

SUPPLEMENTARY DATA 1

A new lepidosauromorph reptile from the Middle Triassic (Ladinian) of Germany and its phylogenetic relationships

RAINER R. SCHOCH¹ and HANS-DIETER SUES²

¹Staatliches Museum für Naturkunde Stuttgart, Rosenstein 1, D-70191 Stuttgart, Germany,
rainer.schoch@smns-bw.de;

²Department of Paleobiology, National Museum of Natural History, Smithsonian Institution,
MRC 121, Washington, D.C. 20560, U.S.A., sush@si.edu

APPENDIX 1. Characters and character-states for phylogenetic analysis by Ezcurra et al. (2014)
who provide additional details and primary references.

- (1) Teeth, tooth attachment: subthecodont (protothecodont) (0); ankylothecodont (1); pleurodont (2); acrodont (3); thecodont (4).
- (2) Teeth, distal curvature of marginal teeth: strong (0); slight (1); absent (2). ORDERED.
- (3) Teeth, serrations on crown: absent (0); present (1).
- (4) Teeth, lateral compression of marginal dentition: only distally or absent (0); over two-thirds of tooth (1).
- (5) Snout, shape of antorbital region: broad, nasal largely dorsal element (0); narrow and tall, nasal has nearly vertical contribution to snout (1).

- (6) Snout, antorbital-postorbital ratio: postorbital part (posterior margin of orbit to caudal tip of skull) longer than antorbital part (0); antorbital part of snout (tip to anterior margin of orbit) longer but nasal shorter or equal in length to frontal (1); antorbital part of snout (tip to anterior margin of orbit) longer and nasal longer than frontal (2). ORDERED.
- (7) Snout, proportions: width > height (0); width < height (1).
- (8) Premaxilla, number of teeth: ≥ 5 (0); 2 to 4 (1); 0 (2). ORDERED.
- (9) Premaxilla, anterior process: absent (0); present (1).
- (10) Premaxilla, downturned alveolar margin: no (0); slightly (1); strongly (2). ORDERED.
- (11) Premaxilla, narial shelf: more or less sharp edge between lateral (= sculptured, if sculpture is present) surface of skull and ventral wall of naris (0); rounded ventral narial shelf that transitions smoothly into ventral edge of skull (1).
- (12) Premaxilla, postnarial process (= dorsolateral process): absent (0); small, extends slightly behind naris but maxilla forms most of the border of the external naris (1); well-developed, forms more of the border of the external naris than the maxilla or excludes the maxilla from participation in the external naris (2). ORDERED.
- (13) Maxilla, dorsal process: absent (0); starts just behind external naris, extends to level of dorsal narial margin (1); spike-like, just in front of orbit, overlies lacrimal (2); massive, pillar-like, extends above narial margin (3).
- (14) Maxilla, contact with prefrontal: absent (0); present (1).
- (15) Maxilla, tooth number: 25 or fewer (0); 26 or more (1).
- (16) Maxilla, caniniform region: region absent (0); region present (1); one or two caniniform teeth present (2). ORDERED.

(17) Maxilla, dorsal of caniniform tooth or region: flat (0); swollen (1); well-defined buttress (2).

ORDERED.

(18) Septomaxilla, shape: pillar-like (0); curled sheet (1); absent (2). ORDERED.

(19) Septomaxilla, lateral sheet-like exposure: absent (0); present (1).

(20) External naris, position: marginal (minimal distance between nares ≥ 0.35 snout width at same level) (0); close to midline (1); confluent (2). ORDERED.

(21) External naris, posterodorsal expansion: absent (0); pinched between nasal and maxilla (1); greatly enlarged, between nasal and lacrimal (2). ORDERED.

(22) Nasal, external narial shelf: absent (0); present (1).

(23) Lacrimal, length: participates in margin of external naris (0); does not reach external naris (1).

(24) Lacrimal, duct: opens on posterior edge of lacrimal (0); opens laterally near posterior edge of lacrimal (1); opens laterally on concave surface of lacrimal (2). ORDERED.

(25) Frontal, orbital border: absent or narrow (0); broad and forms most of dorsal edge (1).

(26) Frontal, posterolateral process: absent, frontal-parietal suture forming right angle to parasagittal plane (0); absent or very short, f-p suture forming obtuse angle to parasagittal plane (1); long, narrow, f-p suture forming acute angle with parasagittal plane (2).

ORDERED.

(27) Parietal, extension over interorbital region: absent or marginal (0); present (1).

(28) Parietal, ventrolateral flange: absent (0); present (1).

(29) Parietal, sagittal crest: absent (0); present (1).

(30) Parietal, size of pineal foramen: large, more than 25% of mid-parietal length (0); small, less than 25% of mid-parietal length (1); absent (2). ORDERED.

(31) Parietal, position of pineal foramen in dorsal view: completely enclosed by parietals in the anterior half of the bone (excluding posterolateral processes of the parietals) (0); completely enclosed by parietals close to mid-length or in the posterior half of the bone (excluding posterolateral processes of the parietals) (1); enclosed by both frontals and parietals (2).

ORDERED.

(32) Prefrontal, suture with nasal: parasagittal, at least in its caudal third (0); anterolateral (1).

(33) Prefrontal and jugal, tuberos ornamentation on their external surface: absent (0); present (1).

(34) Squamosal, anterodorsal process: no or little underlap of posterior process of postorbital (0); extensive underlap of posterior process of postorbital (1).

(35) Squamosal, posterodorsal process: absent (0); present (1).

(36) Squamosal, ventral process: broad, with proximal length approximately equal to dorsoventral height (0); narrow, with proximal length less than dorsoventral height (1); squamosal confined dorsally (2). ORDERED.

(37) Squamosal, occipital shelf: broad, contributes to occipital surface of skull (0); narrow, quadrate exposed in occipital view (1); absent, posterior edge of quadrate exposed in lateral view (2). ORDERED.

(38) Upper temporal fenestra: absent (0); present, postfrontal does not enter (1); present, postfrontal enters (2). ORDERED.

(39) Lower temporal fenestra: absent (0); present, quadratojugal excluded (1); present, quadratojugal enters or is absent (2).

- (40) Postorbital region, ventral temporal bar (zygomatic arch): absent (no fenestra) (0); tall, occupying more than 20% of skull height (1); narrow but complete, occupying less than 20% of postorbital skull height (2); incomplete (3); absent (with fenestra) (4). ORDERED.
- (41) Postorbital region, ventral margin: straight or convex (0); concave, though nowhere dorsal to tooth row (1).
- (42) Postorbital, dorsal and lateral surfaces: form smooth curve (or dorsal surface absent, postorbital not participating in skull roof) (0); sharply divided (meeting at edge) (1).
- (43) Postorbital, lateral boss at orbital margin: absent (0); present (1).
- (44) Postorbital, posterior process if temporal fenestrae are absent reaches supratemporal or if at least one fenestra is present extends up to or beyond posterior margin of fenestrae: absent (0); present (1).
- (45) Quadratojugal, anterior extent: maxilla-quadratojugal suture (0); extending anterior to ventral portion of squamosal, but not contacting maxilla (1); \leq anterior extent of ventral portion of squamosal (2); quadratojugal absent (3). ORDERED.
- (46) Quadratojugal, anterodorsal process: absent (0); present, covered by squamosal (1); present and superficial (2).
- (47) Palate, suborbital fenestra: absent (0); present (1).
- (48) Pterygoid, teeth on transverse flange: single row on edge (0); additional teeth anterior to single row (or no rows recognizable) (1); absent (2).
- (49) Parasphenoid, dentition posterior to level of transverse flange: absent (0); along edges (1); on edges and posterior body (2).

- (50) Basisphenoid, basiptyergoid processes: short, broad, with short articulating facets facing anterolaterally (0); long, wing-like, with long articulating facets facing anteriorly (1); long, with hemispherical articulating facets facing more or less anterolaterally (2).
- (51) Supratemporal: broad element of skull table (0); slender, in parietal and squamosal trough (1); absent (2). ORDERED.
- (52) Tabular: large, sheet-like (with ventral expansion) (0); narrow, slender (1); absent (2). ORDERED.
- (53) Postparietal, size: sheet-like, both together not much smaller than suproccipital in state when the posttemporal fenestra is small (because of broad, plate-like dorsal process of suproccipital) (0); small, splint-like (1); absent (2). ORDERED.
- (54) Quadrate, shape: straight posteriorly (0); shallowly emarginated (1); with conch (2). ORDERED.
- (55) Quadrate, occipital margin: anterior slope $\geq 80^\circ$ (0); $80^\circ > \text{anterior slope} > 50^\circ$ (1); anterior slope $\leq 50^\circ$ (2). ORDERED.
- (56) Opisthotic, paroccipital process shape: vertical or nearly vertical sheet, height ≥ 0.5 transverse length (0); elliptical in cross-section, height < 0.5 transverse length (1).
- (57) Opisthotic, paroccipital process attachment: ends freely (0); weak contact (1); strong contact (2). ORDERED.
- (58) Posttemporal fenestra, size: large compared to suproccipital (narrow dorsal process of suproccipital tapers dorsally) (0); small (because of broad, plate-like dorsal process of suproccipital) (1); more or less foramen (2); absent (3). ORDERED.
- (59) Coronoid bones, number: two (0); one (1).
- (60) Angular, shape of posteroventral edge: ridged or keeled (0); rounded (1).

- (61) Angular, size of lateral exposure: wide (0); narrow (1).
- (62) Retroarticular process, size: absent (0); small (1); large (2). ORDERED.
- (63) Retroarticular process, composition: composite (0); formed only by articular (1).
- (64) Stapes, shape: robust, with thick shaft (0); slender, rod-like shaft (1).
- (65) Stapedial foramen: present (0); absent (1).
- (66) Hyoid: short, directed to quadrate region (0); long, directed posteriorly beyond skull (1).
- (67) Vertebrae, notochordal canal: present throughout ontogeny (0); absent in adults (1).
- (68) Cervical vertebrae, centra length: no longer than posterior dorsals (0); longer than posterior dorsals but fourth and fifth cervical centra less than three times their height (1); longer than posterior dorsals and fourth and fifth cervical centra equal or more than three times their height (2).
- (69) Cervical vertebrae, ventral surface of centra: rounded (0); strongly keeled (1).
- (70) Cervical vertebrae, neural arch excavation (lateral to the base of the neural spine): absent (0); shallow (1); deep, represented by a pit (2). ORDERED.
- (71) Cervical vertebrae, neural spines: triangular (0); rectangular (1).
- (72) Dorsal vertebrae, ratio of height of mid-dorsal neural spines from base of zygapophysis: maximum centrum height: ≤ 1.5 (0); > 1.5 (1).
- (73) Dorsal vertebrae, mid-ventral surface of centra: rounded (0); ridged (with slightly swollen sides) (1); keeled (sharp edge) (2). ORDERED.
- (74) Dorsal vertebrae, transverse processes in trunk: short (0); moderately long (1).
- (75) Cervical and dorsal vertebrae, mammillary processes on posterior cervical and anterior dorsal neural spines: absent (0); present (1).

- (76) Cervical vertebrae, accessory process on anterolateral surface of anterior cervical ribs:
absent (0); present (1).
- (77) Cervical vertebrae, proximal rib heads: some or all holocephalous (0); all dichcephalous (1).
- (78) Dorsal vertebrae, trunk ribs: dichcephalous (0); holocephalous (1).
- (79) Sacral vertebrae, sacral ribs: two unequal (0); two equal (1); three (2). ORDERED.
- (80) Sternum: not mineralized (0); mineralized (bone or calcified cartilage) (1).
- (81) Interclavicle, anterior half shape: cross-shaped (anterior process present) (0); T-shaped (anterior process absent) (1).
- (82) Interclavicle, webbed between lateral and posterior processes: yes (head triangular or diamond-shaped) (0); no (rather sharp angles between processes) (1).
- (83) Interclavicle, minimal shaft width: ≤ 0.105 tip-to-tip width (0); ≥ 0.137 tip-to-tip width (1).
- (84) Cleithrum: present (0); absent (1).
- (85) Scapula, anterior margin: straight, at least dorsally (0); convex along entire length (1).
- (86) Scapula, supraglenoid foramen: absent (0); present (1).
- (87) Coracoid, triceps process: absent or small (0); large (1).
- (88) Humerus, ratio of width of distal head to shaft length: ≥ 0.3 (0); < 0.3 (1).
- (89) Humerus, entepicondyle: moderately large (0); strongly developed at maturity (1).
- (90) Humerus, entepicondylar foramen: present (0); absent (1).
- (91) Humerus, ectepicondylar region: foramen, process bridged (0); supinator process present, groove present (1); process, groove and foramen absent (2). ORDERED.
- (92) Radius-humerus, length ratio: < 0.68 (0); 0.68 to 0.82 (1); > 0.82 (2). ORDERED.
- (93) Radius, shape: straight (0); twisted in lateral view (1).

- (94) Ulna, olecranon process: absent or very low (0); prominent but lower than its transverse depth at base (1); strongly developed, being higher than its transverse depth at base (2).
- (95) Carpus, medial centrale carpi: present (0); absent (1).
- (96) Carpus, lateral centrale carpi: large (0); small or absent (1).
- (97) Pelvic girdle: solid (0); fenestrate (= open acetabulum) (1).
- (98) Pubis, lateral and distal pubic tubercles: small or absent (0); large (1).
- (99) Pelvic girdle, acetabulum: elongate (0); circular (1).
- (100) Hind limb–trunk length ratio: hind limb much shorter than trunk (0); hind limb almost as long as trunk or longer (1).
- (101) Femur, distal articular surface: uneven, fibular condyle projecting distinctly beyond tibial condyle (0); both condyles prominent and approximately at same level (1); both condyles do not project beyond shaft (distal articular surface concave or almost flat) (2).
- (102) Femur, maximum length/distal width ratio: < 4 (0); ≥ 4 (1).
- (103) Femur-humerus, length ratio: > 1.2 (0); 1 to 1.2 (1); < 1 (2). ORDERED.
- (104) Femur-humerus, shaft diameters: femur = 150% humerus (0); more or less equal (up to 120%) (1).
- (105) Distal hind limb–pes length, ratio: articulated tibia + tibiale/astragalus longer than articulated 4th metatarsal + digit (0); shorter (1).
- (106) Proximal tarsals, astragalus-calcaneum articulation: flat (0); concave-convex (1); foramen on calcaneum, articulation expanded (2); sutured or fused (3).
- (107) Proximal tarsals, lepidosauriform ankle joint: absent (0); present (1).
- (108) Proximal tarsals, lateral tuber on calcaneum: absent (0); present (1).
- (109) Metatarsus, metapodials overlapping proximally: absent (0); present (1).

- (110) Metatarsus, metatarsal IV: short (0); long (at least 40% of digit IV) (1).
- (111) Metatarsus, fifth distal tarsal: present (0); absent (1).
- (112) Metatarsus, metatarsal V: straight (0); hooked (1).
- (113) Skull, relative length of snout: <50% of total skull length (0); equal to or >50% of total skull length (1).
- (114) Premaxilla, contact with prefrontal: absent (0); present (1).
- (115) Premaxilla, body size: small, the premaxillary body forms less than half of snout in front of the posterior border of the external nares (0); large, the premaxillary body forms half or more than half of snout in front of the posterior border of the external nares (1).
- (116) External nares, shape: rounded (0); elongate (1).
- (117) Snout, diastema between maxillary and premaxillary teeth: absent (0); present (1).
- (118) Antorbital fenestra: absent (0); present (1).
- (119) Maxilla, antorbital fossa exposed in lateral view: absent (0); present (1).
- (120) Maxilla, anterior maxillary foramen: absent (0); present (1).
- (121) Maxilla, ventral margin: straight, concave or sigmoid (0); convex (1).
- (122) Maxilla, posterior extension: at level or posterior to posterior orbital border (0); anterior to posterior orbital border (1).
- (123) Maxilla, orbital exposure: absent (0); present (1).
- (124) Maxilla, tooth plate: absent (0); present (1).
- (125) Maxilla, number of tooth rows: single row (0); multiple rows (1).
- (126) Maxilla, location of teeth: only on occlusal surface (0); on occlusal and lingual surfaces (1).

- (127) Nasal, shape of anterior margin at midline: strongly convex with anterior process (0); transverse with little convexity (1).
- (128) Frontal, suture with nasal: transverse (0); oblique, forming an angle of at least 30° with long axis of the skull and frontal(s) entering between both nasals (1); oblique, and nasal entering considerably between frontal(s) in a non-interdigitating suture (2).
- (129) Frontal, narrowly approaches or enters the anteromedial margin of the supratemporal fossa: absent, in which the suture between the frontals and parietals is usually transverse (0); present (1).
- (130) Frontal, shape of dorsal surface next to sutures with postfrontal and parietal: flat to slightly concave (0); longitudinal depression with deep pits is present (1).
- (131) Postfrontal, shape of dorsal surface: flat or slightly concave towards raised orbital rim (0); depression present with deep pits (1).
- (132) Quadratojugal, anterior process: present (0); absent (1).
- (133) Parietal, median contact between both parietals: suture present (0); fused with loss of suture (1).
- (134) Skull roof, distinct posterior emargination in late ontogeny: absent (0); present (1).
- (135) Vomer, contact with maxilla: absent (0); present (1).
- (136) Palatine, palatal teeth: present (0); absent (1).
- (137) Pterygoids, contact between each other: join cranially (0); remain separate (1).
- (138) Pterygoid, palatal process: extends anterior to the anterior limit of the palatine (0); forms oblique suture with palatine but process ends before reaching anterior limit of palatine (1); forms transverse suture with palatine (2).

- (139) Pterygoid, teeth on palatine ramus: present in two fields (0), present in one field (1), present in three fields (2); absent (3).
- (140) Pterygoid, orientation of the transverse flange: directed predominately laterally (0); directed anterolaterally (1).
- (141) Pterygoid, transverse flange lateral margin: posterolateral margin with an acute corner (0); posterolateral margin merges smoothly into anterolateral margin forming a smoothly convex lateral outline (1).
- (142) Ectopterygoid: simple overlap of ectopterygoid and pterygoid (0); complex overlap between ectopterygoid and pterygoid (1); ectopterygoid absent (2).
- (143) Ectopterygoid, shape along suture with pterygoid: transversely broad (0); posteroventrally elongate and does not reach lateral corner of transverse flange (1); posteroventrally elongate and reaches corner of transverse flange (2). ORDERED.
- (144) Ectopterygoid, contact with maxilla: absent (0); present (1).
- (145) Ectopterygoid, posterior expansion in contact with jugal: absent (0); present (1).
- (146) Opisthotic, paroccipital process orientation: extends laterally forming 90° with parasagittal plane (0); deflected posterolaterally at an angle of about 20° from the transverse width of the skull (1).
- (147) Opisthotic, paroccipital process shape: slender (0); robust, with anteroposterior dimension at least one third greater than dorsoventral dimension (1) (deBraga and Rieppel, 1997; modified from Müller, 2004:159).
- (148) Opisthotic, club-shaped ventral ramus: absent (0); present (1).
- (149) Laterosphenoid: absent (0); present (1).

- (150) Parasphenoid, position of foramina for entrance of internal carotid arteries leading to the pituitary fossa: lateral wall of braincase (0); ventral surface of parasphenoid (1).
- (151) Basioccipital-basisphenoid: separate (0); fused to each other (1).
- (152) Parasphenoid, cultriform process: reaching forward to the level of the posterior limit of the internal nares (0); short, not reaching the level of the internal nares (1).
- (153) Prootic, lateral surface: continuous and slightly convex (0); crista prootica present (1).
- (154) Prootic, anterior inferior process: absent (0); present (1).
- (155) Prootic, contact with parietal: absent (0); present (1).
- (156) Abducens foramina: in dorsum sellae (0); between prootic and dorsum sellae (1).
- (157) Occipital condyle, position: even with craniomandibular joint (0); anterior to craniomandibular joint (1); posterior to craniomandibular joint (2).
- (158) Lower jaw, distinct dorsal process behind the alveolar margin: absent, with a slightly convex dorsal margin behind the alveolar portion (0); present, formed by a dorsally well-developed surangular (1); present, formed by a dorsally well developed coronoid and sometimes the posterodorsal ramus of the dentary (2); present, formed only by a dorsally hypertrophied coronoid bone (3).
- (159) Lower jaw, Meckelian fossa orientation: dorsomedially (0); mostly dorsally due to greatly expanded prearticular resulting in a ventral border of the fossa situated dorsal to the half height of the lower jaw at that level (1).
- (160) Dentary, number of tooth rows: one (0); two (1); more than two (2). ORDERED.
- (161) Jaw occlusion: single-sided overlap (0); flat occlusion (1); blade and groove (2).
- (162) Surangular, anterior extension: beyond coronoid eminence (0); posterior to reaching the anterior border of the coronoid eminence (1).

- (163) Surangular, lateral shelf: absent (0); present (1).
- (164) Surangular, anterior surangular foramen: absent (0); present (1).
- (165) Surangular, posterior surangular foramen: absent (0); present (1).
- (166) External mandibular fenestra: absent (0); present (1).
- (167) Retroarticular process: not upturned (0); upturned (1).
- (168) Cervical vertebrae, postaxial cervical intercentra: present (0); absent (1).
- (169) Cervical vertebrae, distinct longitudinal lamina extending along the lateral surface of the centrum at mid-height in anterior cervical vertebrae: absent (0); present (1).
- (170) Cervical vertebrae, longitudinal lamina connecting the prezygapophysis and postzygapophysis on the third cervical neural arch: absent (0); present (1).
- (171) Cervical vertebrae, dimensions of postaxial anterior cervical neural spines: tall, with height and length approximately equal (0); long and low, with height lower than length (1).
- (172) Cervical vertebrae, postaxial cervical neural spines with an anterior overhang: absent (0); present (1).
- (173) Cervical ribs, slender and tapering at low angle to vertebrae: absent (0); present (1).
- (174) Cervico-dorsal vertebrae, parallelogram-shaped centra in lateral view, in which the anterior articular surface is situated higher than the posterior one: absent (0); present (1).
- (175) Dorsal vertebrae, intercentra: present (0); absent (1).
- (176) Dorsal vertebrae, length of the anterior dorsal centra: subequal to the height of the centrum (0); more than two times the height of the centrum (1).
- (177) Dorsal vertebrae, subcentral foramen in the lateral surface of the centrum: absent (0); present (1).

- (178) Dorsal vertebrae, ratio between transverse width of diapophysis and length of the centrum in anterior dorsal vertebrae: <0.65 (0); >0.75 (1).
- (179) Dorsal vertebrae, anterior and middle dorsal neural spines: sub-rectangular, with the anterior margin vertical, anterodorsally or slightly posterodorsally inclined (0); sub-triangular, with the anterior margin strongly posterodorsally oriented (1).
- (180) Dorsal vertebrae, anterior centrodiapophyseal lamina or paradiapophyseal lamina: absent (0); present (1).
- (181) Dorsal vertebrae, posterior centrodiapophyseal lamina: absent (0); present (1).
- (182) Dorsal vertebrae, prezygodiapophyseal lamina on posterior cervicals and anterior and middle dorsals: absent (0); present (1).
- (183) Dorsal vertebrae, postzygodiapophyseal lamina on anterior dorsals: absent (0); present (1).
- (184) Dorsal vertebrae, dorsally opened pit lateral to the base of the neural spine: absent (0); present (1).
- (185) Dorsal vertebrae, zygapophyses close to each other medially, respectively, in anterior-middle dorsals: absent, zygapophyses laterally divergent beyond the lateral margin of the centrum (0); present, zygapophyses mainly oriented in the parasagittal plane (1).
- (186) Dorsal vertebrae, zygosphenes-zygantrum articulation: absent (0); present (1).
- (187) Sacral ribs, second sacral rib: not bifurcate (0); bifurcate with posterior process pointed bluntly (1); bifurcate with posterior process truncated sharply (2).
- (188) Sacral and/or anterior caudal vertebrae, transverse processes and ribs: sutured to the vertebra (0); fused to the vertebra (1).

- (189) Caudal vertebrae, anterior caudal neural spine height: moderately tall with height/length between >1.0 and <2.0 (0); low with height/length <1.0 (1); tall with height/length >2.0 and <3.0 (2); very tall with height/length >3.0 (3).
- (190) Caudal vertebrae, transverse processes: absent beyond fifth caudal (0); present beyond fifth caudal (1).
- (191) Caudal vertebrae, ratio of lengths of transverse processes and centra in anterior caudal vertebrae: equal or <1.0 (0); >1.0 (1).
- (192) Chevrons, distal width of haemal spine: equivalent to proximal width (0); tapering (1); wider than proximal width (2).
- (193) Gastralia: present (0); absent (1).
- (194) Clavicles, position: anteroventral to the interclavicle (0); dorsal to interclavicle (1).
- (195) Interclavicle, anterior margin with a median notch: absent (0); present (1).
- (196) Interclavicle, posterior stem: little change in width along entire length (0); expansion present (1).
- (197) Humerus, torsion between proximal and distal ends: around 45° or more from one another (0); 20° or less from one another (1).
- (198) Humerus, capitellum (radial condyle) and trochlea (ulnar condyle): strongly developed as distinct ball-shaped structures (0); poorly developed but distinct from the ectepicondyle and entepicondyle (1); absent (2). ORDERED.
- (199) Humerus, trochlea (ulnar condyle) situated approximately at mid-width of the distal end of the bone: present (0); absent, it is considerably laterally displaced (1).
- (200) Ulna, olecranon process as a separate ossification: absent (0); present (1).

- (201) Ulna, olecranon process in lateral view: tapering toward its distal end (0); subrectangular or slightly expanded towards its distal end (1).
- (202) Radius, length: shorter than ulna (0); longer than ulna or approximately of the same length as the ulna (1).
- (203) Manus: greater than humeral length (0); subequal to or lower than humeral length (1).
- (204) Metacarpus, metacarpal IV: longer than metacarpal III (0); equal or shorter than metacarpal III (1).
- (205) Ilium, anteroposterior development of the iliac blade: well-developed (0); reduced (1).
- (206) Ilium, iliac blade: posterior process only (0); large posterior process and smaller anterior process (1); equally developed anterior and posterior processes (2); large anterior projection (3).
- (207) Pubis, pectineal process: absent (0); present (1).
- (208) Pubis and ischium, thyroid fenestra: absent (0); present (1).
- (209) Pubis, anterior apron: absent (0); present (1).
- (210) Femur, shaft: diameter constant or increasing distally (0); diameter distally decreasing (1).
- (211) Tibia, articulation with astragalus: loose fitting (0); tightly fitting with well-developed articulation (1).
- (212) Tarsus, foramen for the passage of the perforating artery between the astragalus and calcaneum (= perforating foramen): present (0); absent (1).
- (213) Astragalus, articulation with fourth distal tarsal: poorly defined (0); well defined (1); absent (2).

- (214) Tarsus, number of pedal centralia: both medial and lateral centralia present (0); only lateral pedal centrale and does not contact tibia (1); only lateral pedal centrale and contacts the tibia (2); pedal centralia absent as sperate ossifications (3). ORDERED.
- (215) Tarsus, first distal tarsal: present (0); absent (1).
- (216) Metatarsus, ratio of lengths of metatarsals I and IV: equal or >0.42 (0); <0.42 and equal to or >0.32 (1); equal to or <0.32 (2). ORDERED.
- (217) Metatarsus, metatarsal V lateral plantar tubercle in late ontogeny: absent (0); present (1).
- (218) Metatarsus, metatarsal V medial plantar tubercle in late ontogeny: absent (0); present (1).
- (219) Pedal digits, ratio of lengths of digits III and IV: equal or <0.8 (0); >0.8 and <0.9 (1); equal to or >0.9 (2). ORDERED.

Additional Characters with Character States

- (220) Anterior (premaxillary) process of maxilla, length: short (0), greatly elongated (1).
- (221) Maxillary and dentary tooth crowns with short parallel striae near apex on the lingual surface: absent (0), present (1).

APPENDIX 2. Character-taxon matrix

Tseajaia campi

01000101?[01]1000021100000?010-001?0-0-10000000100100000110010000-
00?000010000010
00?0100100101101?00?000?10000000?0001110-011000000-
00000011110000?00000?00000?0110000000-
000???00010000000001??1??0?110?0?010000000010?????00

Casea broilii

[01]10000011[01]001000-0000100010-0010001000110001010100001010120000-
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20000000001010010001000021100000000?0100-0001000??-
????0?000101????000???1????0000010000-
1?000???0??0????????????0???00?0???0310?0000[0 1]00???00

Eothyris parkeri

[01]1000001100200021?000100010-00100010001100010101?00000100[23]00?0-
????????????????
????????????????????????001100-000100001-00000????0?????0?0?1????00?0000000-
????????????
??00

Archaeothyris florensis

0100121?0??000110??00000120-001?00?0??11110111?0?010[01]0??03?0?0-
0??0?00111?0??000111??0?0

101????01?001????0?0??????0-?0?0000?1-00?00????????????????????0?00?????-
?00000000000?00

0000?0?1?0???00?????0010?0????????00

Ophiacodon retroversus

[01]1?112100000001100000000110-0010000000111101110000100010030000-
000000011110010000[0 1]100000101102000100001000001000101100-011000001-
00000010?000??1000000?1000?1200011001-
0?00000000101000010?031000000000011?001000000001?0000

Mycterosaurus longiceps

[01]0111110001031010?001011121-
0010101010120111210?11110010120?0?0010111111?00?010????
110?001?000?010?1100?000?00000?100-0010000?1-
00000?0????????000?1?1????10???10000?????????
????????????????????0????????????1?????00

Mesenosaurus romeri

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0?0?0001100-001?00000-
0000000000110010?01?0?0???02000010000????????????????????0?????????????
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?????00

Elliotsmithia longiceps

0011?11??????????????121-

001?1110101201111100??1100201[123]?0010??1???????????????????

????????????????????????????1?000??-00000????[01

2]0??????????????0?00??0?0?0000???????

????????????????????????????????00

Aerosaurus wellesi

000111110010200120102012121-

001011?12022011012002111?0201?01010??10111111000102000000000

00110000000111??12001100001000-000000002-

00000???0?????110000?000010000000000???000

?0?0?000000??[1 2]1?1??00??0?0?10000?0?0000?0????00

Varanops brevirostris

[01]00111110010201120102012121-

0010111120220110120?211110201?010100?10?1111200010200010

00100012000000010101120011000010?1010000000?-00000????[01

2]?????1???0?000?10?0000?0010??

??0?000000000110?1????0???0000??00000000000?0????00

Varanodon agilis

[01]00110110012201120112012121-001011?12022011012?0?11110201[2

3]01010??10111112100102

0???0001000110000?00??10?????11??00100100000000000-

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?00?00000?????????0?????0?1?0????????????????00

Archaeovenator hamiltonensis

[01]100111100100010-0102010121-001000101012010121000111000??[123]?000-
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?0???????01?100?00???????001000000100???00

Captorhinus aguti

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0102002000001001110000000001000-001011100-00000[01]00?0002---
??0010???0000021?00000??
?000?0???100000??01???1001000100?0?000000000[0 1]00???00

Paleothyris acadiana

[01]1000100000000120100000?110-01100-0-0000000020010011001?011000-
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01002000000011010000000001000-000000000-000000001000???000?01????0000010000-
000100?0000
1000000??0?1??001000100??1001000?00000??000

Petrolacosaurus kansensis

010001000000000120100000012100110000011210000101110110001011000-
00?0112111011000000101111001202000101001000001000000100-
10100000100000000000011000000?010100??0000000000-
000100?0000010001??000101101000?0?100011000000100??000

Araeoscelis gracilis

010001?0000000020??00000121001000-0-11000000201100110001111000-
00?0212001011000100101111100202000101010000001000001100-001000002100000??[0
1]01100100000000????0000010100-
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Apsisaurus witteri

[0 1 2]100????????????????????????????1??02?120???210[0 1]?1???0[0
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?[0 1]?0??????0?0?????0???01000?10??1?10?00?101000??00?0?0??02-0-
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Coelurosauravus jaekeli

210010?000001100-??0101?121100110?0?2224-000201???02200????101????00?0[0
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Acerosodontosaurus piveteaui

0100???????[1 3]11?-????11121?????001?[1 2]231??1[1 2 3]????????????1??1????00?01[0
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?010000?????????????????0?????????????0?00???01???0?0101?01000000?????0???100-
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Youngina capensis

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001000000100000000120100?01010001010100000?0000000000000000010000000?111210000
100-1?010100000010100000

Trilophosaurus buettneri

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2]100?10110100?10011000000101??000

Prolacerta broomi

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1010000011001010010000?00?11101001101100000011010011111000001010110110112?0100
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Planocephalosaurus robinsonae

3100010100001100-
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Chalarodon madagascariensis

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00100000200?-

10011111101100100??011??23000111000????????????????????????????1?????????????
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Huehucuetzpalli mixtecus

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Dalinghosaurus longidigitus

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001100111?0001?000[1 2]?1?1?1110013101111000100-011000002000-
1000??1????10???0??????003?000110000?0??0?10?0-
0000??001?11010100????01101110011?310??000

Proterosuchus fergusi

10110210020210[0 1]0-101001?1[0 1 2][0 1]10[1 2]110001212[2 3]00012010001201012[1
3]11020111111[1
2]10011101001111000?011?001?001?10???1011?11[01]011110110000001100[01]010010200?
2011111111111110000011111000001100010100[0 1]11021[0 2]1120010?2-
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Erythrosuchus africanus

4011021001021000-2-10011000102-
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Aenigmastropheus parringtoni

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Tanystropheus longobardicus

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Euparkeria capensis

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Mesosuchus browni

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Howesia browni

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Protorosaurus speneri

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Archosaurus rossicus

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Paliguana whitei

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Macrocnemus bassanii

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Noteosuchus colletti

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Gephyrosaurus bridensis

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Eorasaurus olsoni

??[01]11???1??????????

??010?

??1???10111001??00

Marmoretta oxoniensis

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1010022230000??1202?221????????????????????????????????????

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Sophineta cracoviensis

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?1?11????0??????101100????????00

Fraxinisaura rozynekae

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????????????????000100-

101100001100?00?00120????????????????0????????0000?1010000001

?1?11????0??????101?00????????11

Icarosaurus sieferi

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0?10?00?01????????1?01????????12?0?0?00?1?0????????0?

SUPPLEMENTARY DATA 2

Characters and character-states for phylogenetic analysis by Evans & Borsuk-Białynicka (2009)
from Renesto & Bernardi (2014).

-
1. Lacrimal large with extensive exposure on cheek, 0; small, confined to orbital rim, 1; absent, 2.
 2. Greatest width of nasals exceeds greatest width of both external nares, 0; is less than the latter, 1.
 3. Frontoparietal suture more or less W shaped, subequal to or narrower than the nasofrontal suture in width, 0; suture more or less straight, broader than nasofrontal suture, 1.
 4. Parietal foramen within parietal, 0; on frontoparietal border or within frontal, 1; absent, 2.
 5. Postparietals present, 0; absent, 1.
 6. Tabulars present, 0; absent, 1.
 7. Postorbital overlain by postfrontal, 0; postfrontal overlain by postorbital, 1.
 8. Squamosal extends anteriorly halfway or less over lower temporal fenestra and is widely separated from jugal by postorbital, 0; extends more than halfway over lower temporal fenestra and comes close to or contacts jugal below postorbital, 1.
 9. Anterior process of quadratojugal present, 0; absent, 1.
 10. Posterior process of jugal extends about halfway back or less below lower temporal fenestra, 0; extends more than halfway back below lower temporal fenestra, 1.
 11. Quadratojugal always present as a separate element at some point in ontogeny, 0; never present as a separate element, 1.
 12. Supratemporal present, 0; fused or lost, 1.
 13. Supratemporal lies superficially, 0; lies deep association with ventral face of postparietal process, 1.
 14. Ventral process of squamosal present, 0; absent, 1.

15. Adductor chamber small, quadrate does not extend well below level of occipital condyle, 0; enlarged adductor fossa and quadrate extends well below adductor fossa, 1.
16. External nares paired, 0; confluent, 1.
17. Quadrate narrow in posterior view, 0; wide in posterior view forming lateral conch, 1.
18. Quadrate foramen present, 0; absent, 1.
19. Vomerine teeth numerous, 0; few or absent, 1.
20. Teeth or transverse flange of pterygoid present, 0; absent, 1.
21. Abducens canal absent or incomplete, 0; present and complete, 1.
22. Parasphenoid teeth present, 0; absent 1.
23. Paroccipital process does not extend laterally to contact quadrate, 0; process contacts quadrate, 1.
24. Paroccipital process not expanded distally, 0; expanded distally, 1.
25. Stapes thick and perforated for passage of stapedial artery in adults, 0; stapes thinner and imperforate in adults, 1; stapes columelliform and usually imperforate in adults, 2.
26. Quadrate straight in lateral view, 0; bowed, 1.
27. Postorbital contacts parietal, 0; separated from parietal, 1.
28. Posterior process of postorbital does not reach to posterior end of upper temporal fenestra, 0; process extends beyond posterior margin of upper temporal fenestra, 1.
29. Choanal fossa on palatine absent, 0; present, 1.
30. Snout comparatively shorter and broader, 0; longer and narrower, 1.
31. Premaxillae paired in full grown adults, 0; fused prior to hatching, 1.
32. Parietals paired in full grown adults, 0; fused prior to hatching, 1.

33. Exoccipital sutured to opisthotic above and below metotic fissure, 0; fused only above metotic fissure with metotic fissure extended ventrally into basioccipital, 1; metotic fissure subdivided to create a dorsal vagus foramen and a ventral opening for the glossopharyngeal nerve and perilymphatic sac, 2.
34. Frontals paired, 0; fused, 1.
35. Splenial present, 0; absent, 1.
36. Angular extends posteriorly to articular condyle, 0; does not, 1.
37. Angular extends more than one-third up lateral face of mandibular ramus, 0; less than one third, 1.
38. Retroarticular process relatively small or absent, 0; large, 1.
39. Outer one third of articular condyle formed by surangular, 0; formed entirely by articular, surangular forming only outer rim, 1.
40. Teeth set in shallow sockets or depressions, 0; superficially attached to medial side of jaw with labial wall higher than lingual one, but only slightly, 1; labial wall significantly higher than lingual wall (pleurodont), 2.
41. Neural arches fuse to their respective centra in postembryonic development, 0; in embryo, 1.
42. Zygosphenes and zygantra, absent, 0; present, 1.
43. Caudal autotomy septa absent, 0; present, 1.
44. Trunk vertebrae without accessory articulations between neural spines, 0; accessory articulations present, 1.
45. Intercentra present in trunk, 0; absent, 1.
46. Vertebrae amphicoelous notochordal, 0; amphicoelous solid, 1; procoelous, 2.
47. Transverse processes not elongated, 0; short, 1; long, 2.

48. One or more cervical ribs bear two distinct heads, 0; all ribs single-headed, 1; one or more ribs with three heads, 2.
49. No trunk vertebrae without free ribs, 0; one or more postsacrals without free ribs (lumbar), 1.
50. Sacral and caudal ribs fuse to their respective centra in postembryonic development, 0; fuse in embryo, 1.
51. Rib-bearing portion of sternum a single rod, 0; this region of sternum enlarged and formed from two plates, which remain paired until nearly maximum size, 1; paired sternal plates fuse in embryo, 2.
52. Anterior margin of scapulocoracoid without fenestrae, 0; fenestrate, 1.
53. Interclavicle robust, 0; gracile, 1.
54. Entepicondylar foramen of humerus present, 0; absent, 1.
55. Prominent posteromedial process of distal epiphyses of radius absent, 0; present, 1.
56. Metacarpal IV longer than third, 0; metacarpals III and IV subequal, 1; metacarpal IV shorter than metacarpal III, 2.
57. Ilium includes 80–85 % of acetabulum, 0; 60–65 % of acetabulum, 1.
58. Pubic flange on ilium absent, 0; present, 1.
59. Iliac blade long, 0; short, 1.
60. Anteromedial portion of pubis not out-turned dorsally, 0; out-turned dorsally, 1.
61. Dorsal edge of ilium essentially horizontal, 0; more steeply inclined, 1.
62. Pelvis a solid plate, 0; small thyroid fenestra with broad pubic symphysis, 1; large fenestra with small pubic symphysis, 2.
63. Ischial tubera short, 0; long, 1.
64. In fully grown individuals, pelvic elements separate, 0; fused, 1.

65. Fibula and femur articulate end to end, distal femoral condyles symmetrical, 0; fibula sits in a recess on lateral margin of distal end of femur, distal femoral condyles markedly asymmetrical, 1.
66. Articular surface of fibula for astragalocalcaneum restricted to small portion of the distal end, 0; covers most of distal end of fibula, 1.
67. Astragalus and calcaneum separate throughout ontogeny, 0; fused prior to fusion of scapulocoracoid, 1.
68. Lateral centrale of pes discrete throughout ontogeny, 0; fused to astragalus in embryo, 1.
69. Distal tarsal 1 present, 0; absent 1.
70. Distal tarsal 2 present, 0; absent 1.
71. Distal tarsal 5 present at some point in postembryonic ontogeny, 0; absent or fused in embryo, 1.
72. Metatarsal V straight, 0; inflected, somewhat hooked but without enlarged plantar tubercles, 1; hooked, inflected angulated proximally and with enlarged medial and lateral plantar tubercles, 2.
73. Ridge on distal extremity of tibia for astragalar articulation, 0; no ridge present, 1.
74. No tongue and groove articulation between distal tarsal 4 and astragalocalcaneum, 0; process on distal tarsal 4 extends under astragalocalcaneum to form partial tongue and groove articulation, 1; full tongue and groove articulation, 2.
75. Premaxilla without posterolateral process excluding maxilla from narial rim, 0; with posterolateral process, 1.
76. Cervical vertebrae not elongated, 0; elongated, 1.

77. Astragalus and calcaneums without specialized joint between them, 0; with specialized joint,
1.

Petrolacosaurus

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000?0 10

Youngina

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?0?00 00

Paliguana

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Saurosternon

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00

Kuehneosaurus

0001? 100?0 11?11 11100 00100 10000 00100 01100 ?0000 12311 ?011? 11000 11001 00???
?1?01 00

Marmoretta

1?02? ?0010 0?000 000?1 01??? 00010 01011 01?11 0000? 111?? ????? ?11?? 1?0?? ?????
????0 0?

Sophineta

1?001 10110 0000? 010?? ????? 110?0 0??0? ?????2 0100? 001?? ????? ?????? ???0? ????? ?????0
0?

Gephyrosaurus

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12?20 00

Squamata

111?1 10??0 10111 01111 11112 11010 ?12?0 11112 11101 201?1 21111 21101 12011 11111
12120 00

Prolacerta

000?1 11001 00000 00000 01001 10001 00000 011?0 ?0001 1100? ?0010 01000 00000 00100
11?01 11

Megachirella

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0?

Fraxinisaura

??011 1???0 ???0? 0??11 ?0??? ?10?? 00?00 00??2 0???1 1?1?? ?001? ?1000 11000 ?????? ???0
0?

LITERATURE CITED

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