

# Supporting Information

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## SI Text

**Cladistic Analysis.** To explore the phylogenetic affinities of *Pamphoneus biccai* gen. et sp. nov., we added this taxon to a modified version of the recent data matrix for Anteosaurid dinocephalians presented in ref. 1. The taxon was included in the second block of data presented by the aforementioned author. This dataset only includes dental characters of the holotype of “*Stenocybus*,” which is considered a juvenile specimen of *Sinophoneus yumenensis*. In addition to the taxon, the herbivorous dinocephalian *Ulemosaurus svijagensis* from Russia was included in the data matrix. The analysis was run on TNT (2), all characters having equal weights, using the implicit search algorithm (an exact solution is warranted) under collapsing rule 1 (collapsing branches if supported ambiguously), which produces more conservative phylogenetic hypotheses. Throughout the text, character numbers used by ref. 1 are indicated by a letter “K” in brackets. Some characters were proposed by previous authors; for more references, see ref. 1.

**Specimens Examined.** Institutional abbreviations: BP, Bernard Price Institute for Paleontological Research, University of the Witwatersrand, Johannesburg, South Africa; NM, National Museum, Bloemfontein, South Africa; PIN, Paleontological Institute, Moscow, Russia; SAM, Iziko South African Museum, Cape Town, South Africa.

*Biarinosuchus tener*: PIN 1758/2.

*Anteosaurus magnificus*: SAM PK-11296, BP/1/1369, NM QR3074.

*Archaeosyodon praeventor*: PIN 1758/3 (holotype), 1758/93, 1758/95, 1758/118, 1758/193, 1758/293, 1758/294, 1758/295, 1758/297, 1758/309, 1758/311, 1758/315, 1758/328.

*Australosyodon nyaphuli*: NM QR3152 (holotype).

*Estemmenosuchus mirabilis*: PIN 1758/6.

*Microsyodon orlovi*: PIN 4310/2 (holotype).

*Notosyodon gusevi*: PIN 2505/1 (holotype).

*Syodon biarmicum efremovi*: PIN 157/2, PIN 157/677.

*Tapinocaninus pamela*: NM QR2987 (holotype), NM QR2986, NM QR2985, and SAM (ROZ) K95.

*Titanophoneus potens*: PIN 157/1 (lectotype), PIN 4662/1, PIN 4662/2.

*Ulemosaurus svijagensis*: PIN 2207/2 (lectotype) and PIN 2207/1.

**Character List.** New characters are indicated by an asterisk. A plus sign indicates that the character was treated as ordered (additive).

0. Number of upper postcanine teeth: [0] 10 or fewer; [1] more than 10. \*
1. Postcanine morphology: [0] blade-like; [1] robust, bulbous at the base of the crown; [2] phylliform, laterally compressed, and leaf-shaped. [K1]
2. Postcanine basal-apical length  $\times$  meso-distal length: [0] basal-apical length larger; [1] nearly equivalent. \*
3. Posteriorly directed maxillary postcanine cusps: [0] present; [1] absent. \*
4. Sectorial edge of postcanines: [0] directed anteroposteriorly; [1] angled anterolingually and posterolabially. [K2]
5. Posteriormost upper postcanines canted posterolaterally: [0] absent; [1] present. [K3]
6. Canine curvature: [0] straight or slightly recurved ( $<40^\circ$ ); [1] strongly recurved ( $>70^\circ$ ). [K4]
7. Incisors with lingual heels: [0] absent; [1] weak; [2] strong (heel width 30% or more larger than the base of the tooth apex). [K5] +

8. Location of external naris: [0] terminal; [1] nonterminal. [K6]
9. Alveolar margin of premaxilla: [0] subhorizontal; [1] canted upward. [K7]
10. Premaxilla forming broad, triangular plate palatally that separates anterior edge of vomers from incisor tooth row: [0] absent; [1] present. [K9]
11. Vomers with “scroll-like” raised edges: [0] absent; [1] present. [K10]
12. Morphology of the dentigerous region of the palate: [0] elongate triangular region; [1] distinct reniform boss. [K11] (In *Ulemosaurus* and *Tapinocaninus*, the score is based in the presence of a reniform boss, although there are no teeth in that structure.)
13. Dentition on palatine: [0] multiple tooth rows; [1] single tooth row. [K12]
14. Palatine bosses: [0] well-separated; [1] close or interconnected (but suture still visible). \*
15. Dentition on palatal ramus of pterygoid: [0] numerous teeth; [1] reduced to 1 or non-tooth. [K13]
16. Dentition on transverse process of pterygoid: [0] extensive; [1] absent or reduced to a few teeth at the medial edges of the processes. [K14]
17. Posterior shelf on transverse process of pterygoid: [0] absent; [1] present. [K15]
18. Transverse process of pterygoid: [0] not expanded distally in palatal view; [1] palmate, massively expanded distally. [K16]
19. Quadrangle rami of pterygoid intimately appressed, bifurcating the anterior margin of the basisphenoid: [0] absent; [1] present. [K17]
20. Dorsal margin of maxilla: [0] gently rounded, with no overhang on lacrimal; [1] acute, with no overhang on lacrimal; [2] with dorsoposterior process partly overhanging upper margin of lacrimal.
21. Dorsal margin of snout: [0] gradually sloping toward tip; [1] markedly concave, sloping upward acutely postnaris. [K20]
22. Snout proportions: [0] short, broad, 35% of total skull length; [1] long, narrow,  $>25\%$  of total skull length. [K21]
23. Ridge extending along external surface of jugal-lacrimal suture: [0] absent; [1] present. [K22]
24. Location of fronto-nasal suture: [0] far anterior to orbits; [1] at anterior edge of orbits behind the anterior edge of the orbit. [K23]
25. Ornamentation consisting of anteroposterior ridges and sulci on the surface of lacrimal and maxilla: [0] weak or absent; [1] well-developed. \*
26. Interorbital crest on midline of frontals: [0] absent; [1] present. [K24]
27. Crest lateral to the pineal foramen extending to the postorbital bar: [0] absent; [1] low; [2] well-developed (Fig. 1A). + \*
28. Frontal contribution to anterior border of pineal boss: [0] absent; [1] present. [K25]
29. Frontal forms anterior margin area of jaw adductor musculature attachment: [0] no; [1] frontal forms only medial anterior border of adductor area; [2] frontal forms majority of the adductor area, excepting only the orbital rim, made of the postorbital. [K26] +
30. Shelf on posterior margin of orbit: [0] absent; [1] present. \*
31. Ventral margin of posterior portion of zygoma on jugal: [0] straight; [1] convex; [2] convex and bearing a lateral bony process. \*
32. Jaw adductor musculature attachment on pineal boss: [0] absent; [1] present. [K27]

33. Shape of postorbital bar: [0] not or gently curved; [1] strong anteroventral curvature, temporal fenestra undercuts orbit. [K28]
34. Postorbital bar: [0] transversally narrow; [1] transversally moderately expanded; [2] transversally prominently expanded. [K29]
35. Pachyostosis of the skull: [0] absent; [1] present but restricted to orbital and temporal rims; [2] entire surface of the skull pachyostosed. [K30] +
36. Shape of the symphyseal region of mandible: [0] anterior edge gradually sloping upward; [1] anterior edge massive, nearly vertical. [K31]
37. Marked “step” down after the last incisor on dentary: [0] absent; [1] present, canine on an elevated platform relative to all postcanines. [K32]
38. Angular ornamentation: [0] absent; [1] boss; [2] prominent crest. [K34]
39. Angular boss morphology: [0] bar; [1] lenticular or diamond-shaped. \*
40. Position of jaw articulation: [0] at back of skull; [1] rotated forward. [K35]

#### Character Modifications.

7. Incisors with lingual heels [K5]: State [1] “yes,” was divided in two new states: [1] weak; [2] strong (heel width 30% or more larger than the base of the tooth apex).
20. Dorsal margin of maxilla [K19]: State [0] “gently rounded, with no overhang on lacrimal,” was divided in two new states: [0] gently rounded, with no overhang on lacrimal; [1] acute, with no overhang on lacrimal. The new state [1] was coded present for *Tapinocephalus* and *Ulemosaurus*. The old state [1] “with dorso-posterior process partly overhanging upper margin of lacrimal” is now state [2].
38. Angular ornamentation [K34]: Wording changed, and one state was added: [2] prominent crest.

**Excluded Characters.** Three characters were excluded from the data matrix by ref. 1, following their original numbers:

1. Kammerer CF (2011) Systematics of the Anteosauria (Therapsida: Dinocephalia). *J Syst Palaeontology* 9:261–304.

8. Alveolar margin of the precanine region: [0] straight; [1] concave.
18. Ventral margin of maxilla: [0] subhorizontal; [1] highly convex.
33. Dentary proportions in the region posterior to the canine and anterior to the coronoid process: [0] dorsoventrally narrow, constricted at region of postcanine tooth row; [1] tall, of constant height.

These characters were excluded because it was difficult to establish a boundary between the character states in certain taxa included in this study; in addition, character [K33] could not be coded for some taxa in which the relevant area of the skull is not sufficiently preserved (e.g., *Australosyodon*).

**Rescored Character States.** The scoring of some characters was modified from ref. 1 for some taxa, following first-hand examination and interpretation of the relevant specimens.

1. Postcanine morphology [K1]: [0] blade-like; [1] robust, bulbous at the base of the crown; [2] phylliform, laterally compressed, and leaf-shaped. Rescored from [1] to [0] in *Australosyodon*.
4. Sectorial edge of postcanines [K2]: [0] directed anteroposteriorly; [1] angled anterolingually and posterolabially. Rescored from [1] to [0] in *Australosyodon*. Rescored from [?] to [0] in *Archaeosyodon* (coded from left side of PIN 1758/293 and PIN 1758/297).
10. Premaxilla forming broad, triangular plate palatally that separates anterior edge of vomers from incisor tooth row [K9]: [0] absent; [1] present. Rescored from [1] to [?] in *Australosyodon*, as the relevant area is not well-preserved.
26. Interorbital crest on midline of frontals [K24]: [0] absent; [1] present. The state [?] was rescored as [-] not applicable.
35. Shape of the symphyseal region of mandible [K31]: [0] anterior edge gradually sloping upward; [1] anterior edge massive, nearly vertical. Modified from [0] to [1] in *Australosyodon* after observation of the holotype.
36. Marked “step” down after the last incisor on dentary [K32]: [0] absent; [1] present, canine on an elevated platform relative to all postcanines. Rescored from [0] to [1] in *Biarmosuchus tener* (PIN 1758/2).

2. Goloboff PA, Farris JS, Nixon K (2008) TNT: Tree Analysis Using New Technology (Willi Hennig Society Edition), Version 1.1. <http://www.zmuc.dk/public/phylogeny/TNT>.

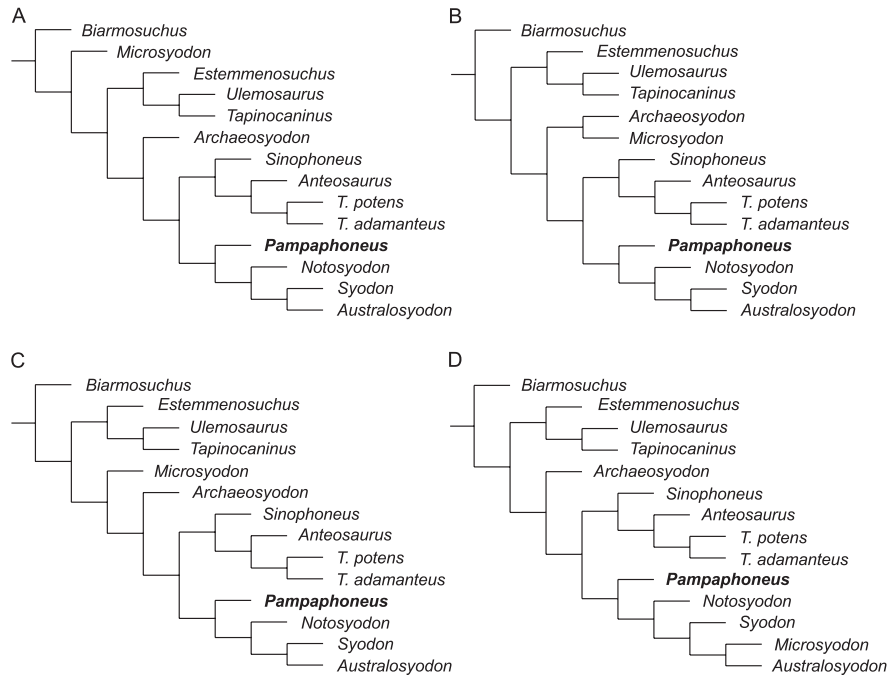


Fig. S1. The four most parsimonious trees recovered in the phylogenetic analysis.

Table S1. Taxon/character matrix used in this analysis

Taxon	+	1111111111	2222222222	3333333333
	0123456789	0123456789	0123456789	0123456789
<i>Biarmosuchus tener</i>	000000000	000000000	001000000	10000010-0
<i>Estemmenosuchus uralensis</i>	120100000	0010000100	?00010000	020012000-1
<i>Ulemosaurus svijagensis</i>	0201A?02?0	001?01110?	100020000?	000022102?1
<i>Tapinocaninus pamela</i>	0?01000210	0011011100	100010000	010022002-1
<i>Archaeosyodon praeventor</i>	1101001101	0110000001	0001010200	100100000-0
<i>Sinophoneus yumenensis</i>	0100?00111	1?11011011	2001111200	1?010111?0
<i>Anteosaurus magnificus</i>	01A1110111	1111011011	210111-100	11011211101
<i>Titanophoneus adamanteus</i>	?10?110111	1111011011	2101111200	11011211111
<i>Titanophoneus potens</i>	0100110111	1111011011	21011???00	1?011211111
<i>Pampaphoneus biccai</i>	0111001111	?11110000?	2001111210	1111?10110?
<i>Notosyodon gusevi</i>	??????????	??????????	??????????	101101????0
<i>Sydon biarmicum</i>	0111101111	1111111001	2011111112	111101010-0
<i>Australosyodon nyaphuli</i>	10A0000111	?111101001	0011111112	1?1100110-0
<i>Microsyodon orlovi</i>	1000001???	??????????	0? ????????	???????????

Ordered characters are indicated by a plus sign. Question marks represent missing information. Hyphens indicate inapplicable characters. A = 0,1.