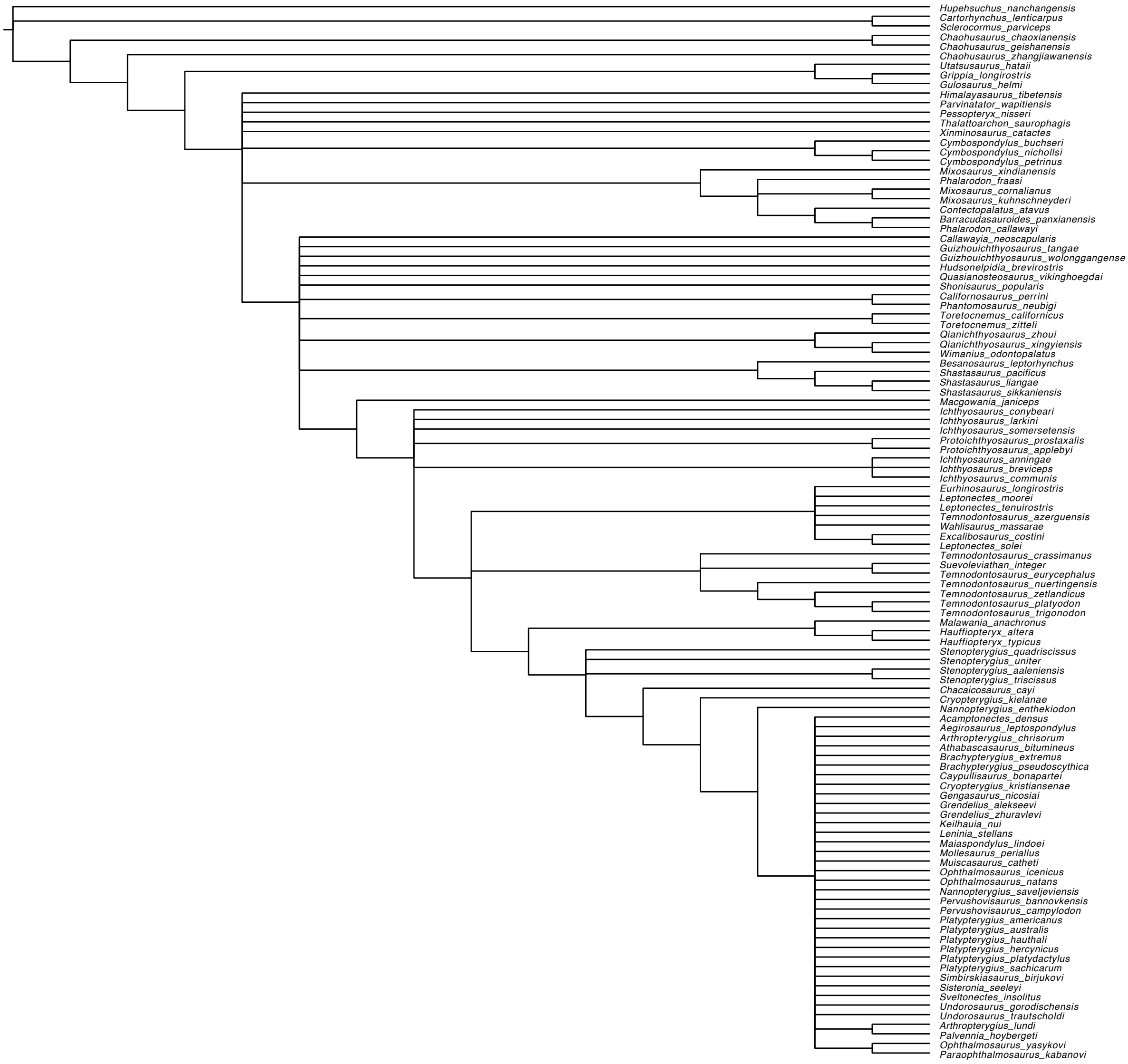

Figure S5: Majority rule consensus cladogram generated with a non-clock Bayesian analysis.

Table S1. Selected measurements (mm) and notable cranial ratios between *T. zetlandicus, 'I'. acutirostris* and *T. trigonodon*.

Species	***Temnodontosaurus zetlandicus***	***'Ichthyosaurus' acutirostris***	***Temnodontosaurus trigonodon***			
Specimens	CAMSM J35176	NHMUK PV OR 14553	PB1	SMNS 13128	SMNS 15950	SMSN 17560
Skull length	~ 990	–	1938	1202	1520	1471
Rostrum length	~ 680	–	1372	890	1057	1054
Orbit length	201	77	281	214	248	223
Postorbital region length	101	66	301	126	201	213
Rostrum ratio	~ 0. 69	–	0.71	0.74	0.70	0.72
Orbit ratio	~ 0.20	–	0. 15	0.18	0.16	0.15
Postorbital ratio	~ 0.10	–	0.16	0.10	0.13	0.15
Length of the postorbital region/length of the orbit ratio	0.53	0.78	1.07	0.60	0.80	0.96

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